THE SLING AS A WEAPON

This manual missile launcher is not as well known as the archer's bow, yet it was used by lightly armed troops from India and Persia to Greece and Rome and even survived the advent of gunpowder

by Manfred Korfmann

Everyone knows that David killed Goliath with a sling, but what is the place of the sling in the history of technology? The fact is that slings were a regular weapon of warfare in Europe and the Near East at least from the Bronze Age until the 17th century of our era. Moreover, the sling has been the favored long-range weapon among numerous peoples, past and present, the world over. In Mesopotamia, in Persia and in Greece and Rome a slinger was considered a match for an archer. In that part of the world the sling had probably been known from the beginning of Neolithic times, some 10,000 years ago, and may even have been used toward the end of the Paleolithic.

David's victory over Goliath is often taken to be an allegory, but considering the nature of warfare in David's time, it might better be seen as an example both of the very real skill that slingers possessed and of the trust that they put in their weapon. A review of the encounter, as recorded in the First Book of Samuel, supports this view. David, it will be remembered, was the eighth son of Jesse. As the youngest son, he tended the family flocks. The occupation accounts for his familiarity with the sling; the weapon is used to this day by herdsmen protecting their animals. David had become harpist and armor-bearer to Saul, the king of Israel at a time when the Israelites were at war with the Philistines. The two armies had camped a short distance apart. Each day a Philistine champion, Goliath of Gath, "whose height *was* six cubits and a span," would come out of the enemy camp and offer to fight any Israelite champion and let the outcome of the single combat decide the war.

David came to the Israelite camp at a time when 40 days of Goliath's challenges had failed to rouse a single Israelite warrior. David volunteered to fight Goliath, but he refused to wear the armor or carry the arms that Saul pressed on him. At this point the narrative goes:

"And he took his [shepherd's] staff in his hand, and chose him five smooth stones out of the brook, and put them in a shepherd's bag which he had . . . and his sling *was* in his hand: and he drew near to the Philistine."

"And David put his hand in his bag, and took thence a stone, and slang *it*, and smote the Philistine in his forehead, that the stone sunk into his forehead; and he fell upon his face to the earth."

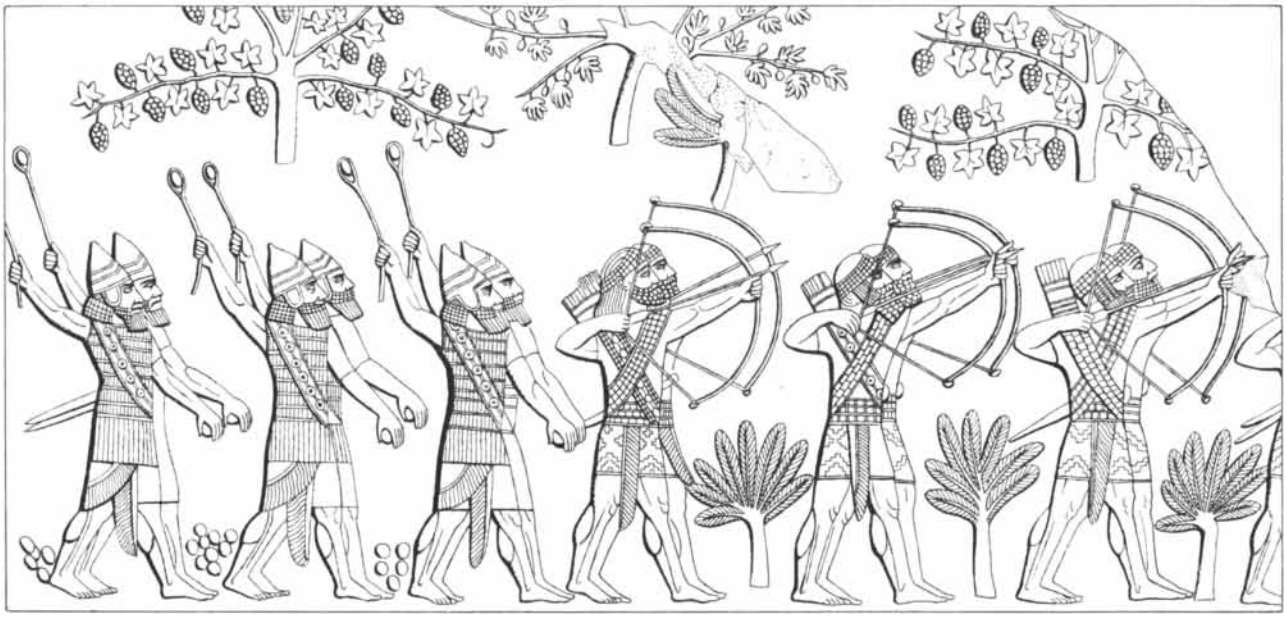
"Therefore David ran and stood upon the Philistine, and took his sword, and drew it out of the sheath thereof . . . and cut off his head therewith. And when the Philistines saw their champion was dead, they fled."

Goliath had been dressed in full armor for the encounter: a metal helmet, a coat of mail, metal greaves on his legs and a small shield slung on his back. He had a bearer who preceded him with a larger shield. The sword David used to cut off Goliath's head is not described, but Goliath's spear had a shaft "like a weaver's beam" and a heavy spearhead. This equipment is not unlike what was carried by a Greek hoplite, or heavy infantryman. It is meant for shock tactics; the spear is not for throwing but for thrusting or for defense against cavalry attack. Goliath's armor and arms, except possibly for the spear, would also have been appropriate for single combat with another warrior similarly armed. They were entirely unsuited, however, for the pursuit of an unarmored, swift-footed adversary, and so David would have been quite safe as long as he kept his distance.

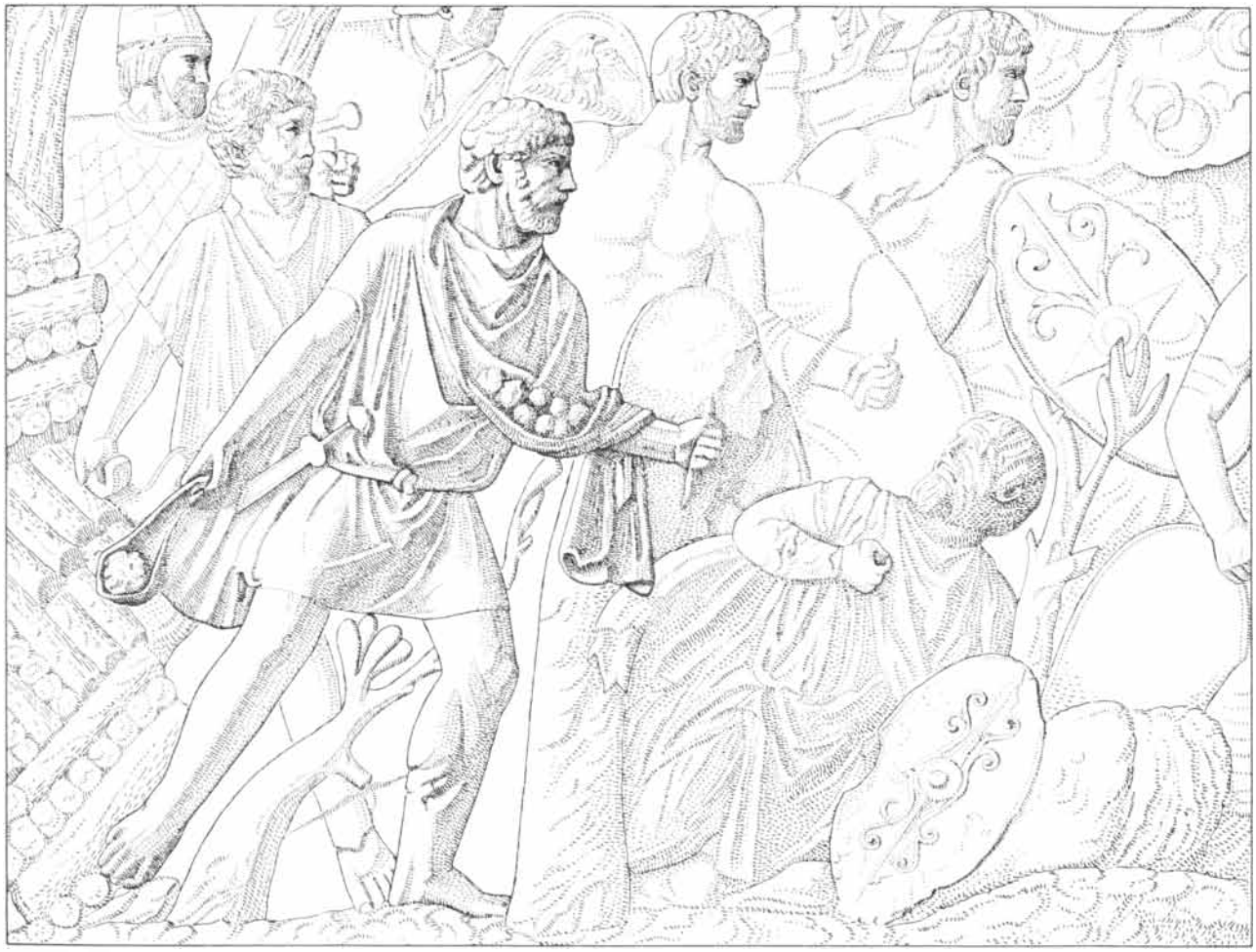
David would have had no intention of closing with his opponent; the sling is a long-range weapon. At the same time, whatever confidence David may have placed in God's help in preparing him for the encounter, he chose not one pebble for his sling but five. If his first shot had not struck Goliath in the face, the vital yet unprotected area that David had certainly aimed at, four more pebbles remained at his disposal. On balance it seems fair to credit David's victory not to divine intervention but to his skill as a slinger.

David is the best-known biblical slinger, but he is not the only one. The left-handed slingers of Benjamin (Judges) caused heavy casualties among the Israelites, and David's own elite corps "could use both the right hand and the left in *hurling* stones" (Chronicles). Why, then, has the sling remained almost unnoticed as a weapon of war? There is some hint of an answer in the *Iliad*. In Homer's account of the siege of Troy an allusion is made to the Locrians, warriors without armor who trusted in their bows and "well-twisted wool." The Greek word for "sling," however, appears only once in the entire epic. Even then the sling is mentioned not as a weapon but as an improvised bandage: one Trojan warrior binds up the wounded hand of another "with a strip of well-twisted wool . . . , the sling [used by] the shepherd of the host." It would appear that Greek peltasts, lightly armed troops whose ranks included slingers, javelin-

DAVID AND GOLIATH appear in the photograph on the opposite page as seen on the wall of a 10th-century Armenian church built on an island in Lake Van. Goliath is seen with his sword drawn. David, his long-range weapon loaded and ready, is standing much too close to Goliath in this portrayal; a cast of 250 yards was not unusual for the slingers of that time.



ASSYRIAN SLINGERS, swinging their slings parallel to their bodies, stand behind the archers in this drawing based on a relief from Nineveh showing one of the campaigns of Sennacherib (704–681 B.C.). Their place in battle suggests that they outranged archers.



ROMAN AUXILIARY in the Dacian wars, his sling at the ready, carries extra missiles in the fold of cloak flung over his shield arm. The figures in this drawing appear on a monument in Rome, the column erected to honor the Emperor Trajan's victory in the wars.

throwers and archers, received little recognition in the days when only hand-to-hand combat between armored warriors was considered honorable. Pictorial representations of hoplites (and even of archers and javelin-throwers) are common enough, but slingers are seldom seen.

Lightly armed troops nevertheless played a major role in warfare during classical Greek times. To them was given the initiation of battle. The shower of javelins, arrows and slingstones they let fly might open a breach in the opposing ranks; at the least it would expose weak points in the enemy formation that the advancing heavy infantry could exploit. Moreover, if the advance was unsuccessful, the lightly armed troops were available to cover the heavy infantry's retreat. An army that entered battle without peltasts was as good as defeated.

We have a detailed account of the fate of just such an army; it had been deprived overnight of almost all its lightly armed troops. This was the force of 10,000 Greek heavy infantrymen that was the backbone of a much larger army seeking to overthrow the king of Persia in 401 B.C. After the pretender to the throne who led them had fallen at the Battle of Cunaxa, the pretender's native forces fled and the Greeks were left alone. The Athenian Xenophon undertook to lead the 10,000 Greek infantrymen to safety, but on their first day's march they were so plagued by small numbers of enemy cavalrymen, archers and slingers that they could travel only some 25 stadia: less than three miles. That night Xenophon declared to his captains: "We need slingers ourselves at once, and horsemen also."

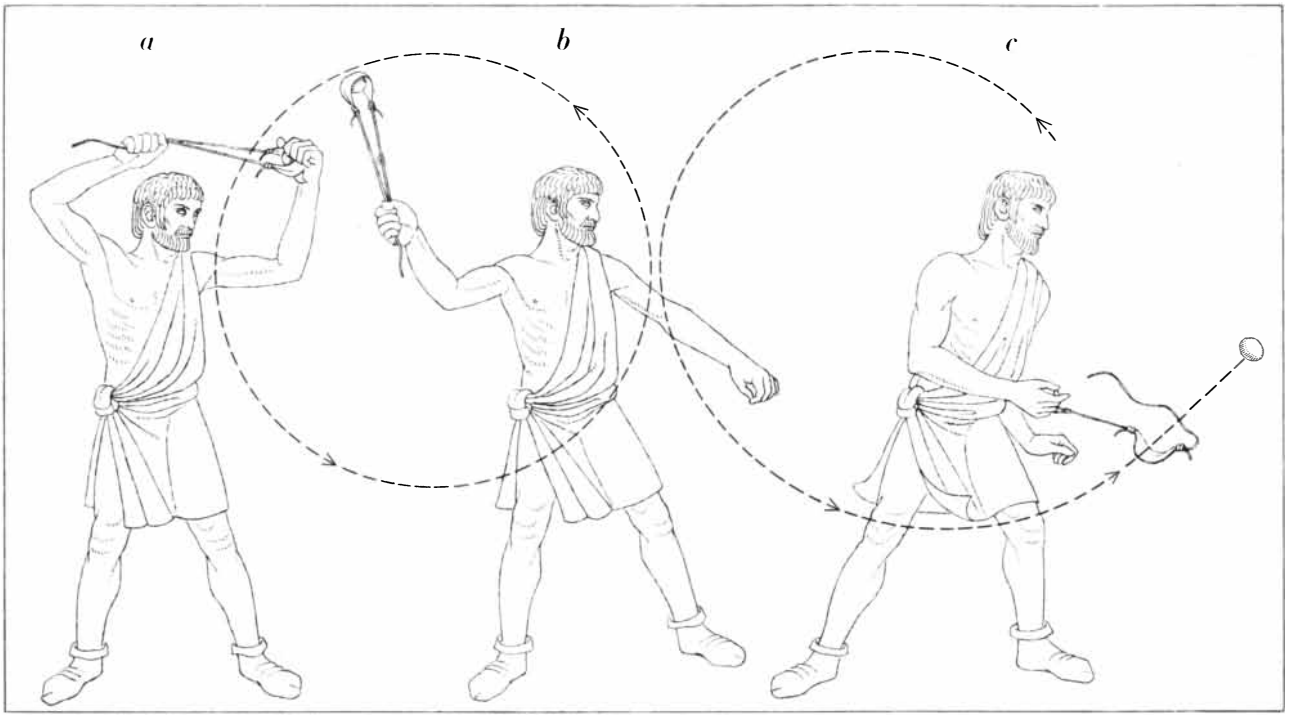
"Now, I am told," Xenophon continued, "that there are Rhodians in our army, that most of them understand the use of the sling, and that their missile carries no less than twice as far as those from the Persian slings. For the latter have only a short range because the stones that are used in them are as large as the hand can hold; the Rhodians, however, are versed also in the art of slinging leaden missiles."

STARTING POSITION, with sling poised above the head, is seen in this sculpture of a Neo-Hittite slinger from Tell Halaf in Syria, executed in the ninth or eighth century B.C.

Xenophon and his colleagues soon recruited from the ranks 200 slingers and a cavalry squadron of 50 men mounted on packhorses. The addition of these lightly armed forces to a body of 200 Cretan archers among the 10,000 enabled the Greeks thereafter to give a good account of themselves against the pursuing Persians. The Cretan archers' range was not the equal of the Persian archers', but the Rhodian slingers, Xenophon noted, "carried farther with their missiles than the Persians, farther even than the Persian bowmen." Considering that the archers of Persia were then regarded as the best in the world, his statement speaks well for the range of the Greek slingers.

Exactly how do the sling and the bow compare in range? The Roman military commentator Vegetius, writing in about A.D. 400, recommended target practice with the bow at a range of 180 meters. Even a modern sporting bow with a 45-pound pull can propel its arrow little more than 200 meters. With a long, light "flight arrow" and a bow with a 60-pound pull an archer trying for distance might achieve a range approaching 275 meters. By way of comparison I asked some young men in eastern Turkey to sling ordinary pebbles for me. In five out of 11 trials the pebbles struck beyond a mark placed 200 meters away, and the three best casts fell between 230 and 240 meters away. None of the young men appeared to be a skilled slinger; at least none had a sling in his possession at the time. Moreover, the missiles were pebbles selected at random rather than the carefully shaped stone, clay or lead missiles launched by slingers in Greek and Roman times. On the basis of Xenophon's comment alone it seems probable that a slinger casting lead missiles could attain a range in excess of 400 meters.

The sling I have been discussing is the flexible hand sling (*funda* in Latin). There is a second kind of sling: the staff sling (*fustibalus* in Latin). The hand sling can be no more elaborate than a strap three feet or so in length and an inch or



HAND SLINGER'S CAST begins (*a*) with the sling loaded and poised; the fixed end of the sling is looped around one finger of the slinging hand and the free end is held between thumb and forefinger. Three or four counterclockwise rotations of the sling (*b*), achieved primarily by the movement of wrist rather than arm, bring the missile up to maximum velocity. The missile is let go (*c*) when the slinger releases the free end of his sling; at the start of its parabolic flight it travels at more than 60 miles per hour.

so in width. At one end the strap is looped, knotted or tasseled, allowing it to be made fast to any of the four fingers of the slinger's throwing hand. The other end, which can be knotted to provide a grip, is held between the thumb and forefinger of the throwing hand. The thrower places the missile in a "pocket," sometimes artificially enlarged, at the end of the dangling loop. If the missile is made of stone or clay, it is usually the size of a small egg. A rotary motion of the wrist sets the sling whirling rapidly, either semihorizontally (around the slinger's head) or vertically (parallel to the body). After three or four revolutions the slinger releases the free end of the strap and the missile flies off on a tangent to the circle described by the sling.

The staff sling is inferior in range to the hand sling. At the same time it is easier to handle and can be employed to throw larger and heavier missiles. The sling, usually made of cord, has one end tied to a pole perhaps three feet long. The free end of the sling is temporarily attached to the end of the pole; either the end of the pole is notched so that the free end of the sling can be slipped into the notch or the free end of the sling is looped so that it can be slipped over the end of the pole. An enlarged pocket at the end of the dangling loop holds the missile. The pole, which at first is held parallel to the ground, is brought abruptly upright above the slinger's head; at the top of the swing the free end of the sling slips off and the missile flies free [*see illustration on opposite page*]. Used in both Greek and Roman times, the staff sling was a popular siege weapon through the Middle Ages. Even with the advent of gunpowder it served as a kind of grenade launcher well into the 17th century.

The longer the sling, within practical limitations, the greater the potential velocity of the missile. The natives of the Balearic Islands to the east of Spain were notable slingers. Indeed, Polybius, a Greek historian of the second century B.C., stated that the islands took their name from this fact, *ballein* being a Greek word meaning "to throw." However that may be, Balearic slingers served as lightly armed troops in many of the wars of classical times, perhaps most notably in the long conflict between Rome and Carthage. They always carried three lengths of sling: a long one for long range, a short one for short range and one of intermediate length for ranges in between.

Turning to the missiles themselves, it is clear that when they are nothing more than water-worn pebbles, the archaeologist cannot easily identify them as missiles. Only when a number of similar stones are found close together and show no evidence of being used for some other purpose (say hammering or rubbing), or best of all when they are of a kind that is foreign to the place where they are found, can such stones be considered potential evidence for the use of the sling at that place and at the time indicated. Fortunately, although vast numbers of naturally formed missiles may never be recognized, a good many ancient sling missiles were manufactured with great care. These artifacts are not always easy to perceive. Even when they have been recognized, they have often only led archaeologists to wonder what purpose such odd "clay eggs" may have served.

In the Near East the first manufactured sling missiles were spherical. They made their appearance shortly before the beginning of the sixth millennium B.C. Biconical projectiles were the next to appear [*see top illustration on page 40*]. A millennium later, around 4000 B.C., ovoid missiles also came into service. Three considerations, all concerned with the improvement of accuracy, seem to have worked together in the development and standardization of the missiles. The first objective was to make the weight of the missiles reasonably uniform, so that the slinger did not have to compensate for a different weight at every cast. The second objective was to provide a uniform, somewhat stream-

lined shape, in the interest not only of accuracy but also of velocity and distance. The third was to have the missile fit the pocket of the sling snugly, so that, as the Roman historian Livy remarked, "the missile may not fly out at random... but, seated firmly while being whirled, may be shot out as if from a bow-string."

In making these shaped sling missiles of stone the makers showed a natural preference for easily worked materials such as limestone. At a very early date, however, even earlier than the prepottery phase of the Neolithic, some men had recognized the advantages of clay as a material. Clay missiles are found in both prehistoric and historical sites all over the world. For example, clay missiles some 7,000 years old have been found at Hassuna, a site in Iraq, and similar missiles have been excavated elsewhere not just by the hundreds but by the thousands. It was not the absence of suitable stone for missiles that led to the use of clay; clay missiles are found at numerous sites where the supply of pebbles was plentiful.

The clay sling missiles are curious on two counts. First, in almost all instances they have been hardened by being dried in the sun rather than by baking. Second, they are surprisingly heavy for their size. The two facts are related. In order to attain maximum weight within rather narrow dimensional limits the makers of the clay missiles did not temper the material with chaff, as is done with pots and even bricks. The missiles were made of pure clay (or, very occasionally, of pebbles sheathed in clay) and are correspondingly dense. If these pure-clay missiles had been baked in a fire, the heat would have cracked them and made them worthless. This was why they were dried slowly in the sun.

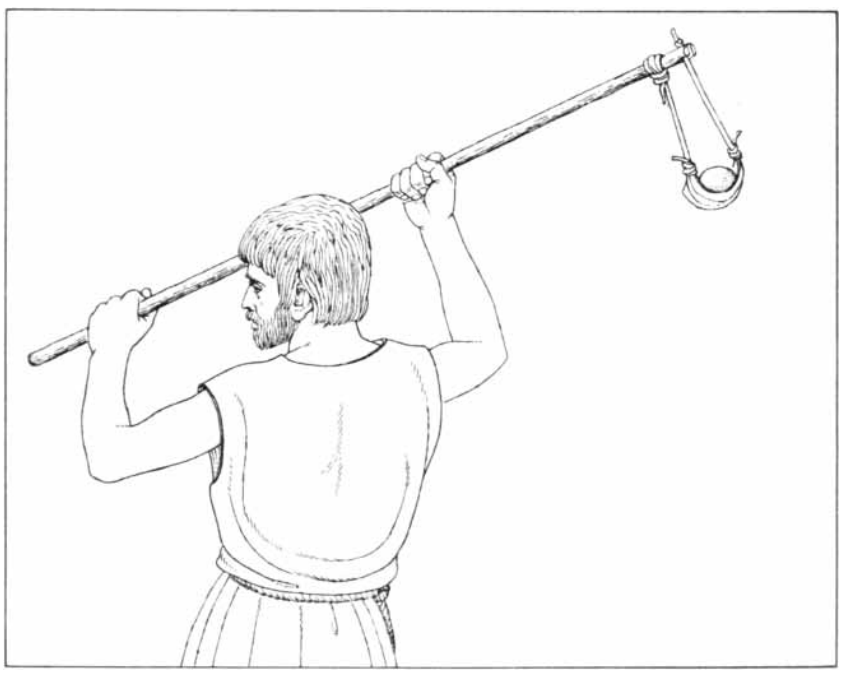
By classical Greek times, if not before, another kind of sling projectile had become common. The new missiles were made of lead. The Romans called them *glandes* because of their supposed resemblance to acorns. They were cast in molds and often carried inscriptions; the same few letters, scratched into the depressions of a mold, might serve to mark many hundreds of missiles. Often the inscriptions were routine: the name or number of the slinger's military formation, the name of the warring state or that of the commanding general. Not a few, however, are less formal. "Take this," reads one; "An Achaean blow," brags another; a third reads, "Your heart for Cerberus"; a fourth, "For Pompey's backside," and a fifth merely "Ouch."

As Xenophon's comparison of Rhodian and Persian sling missiles indicates, the standard missiles varied widely in size and weight. Measurement of a representative sample of biconical and ovoid stone missiles from sites in the Near East indicates how broad the range could be. The minimum weight was 13 grams; the maximum, 185 grams. With respect to volume the range was from about five cubic centimeters to about 65. (If the missiles had been perfectly round, the diameters corresponding to these extremes in volume would have been respectively about two centimeters and five centimeters.)

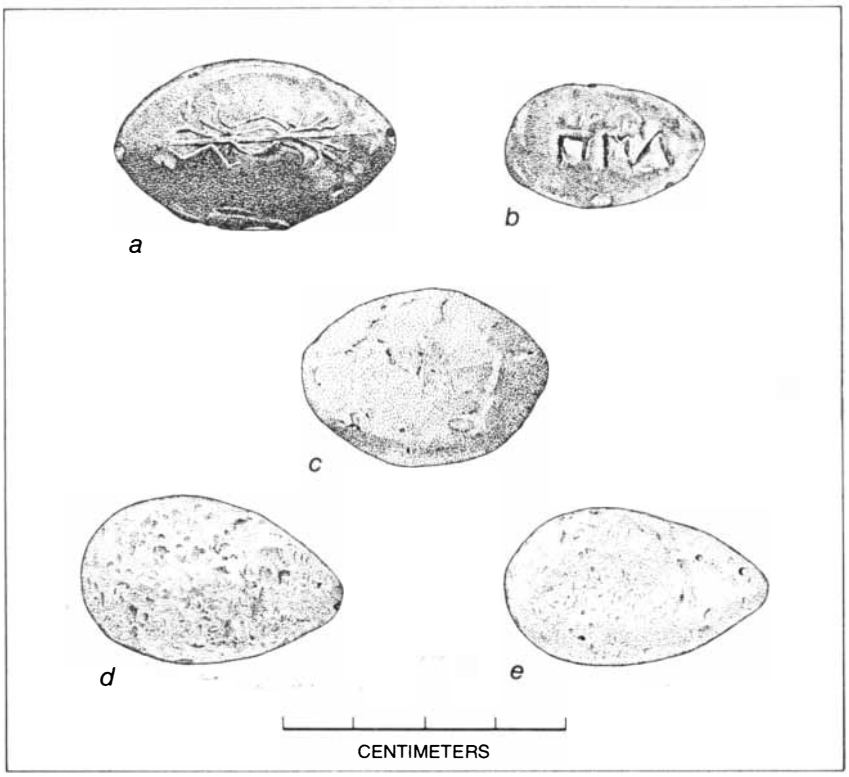
Taking sling missiles in general, whether they were made of stone, clay or lead, the range of weights is usually narrower than this. Few of the lighter missiles weigh less than 20 grams and few of the heavier ones more than 50. This was true, for example, in Roman times. In 1885 the German classical scholar K. Zangemeister published among other findings the weight of sling missiles from certain sites in Sicily and Italy. He found that the missiles with the lightest average weight (ranging from a minimum of 24 grams to a maximum of 46 grams) were from Sicily. The heaviest were from Asculum, a mainland site; their average weight was over 47 grams. Those from a second mainland site, Perusia, were intermediate in weight.

The missiles sometimes used by the Balearic slingers provide a notable exception to even the Near Eastern maximum of 185 grams. The Sicilian-born historian Diodorus Siculus, writing in the first century B.C., gave an account of the Battle of Eknomos, where Carthaginian forces, including 1,000 lightly armed Balearic slingers, defeated Agathocles of Syracuse. The slingers are given much of the credit for the victory. Diodorus stated that their stone missiles weighed one *mina* each. Now, the *mina* is variously calculated to be equivalent either to 330 grams or to 450 grams. If one conservatively chooses the lesser value (which roughly corresponds to the Roman pound and the Attic *mina*) and assumes that the Balearic missiles were made of limestone, each stone would have been 6.3 centimeters in diameter, or nearly the size of a tennis ball. That size and weight probably represent the outside limits for sling missiles made of stone.

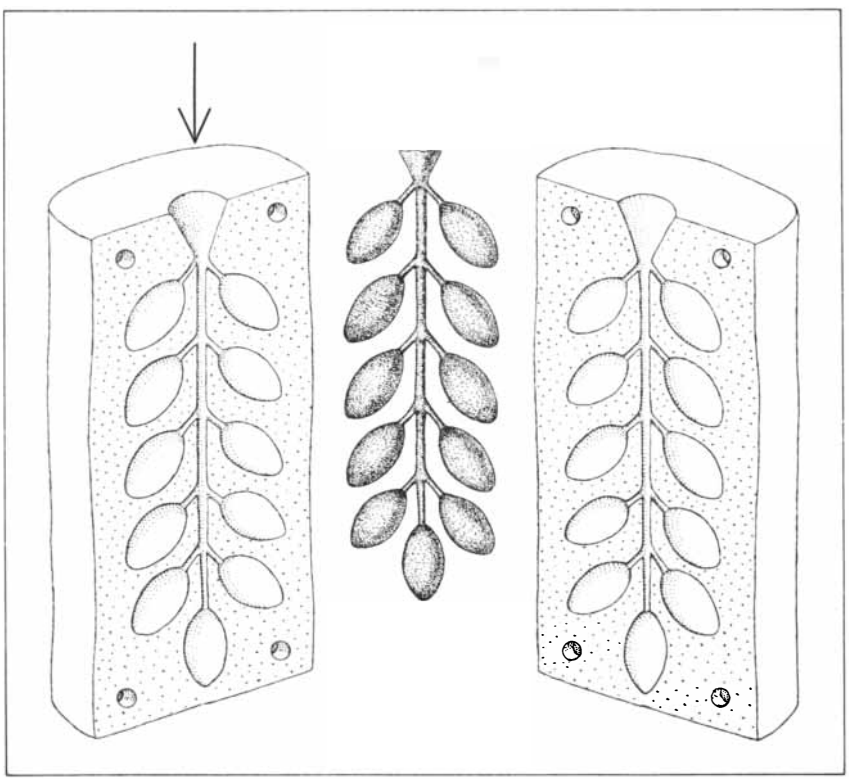
How accurate were the slingers of Greek and Roman times and how much damage could their missiles do? There is an abundance of documentary evidence on both points. Livy declared that Achaean slingers were the finest. He attributed this to the Achaeans' having practiced accuracy by slinging their missiles so that they would pass through a hole in a ring of "moderate circumfer-



STAFF SLINGER'S THROW is a quick snap from a horizontal to an upright position. The free end of the short sling is slipped into a notch at the end of the staff and will disengage at the top of the swing, releasing the missile. Staff slings do not have as great a range as hand slings but they will take heavier loads and were even used to throw grenades.



MAN-MADE MISSILES, as distinguished from pebbles, include large (*a*) and small (*b*) molded lead projectiles. The large one, of Greek or Roman origin, displays a thunderbolt design; the small one is among the hundreds excavated at Olynthus in Greece. The third missile (*c*) is a biconical type, made of sun-dried clay. The others (*d, e*) are ovoids of stone.



TERRA-COTTA MOLD of the "tree" variety was used to cast 11 lead missiles at a time. This reconstruction is based on a part of a mold that was discovered at Olynthus. Between the two halves of the porous mold is shown a tree casting before the detachment of its missiles.

ence" set up at a distance. As a consequence of this training, Livy wrote, the Achaeans "would wound not merely the heads of their enemies but any part of the face at which they might have aimed." One is immediately reminded of David's celebrated first cast.

The skill of the Balearic slingers was also attributed to special training. Diodorus wrote of them "that their mothers compel them, while still young boys, to use the sling continually; for there is set up before them as a target a piece of bread fastened to a stake, and the novice is not permitted to eat until he has hit the bread, whereupon he takes it from his mother with her permission and devours it." Precision in slinging is also reported of the Benjamites, the left-handed slingers mentioned in the Bible: they "could sling stones at a hair *breadth,* and not miss."

As for the effectiveness of the sling as a weapon, it is worth noting that the speed of a missile leaving a sling can easily exceed 100 kilometers per hour. If one assumes that a 25-gram missile had that velocity when it reached the target, the force of its impact would be equivalent to that of a golf ball falling from the top of a seven-story building. The energy of heavier missiles, of course, would be proportionately greater. Vegetius said that biconical sling missiles were more deadly than arrows against opponents clad in leather armor. Even if the missile did not penetrate the armor, Vegetius noted, it was capable of inflicting a fatal internal injury. If the opponent was unarmored, of course, the missile could easily penetrate the body. Celsus, perhaps the most judicious medical author of Greek and Roman times, included in his treatise *De Medicina* instructions for extracting lead and stone sling missiles from the bodies of wounded soldiers. His instructions followed by some centuries the observation by the Greek historian Thucydides that the slingers of a seacoast district in Epirus, the Acarnanians, so distressed invaders with a hail of missiles at long range that "it was not possible for [the invaders] to stir without armor."

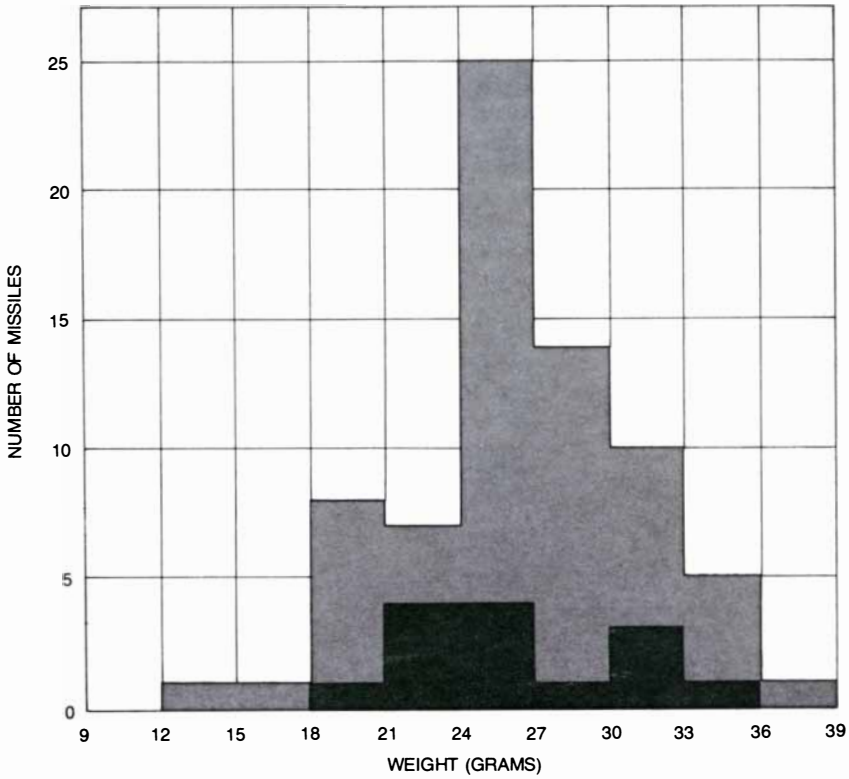
In more recent history we find the conquistadors' comments on the accuracy and effectiveness of Peruvian slingers. "Their chief weapon," wrote one Spanish observer, "is the sling. With it they throw a large stone with such force that it could kill a horse. Its effect is indeed only slightly less than that [of a Spanish firearm]; I have seen how a stone flung from a sling over a distance of 30 paces broke in two a sword that a man was holding in his hand."

In the 1930's some 500 lead sling missiles were uncovered by David M. Robinson in his excavation at Olynthus, an ancient city of northern Greece. More than 100 of the missiles bear inscriptions; some identify the missile as belonging either to the defenders of Olynthus or to the Macedonian troops who, under Philip, the father of Alexander the Great, captured the city in 348 B.C. Not all the inscriptions, however, provide such identifications.

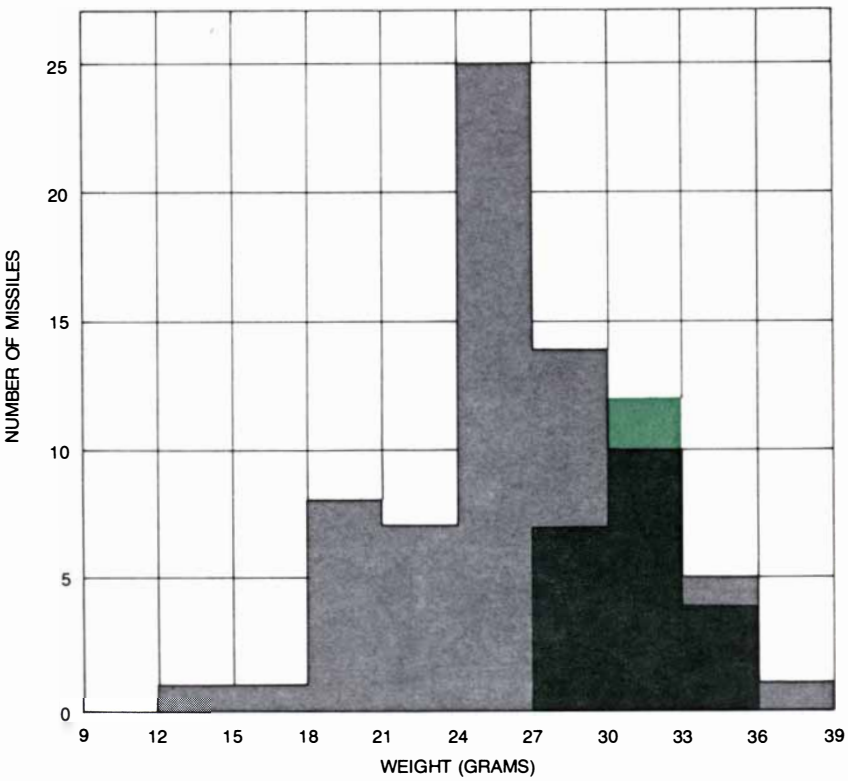
Robinson published detailed measurements of all the inscribed missiles. They ranged in weight from 18 to 35 grams. When the weights are compared with the identifying inscriptions, an interesting correlation emerges: most of the Macedonian missiles are at the heavy end of the range and most of the Olynthian ones run from light to medium [*see illustrations at right*]. This suggests that other missiles found at the site can be at least tentatively assigned to either the Macedonian or the Olynthian forces on the basis of weight. Moreover, on certain of the missiles that can be assigned to the Olynthians on the basis of their light weight there appear names: Potalos for one, and what may be either Timosthenes or Timostratos. Because it was often the custom to mark lead missiles with the names of the generals commanding the troops, it is quite possible that the two men named on the Olynthian missiles were leaders of the defending forces who are otherwise unknown to history. Similar studies of sling projectiles from other classical sites might yield equally unexpected historical information.

Slings continued in military service into the 17th century, but even by A.D. 400 the increasing employment of armor and fast cavalry was making the slinger obsolete. Vegetius recommended that slingers be trained to release their missile after a single swing rather than the customary three; the objective was obviously to increase the slingers' rate of fire. It was mainly the staff sling that survived the introduction of gunpowder and small arms, but I can vouch for the use of the hand sling as late as 1936. In that year, during the Spanish Loyalists' siege of the Alcázar, the fortress where the rebel garrison of Toledo had taken refuge, the besiegers lobbed grenades into the fortress with slings. A motion picture still exists showing one such slinger in action.

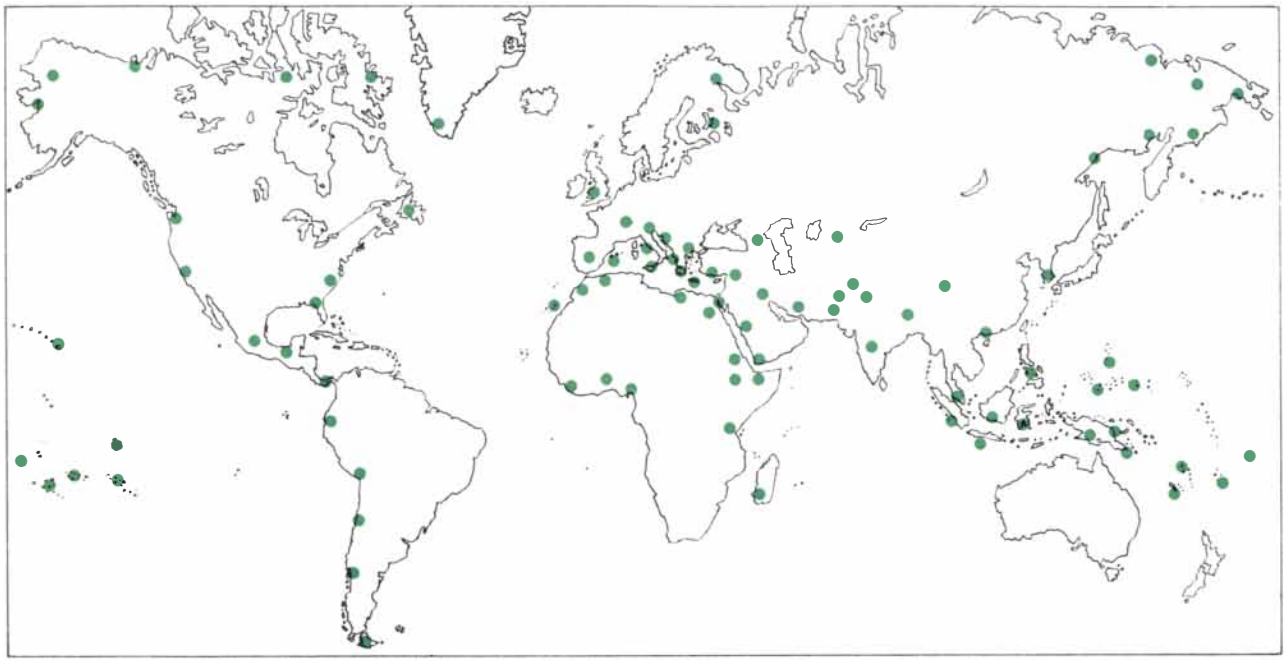
The British prehistorian V. Gordon Childe more than once toward the end of his life attempted to bring the significance of the sling as a weapon to the



DEFENDERS' MISSILES at the siege of Olynthus in 348 B.C. ranged from 19.5 to 33.4 grams in weight (*colored bars*). Nine of the 14, however, weighed less than 27 grams. When their weights are compared with the weight range of other sling missiles excavated at Olynthus (*gray bars*), most of the defenders' missiles cluster on the medium-to-light side of the scale.



ATTACKERS' MISSILES at the siege weighed more than the defenders'. Of the 23 identifiable as Macedonian, 16 weighed between 30 and 35.8 grams. Compared with the weight range of the other missiles (*gray bars*), the Macedonian missiles are on the heavy side.



WORLDWIDE DISTRIBUTION of the sling from the beginnings of history up to recent times (*colored dots*) suggests that there are few major areas of the globe where the weapon is unknown. The early importance of the sling in the Near East and in Europe adds weight to the argument that the art of slinging spread from this nuclear area. Unless the sling was independently invented in the New World, its presence there is also an argument for some kind of connection with the Old World via the Pacific or the subpolar zone.

attention of his colleagues. He met with little success, but I, at least, found his conjectures compelling. Indeed, taking Childe's work as my starting point, I have recently published a hypothetical reconstruction of the relative importance in prehistoric times of the sling and the bow in the Near East. I defined the area of my study as being bounded by the Bosporus on the west, the Indus on the east, the Caucasus on the north and Sinai on the south. In this large area, my evidence suggests, the two weapons were mutually exclusive for a period of several millenniums; that is to say, the peoples who used the one saw no good reason to take up the other.

This polarity of the sling and the bow is first discernible in the eighth millennium B.C.; it continues until the fourth millennium and even later in some parts of Asia. For example, the bow was used almost exclusively in Syria and Palestine before the rise of the city-states in those areas, but the inhabitants of other parts of the Near East preferred the sling. The bow was evidently unknown in the region until almost the end of the eighth millennium, but knowledge of the sling is some thousands of years older. One area of overlap between the two long-range weapons provides an exception to this polarity. In Asia Minor, at Çatal Hüyük and elsewhere about 6000 B.C., both the sling and the bow were used.

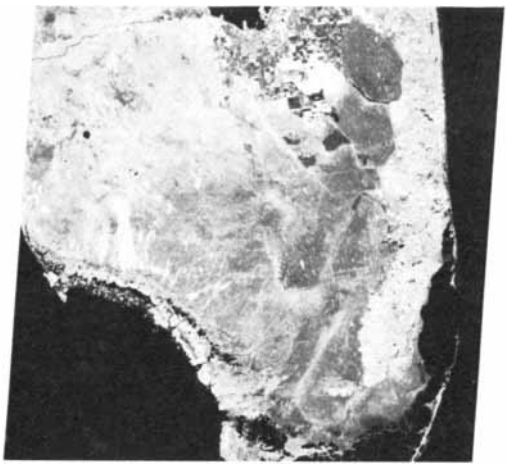
Support for my hypothesis consists of finds at more than 80 sites in the region, all of them fairly reliably dated, that show the presence of one or the other of the two weapons. The evidence is not confined to the Near East. The presence of the bow in Syria and Palestine represents a kind of Asian beachhead for this weapon; the staging area for the landing, so to speak, was clearly Africa. There the preference for shafted projectiles is easy to perceive in the Aterian projectile points of the Upper Paleolithic period, in the rock paintings of archers that are found in Africa and as far away as Spain, and in the thousands of small projectile points that have been found at sites throughout the Sahara. In all probability the Arabian peninsula can be added to this African bowmen's realm, although that region is still virtually terra incognita for the archaeologist. By the same token, at least by the beginning of Neolithic times the realm of the slinger in southwestern Asia had expanded to include not only the Balkans but also southeastern Europe in general.

The polarity in long-range weapons cannot be attributed to a lack of communication between the two realms; the peoples of both areas had ample contact with one another. For example, during the prepottery phase of the Neolithic in the eastern Mediterranean obsidian was regularly transported from parts of Asia Minor where the sling was used to as far south as Beida in southern Jordan, where the bow was supreme. Some explanation other than isolation must be sought. When the explanation is found, it may transcend the weapons themselves and thus lie outside the realm of archaeology proper, with its focus on material culture.

Perhaps future investigation of the separate realms of the sling and the bow will bring about a revival of "Kulturkreise" theory, which envisions the rise and expansion of "culture circles" in prehistoric times. In the present context a Kulturkreise hypothesis would envision one culture circle that expanded from Africa across Spain and western Europe, while another culture expanded from southwestern Asia across the Balkans and southern and eastern Europe. Of course, the bow and the sling would on this hypothesis merely be material-culture indicators of a far more complex constellation of social phenomena.

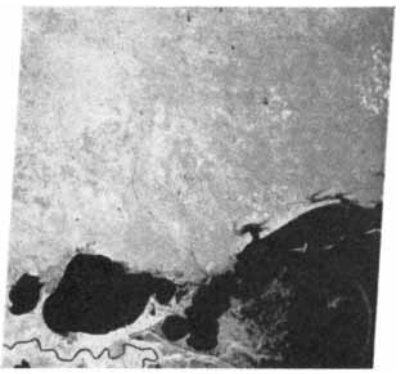
However that may be, it is clear that archaeological work in the future must pay more attention to the sling as a prehistoric weapon of major significance, not only in the Near East but also elsewhere in the world. Even with our present limited knowledge it is clear that the slinger and the archer were equals for thousands of years.

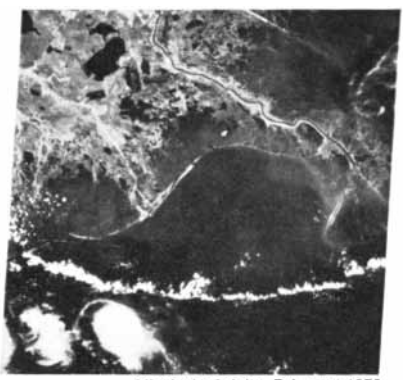
Taxpayers, you have invested in the space program. Now benefit from your investment.



Miami and environs, 22 March 1973

New Orleans and environs, 7 August 1972





Mississippi delta, 7 August 1972

The U.S. Geological Survey, which runs the EROS program (Earth Resources Observation Systems), points out an opportunity to serve the public interest by calling to your attention that imagery is now available of just about any region on earth, except within some 900 miles of the poles.

Everywhere else, NASA's ERTS (Earth Resources Technology Satellite) goes over every 18 days 567 miles high, looking down in four wavelength bands: 0.5-0.6 μm, 0.6-0.7 μm, 0.7-0.8 μm, and 0.8-1.1 μm. Anybody–grade school teacher, ranch broker, botanist, Cub Scout–with $1.75 to spend can have a 9″ x 9″ print of any place selected. The 9″ x 9″ will encompass 115 miles x 115 miles. Changes may be apparent from the previous pass.

For the sake of preserving the earth's glory, let's learn how to look through mankind's new microscope-in-reverse. Let's assume that if Aristotle and his friends had had even ordinary microscopes, we'd all be happier today.

San Francisco and environs, 4 April 1973

Details:

A quick way to get a look through that great new reverse-microscope in the sky is to phone 605-594-6511 between 7 a.m. and 7 p.m. Central Time. Tell what geographical area interests you and what you have in mind. You will be talking to a helpful, well-informed, and quite real person. His or her hand that isn't holding the telephone will be in contact with heavy computer power.

The computer will even know how much was under cloud each time ERTS passed over the region of interest. It might even report that the area was photographed in 1936 and that, if you'd rather have that black-and-white shot from 5,000 feet instead of infrared "false color" from 567 miles, you can so order. Or you might be told the same place was photographed by a Gemini astronaut with a hand-held camera or by completely automatic equipment from Skylab this year, and how would you like *that?*

The EROS price list reflects just the cost of reproducing the photographs. (The cost of the satellite is more widely shared.) A 40″ x 40″ color enlargement on paper, for example, is priced at $25. To avoid misunderstanding, you can take down the numbers of possibly interesting pictures and check them out on a microfilm browse reader at any of 19 locations in the U.S.A. before placing your order. Black-and-white copy negatives or color internegatives can be ordered if you wish to do your own printing. No copyright worries.

If you want to experiment with the color rendition of the bands to emphasize certain signatures, come in person any business day from 7:45 a.m. to 4:30 p.m. to EROS Data Center, 14 miles northeast of Sioux Falls, S.D. Scientific staff members are available there for consultation on instrumentation and interpretation problems.

Don't expect much, though, by way of direct interpretation. *That* the customer does, or consultants the customer may engage, assisted by a fast-growing literature. Aerial photography and the interpretation thereof are not leaving the private sector. On the contrary, those in the business welcome EROS as a tantalizer to swarms of new prospects.

EROS Data Center can also be queried by mail (ZIP 57198).

An article in *American Scientist 61:*175 can take you farther into this fascinating subject. Address reprint requests to Eastman Kodak Company, Dept. 55W, Rochester, N.Y. 14650. But get in touch with EROS, not Kodak, if you want a picture of the old home town from 567 miles up.

You have heard of self-fulfilling prophecy? Its converse, self-denying promise, may threaten if this advertising proves too successful. There must be a limit to how many inquiries a day can be handled in the manner promised here.

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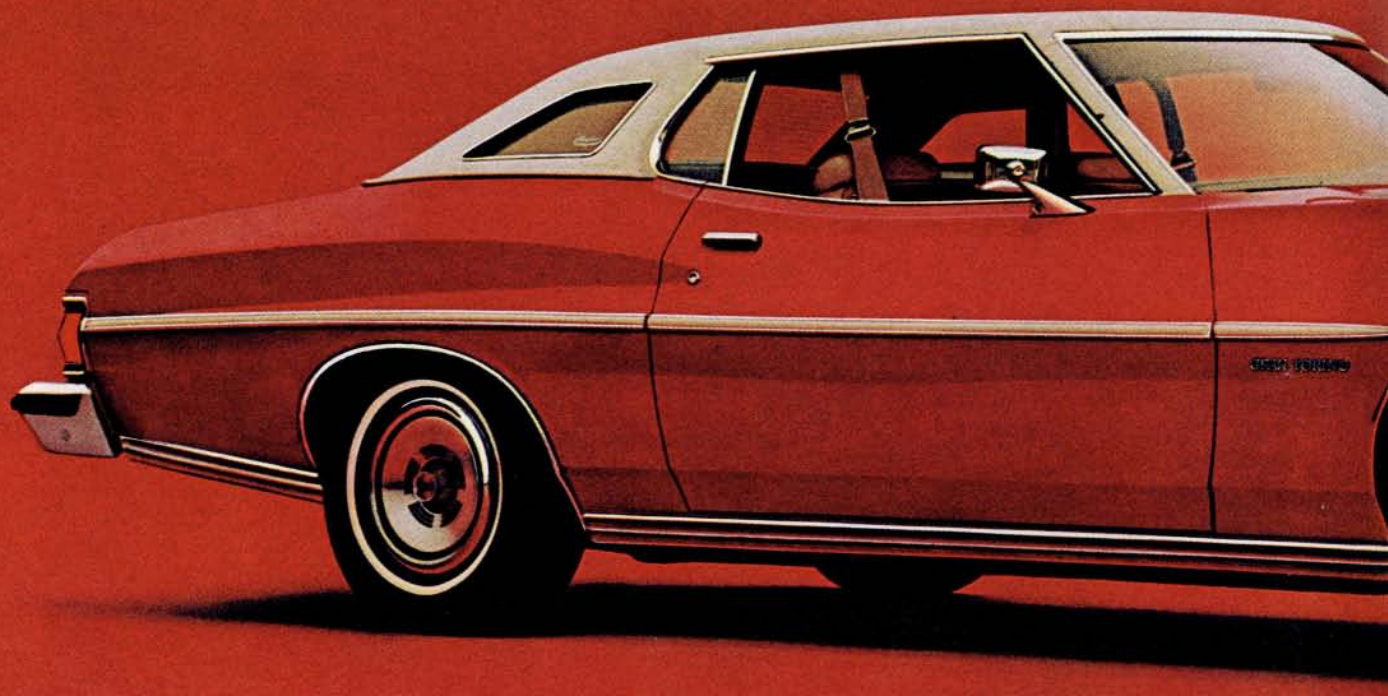
Inside, the Gran Torino Brougham's split bench seats (pictured at right) add a touch of luxury and convenience.

And while you can love Torino for its looks, you can trust it because it's solid. Torino's sus-



1974 Gran Torino Brougham shown with optional deluxe bumper group, electric rear window defroster and convenience group.

TORINO'74

pension, wide track and long wheelbase help give it a smooth and steady ride that spells quiet comfort and confidence on the road. As do Torino's optional steel-belted radial ply tires and power front disc brakes.

In fact, safety and security are part and parcel of Torino's design. And this year, Torino's Lifeguard-Design Safety Features include a new style interlock safety belt system that lets you really move in your seat with ease and comfort.

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FORD TORINO

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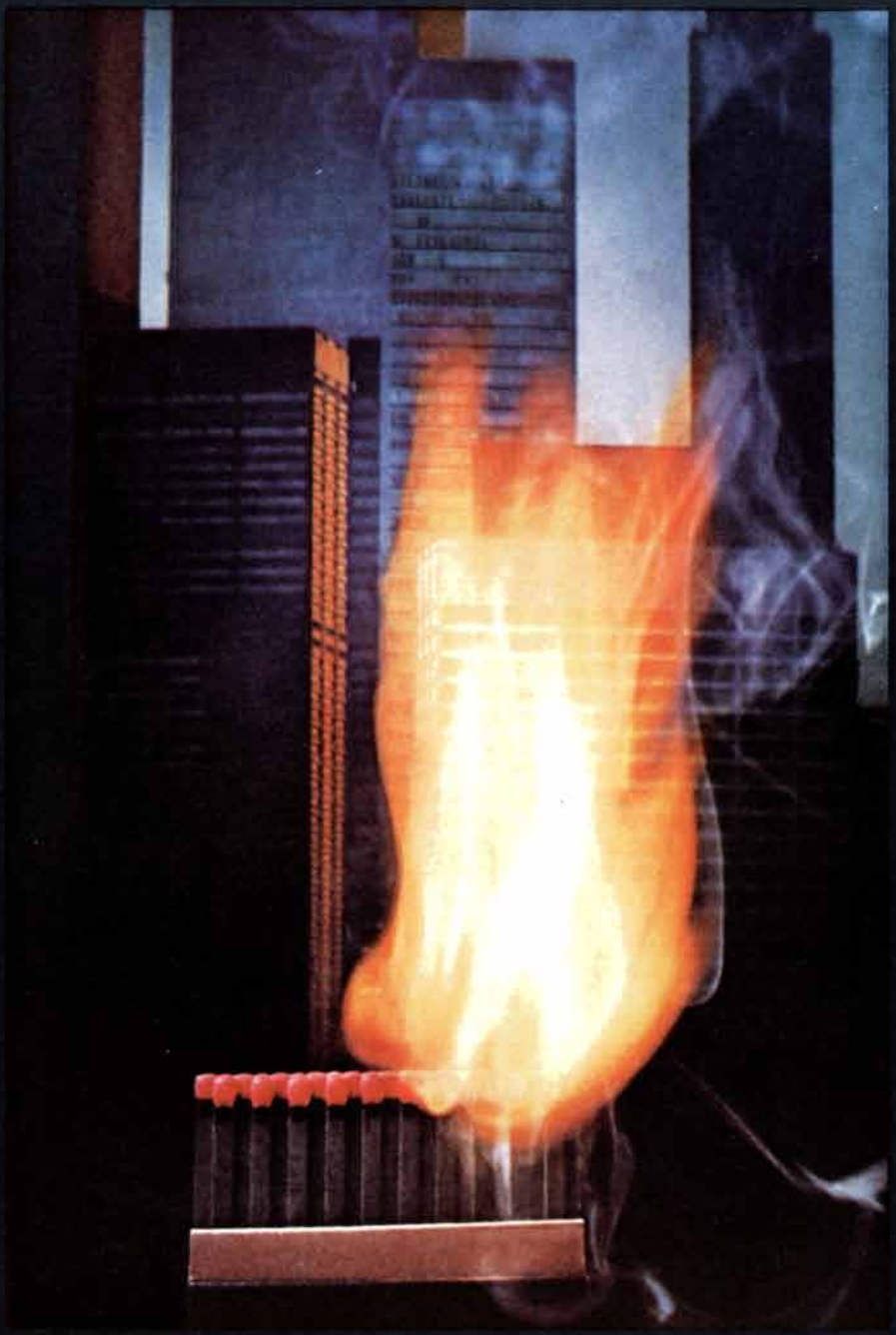
Did you know there's an electronic system that can save lives in a burning building?



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The electronic way

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