CHAPTER 7

A STUDY IN STEEL

Ever in search of a sharper edge, veteran cutler David Boye has come up with new information and techniques

WHAT DO PSYCHOLOGY and steel have in common? Admittedly, not a great deal, unless your name is David Boye and you have relegated yourself to living in an out-of-the-way area of Arizona.

The same David Boye also is doing a great deal to restructure thinking among both custom and commercial knifemakers as to what is the best steel for building a blade. He envisions a blade that will stay sharp longer and require less sharpening to return it to top-grade cutting shape.

By now, you're wondering what this is all about, aren't you? Not surprising, really, but it concerns what David Boye has come to refer to as dendritic steel. What this amounts to is that the knifemaker has started investment casting knives, instead of forging them or using the stock-removal method with which most of us are familiar.

Through his studies which have extended over the past fourteen years, Boye has come to believe that any amount of forging or other type of stress is less than conducive to producing good steel. That includes what the rolling mills do to the metal.

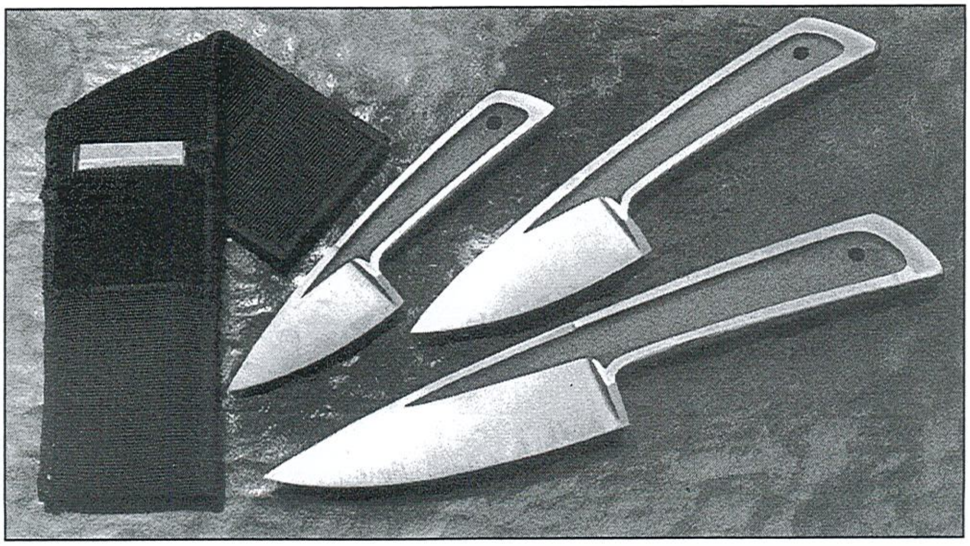
Following this theory, David Boye now investment casts his knives, using a casting grade of 440C stainless. This, coupled with his own heat-treating, results in an edge that registers at 58C on the Rockwell scale. That hardness is more or less standard for the custom cutlery trade, but the Boye knives seem to boast an unusual degree of sharpness and are quite strong.

David Boye has been a recognized force in custom knifemaking for well over twenty years. He dropped out of graduate school where he was seeking a doctorate in psychology. As he recalls now, "I wanted to make tools, but I also recognized the fact that I was seeking some sort of art form, as well."

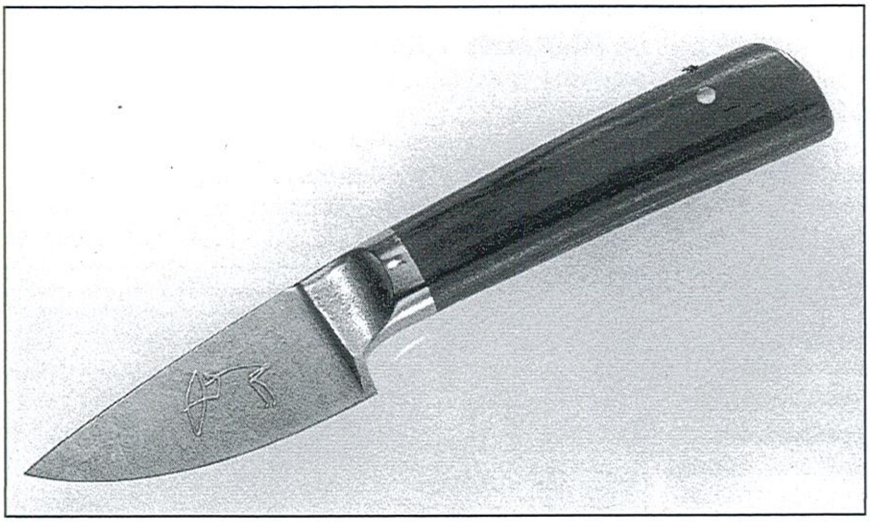
Tools he knew something about, having worked in his

This pile of hemp particles is the result of fifteen hours used to make 3000 cuts in 1-inch rope, using an 8-inch Boye dendritic steel knife. This was done without resharpening the blade.

These dropped-edge sheath knives are called the Boye Basics and are made totally of cast metal. They're sold with a brass-lined Cordura sheath. The wide, curved blade is ground to a .012-inch bevel for durability, cutting efficiency and sharpening ease.



(Below) The Boye Basics can be dressed up on special order with the addition of a cocobolo handle, sacrificing some of the lightness of the standard designs.



Boye taught himself the art of etching. This 2-inch dropped edge features a stick-like figure of a bowhunter etched on the blade.

father's heavy-equipment repair operation during college sessions. He also had taken a college course in jewelry making, because it offered him a "chance to work with the hands as well as the head."

Gone from college and puzzled about how to make a living, Boye came across an old two-man saw blade of the type used by lumberjacks. He decided to make a knife from this material. He sold it the same day he completed it and knew he had ended his search for a livelihood.

A native Californian, Boye studied the knives and swords displayed at a San Francisco museum, thinking in terms of the jewelry-making course he had taken earlier. The craftsman taught himself to etch metal, and this type of decoration soon was finding its way onto each of his knives.

During this period, he continued to make and sell knives, while he searched for better stock and improved techniques. At one point, he even tried a Swedish razor steel, AEB-L.

More than twenty years ago, Boye produced a book, *Step-by-Step Knifemaking*. His original plan, he recalls, was to turn out a pamphlet of perhaps fifty to sixty pages, selling it around Santa Cruz, where he then lived.

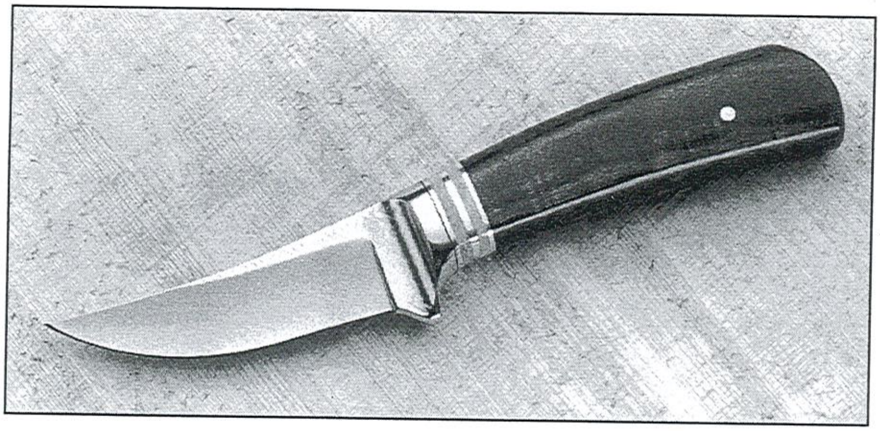
As the book grew, he was encouraged to submit it to publishers. Rodale Press snapped up the heavily illustrated manuscript and published it in 1977. Today, the book has sold more than 150,000 copies and, by the knifemaker's own admission, has kept groceries on the table during some lean periods. This volume, we have found, is in the technical library of most working knifemakers and has been the initial inspiration of any number of these craftsmen.

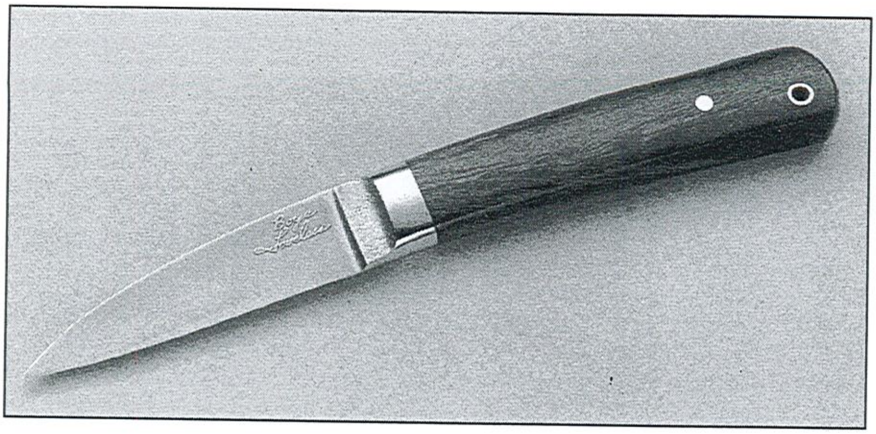
By his own admission, Boye had "achieved the burnout point on grinding knives" when Don Longuevan, a machinist friend, suggested casting them, thus reducing the grinding time of the stock-removal technique being used.

"I knew that gun parts and some cutting tools such as router bits were being investment cast," Boye recalls. He approached people in the casting industry, and most agreed his idea was feasible. The next step came in 1982, when he began working with Larry Venkeer of International Precision Casting. Venkeer has continued to the present to do Boye's casting in his plant in Linden, Utah.

The cast blades of 440C stainless invariably showed a strange grain pattern that Venkeer and Boye considered to be a sign of an inferior steel. What the two men were seeing was dendritic crystal formation, and Boye even built a drop hammer

Boye's little 3-inch blade skinner features some etching, but the craftsmanship in this piece is reflected in the cocobolo handle with its spacers of bone and sterling silver.





The names of both David Boye and Bob Loveless are etched on the blade of this model. It was cast from a pattern that Loveless developed in the mid-1970s.

that was intended to reduce the pattern in the knife casting.

There also were thoughts of forging followed by some experiments. However, the tests for cutting qualities and blade toughness that followed showed that forging reduced the aggressive cutting qualities of those blades.

"Neither of us realized at that time that the carbide crystal structure of cast steel contributed to better edge-holding qualities," Boye recalls today.

To determine just what they had discovered, Boye started out cutting heavy cardboard with his cast knives. That was like cutting butter with a hot knife, so he advanced through several other materials until he settled on using 1-inch manila rope as a test medium.

According to Boye, "When the knife edges were prepared identically, those of dendritic steel consistently outperformed the forged steels selected for the testing.

"Using an 8-inch chef's knife, I cut 3000 pieces of 1-inch hemp rope in 15 hours without resharpening, then I resharpened the knife in only 1 minute, using a small porcelain hand stone."

With the same chef's blade, Boye then went on to chop in half a 6-inch oak log, then cut 9 inches around a heavy steel barrel.

As a result of studies made with the aid of a microscope, Boye learned that the act of forging will break up the microscopic carbides in the steel, at the same time reducing them in size. Thus, according to Boye's theory, the smaller the grain size, as in forged steel, the sharper the blade should become when sharpened. However, it will not have what he describes as much "bite." With the forged blade, the carbide particles are removed from the edge of the blade in the sharpening process, thus reducing the ability of the edge to cut.

Boye contends that, with properly cast dendritic steel, what he calls "pop out" of the carbides does not happen. Thus, with the carbide crystals deep into the composition of the steel, the edge remains aggressively sharp. Photos of 440C knife edges that have been enlarged as much as 200 times lend credence to Boye's statements, for the iron-chrome carbides visible on the blade are much larger and form a rugged pattern in comparison to the deposits in the forged blade of the same material.

According to Boye, what he calls the "dendritic cutting effect" has great similarity to the so-called Damascus cutting effect. In the latter, the meeting of hard and soft layers of steel create a serration effect along the blade's edge. The hard formations of iron-chrome carbides that network throughout the dendritic steel is a good deal harder than the basic Rockwell hardness measurement of 56 to 58C, according to Boye's findings.

Old pro Bob Loveless heard of Boye's steel, and the two of them came up with a straight-edge design made of dendritic steel. Boye made some wax patterns based upon a Loveless design, which the latter said dated back to 1973. From these patterns, the casting proceeded and Loveless called the finished knife "one of the most useful for all-around work that I've ever come up with."

It was in the casting process that Boye's earlier education in jewelry making came into play. The so-called lost-wax process has been used for thousands of years in producing intricate jewelry of gold and silver. Only in recent times has it been introduced for such large items as handgun frames. William B.

David Boye specializes in chefs' cutlery tools and enjoys turning out such sets as this, complete with etched blades. All are of dendritic steel and have cocobolo handles. The price of each knife, however, is in the hundreds of dollars.

Ruger, the noted firearms designer, was one of the first to recognize the value of the process. His Sturm, Ruger & Company, Inc., now has a casting plant in New Hampshire and another in Arizona.

Today, hot wax is flowed into aluminum moulds and, when cooled, is removed. This wax creation is an exact replica of the knife sans the handle, in most cases. The wax models then are dipped in several applications of what is called slurry, a liquid porcelain. Between each coating, sand is added to the surface to give what will become the mould added strength.

Once this progressive operation is completed, the moulds are allowed to dry for up three weeks before going into a high-temperature oven where the wax is burned out, leaving the actual mould in the interior of the hardened porcelain. In the Utah casting plant, molten 440C steel is poured into the porcelain mould while it still is white hot.

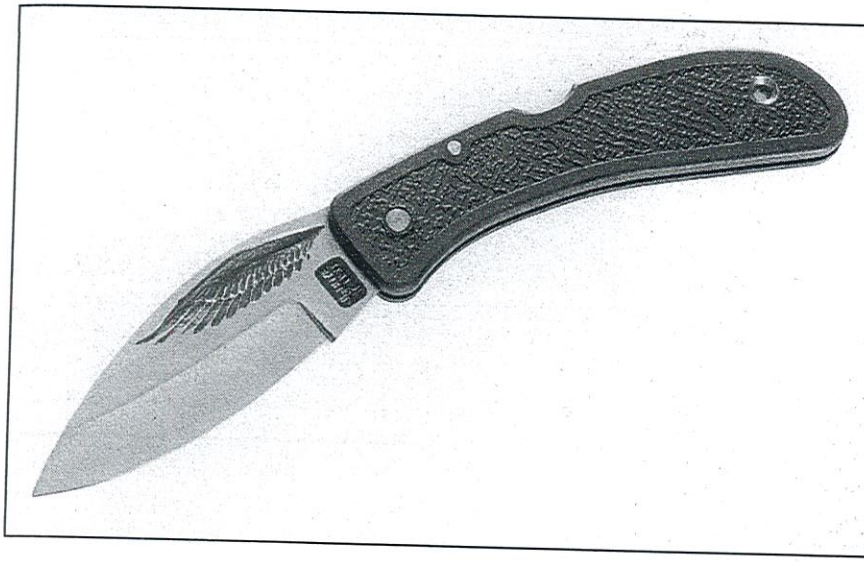
According to Boye and Larry Veenker, as the steel cools in the mould, the network of carbide crystals is formed throughout the blade material. When cooled to handling temperatures, the porcelain cast is broken away and each of the blades is trimmed, annealed and straightened in Veenker's Utah foundry.

According to Boye, "Pound for pound, this method of producing blades is more expensive than any other, but I've found that in the long run it is well worth the effort."

If nothing else, there is little in the way of waste. As might be expected, some of the cast blades are rejected, but these go directly back to the casting room to be melted down and reused.

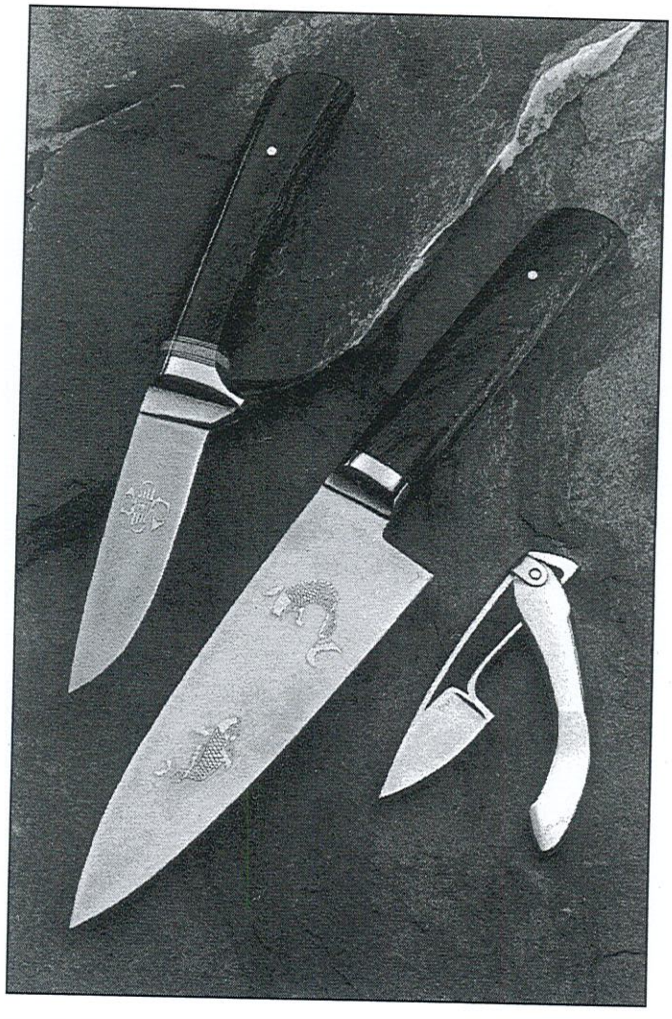
The cast blades are shipped from Utah to Boye's operation in Dolan Springs, Arizona, where he goes about additional blade straightening followed by stock removal, the necessary heat-treating, final grinding and polishing. The blades then are etched with Boye's own designs and fitted with handles of what the craftsman considers a proper material for the knife's design and intended use.

His background in tools and art are combined in Boye's design work, for he makes an obvious effort to combine the



This is David Boye's lightweight lockback folder with unique 3-D art on the blade. Patterns cast into the blade from Boye's original art range from an eagle's wing to a range of mountains, a blue whale to a bowhunter. Other scenes are of a Celtic horse, a sunburst and basketweaving.

(Below) Shown are a typical hunting knife (from left) from Boye, an 8-inch chef's knife of the type he used in cutting 3000 lengths of 1-inch rope, and a version of his Boye Basic design with a fold-over sheath that becomes a handle.



best qualities of a cutting tool with aesthetics. He wants the buyer to like the way the knife fits the hand and does its assigned job.

Boye isn't hooked on "big," either. While some of his kitchen knives have lengthy blades, for daily tasks he prefers small blades and feels his customers do, too.

"The dropped-edge blade is the knife I want to use myself," he is quick to explain. "It affords maximum efficiency in cutting, it protects the user's fingers and it can be used as a skinner and a scraper."

David Boye has an opportunity to test his knives in the field. While he denies that he is an ardent hunter, he does hunt for food and does his own cleaning and butchering. "Whatever I shoot, I eat," he declares, offering his personal philosophy.

Following that philosophy, the craftsman produces a dropped-point hunter and a skinner that features an upswept blade in what he calls his Outdoor Line. He also produces two versions of his dropped-edge blade. All of these knives, incidentally, get handles of American hardwood.

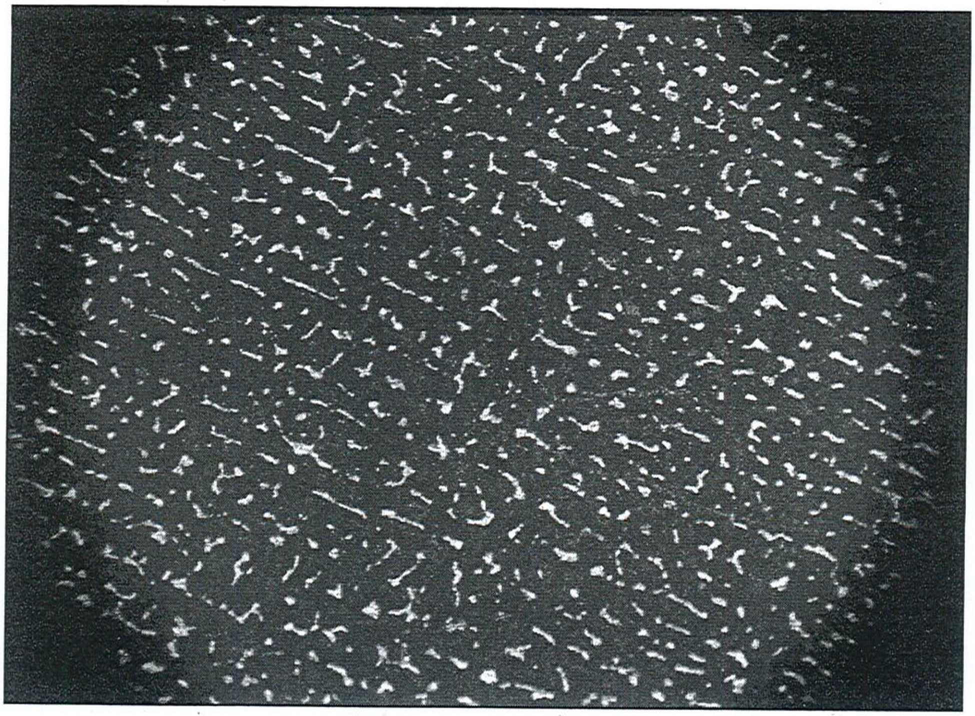
The Arizona craftsman has still another philosophy that has to do with his work: "The most frequently used knife, day to day, is in the kitchen. I believe that using a beautiful, well-made knife goes a long way toward inspiring the cook and, in turn, adds something to food preparation."

Perhaps it doesn't need to be stated that the first knife Boye ever made was a kitchen knife. He considers his real specialty to be the creation and design of fine knives—paring, carving and utility styles—for chefs.

Boye's best sellers at the moment, however, are what he calls the Boye Basics. Sold in sets of three, he describes these as "bare-bones utility knives." These are all-metal sheath knives with blade lengths of 2 1/4, 2 3/4 and 4 inches respectively, all three packaged in a heavy-duty Cordura sheath. Cast as they are, the handles are thin and help to hold down the weight, but around the edge of each knife's handle is integral I-beam-shaped reinforcement for added strength.

Thinking back over his quarter-century as a custom cutler, Boye has come up with some pertinent thoughts on the various facets of his career, what he has learned, and information he is happy to pass on to others.

"My accidental discovery in 1981 of the so-called dendritic cutting effect opened the door for new theoretical considerations regarding edge performance," he states. "Cast dendritic 440C stainless was substantially outperforming forged and roll-forged steels in cutting aggression and endurance tests."



This is a 20x view of the etched flat surface of one of David Boye's cast 440C stainless blades. The light-colored spots actually are the network of carbides. Note that they are distributed quite evenly.

The following is an analysis of the phenomenon from his perspective of making blades from dendritic steel for over sixteen years and ten years of working with other steels before that.

As for cutting theory, "cutting occurs because the point-of-contact pressure breaks the bonds of cohesion and parts the heretofore unitary element of the workpiece.

"What knives do is concentrate pressure. A sharper knife takes the same amount of overall pressure and concentrates it into smaller points of contact, thus yielding higher pressure at the point of contact.

"In blade theory, we need to delineate clearly the factors that actually take part in this concentration of pressure," Boye explains.

Here are listed some of these factors, along with his commentary.

Pressure: "Here we have amount, direction, duration, concentration and speed of application."

Edge Geometry: "The angle of the juncture of the bevels. The narrower this angle, the more pressure is focused on the tip."

Sharpness: "This refers to the precision of the grind of the bevels of an actual knife and the condition of the edge."

Wear Resistance of Blade Material: "Resistance to the removal of blade material by the workpiece."

Cutting Action: "There are two kinds of cutting action: the blade can be pushed into the workpiece directly (vertically) like a razor blade, or it can be rubbed back and forth (horizontally) in the direction of the blade along with vertical pressure, thus producing a sawing effect. Sawing is lateral movement of tooth across the workpiece. This action dynamically increases the application of pressure at the workpoint."

Tooth: "High points along the cutting edge. This can be anything from a wavy edge, to serrations, to any variation of the blade due to sharpening implement, or to damask (patterns) within the steel. The general rule is that more tooth equals more lateral cutting performance."

According to Boye, "Hand-forged Damascus steels and Wootz metals have shown patterns in the steel to translate into more aggressive lateral cutting performance. This Damascus cutting effect derives from the relatively hard and soft steel alloys. Along the edge, tooth is created as the harder structures are exposed and produces a serrated cutting edge.

"Another source of tooth in forged steel," he says, "is the carbide microparticles (grain) which remain after being broken down during the forging process. These appear at the cutting edge and may vary in size from one forging treatment to another."

Boye contends that "with forged material, the limit of how mathematically sharp a blade can get is the size of the carbide particles. The smaller the particles, the sharper the edge can be made without dislodging the carbides along the tip of the edge during sharpening or use." (Such dislodging is known as "carbide pop-out.")

According to the craftsman, "The dilemma here is that the finer the carbide particles, the less tooth the steel has. With lateral cutting action, the fine-grained steel is too smooth to have bite and tends to slide, not cut.

"When the grain is large, it is not as sharp, but can cut more aggressively laterally, because the relatively fewer but larger carbides concentrate more pressure at fewer points than do many more smaller carbides. This is exactly like a saw with fewer, larger teeth that cuts more aggressively than one with many small teeth."

According to Boye, "Experienced bladesmiths and master forgers can reduce grain size or enlarge it. In general, hammering reduces grain size and heating enlarges it. Multiple heat-treatments can, as well. With precise reheating, the beginnings of re-dendriticization may occur. One of the facets of the bladesmith's art is to produce the appropriate microstructure for the given application."

As suggested earlier, with dendritic steel, the original skeleton of hard carbides formed from the molten state and 100 percent bonded throughout the steel is retained. The tips of these hard chrome carbides form tooth along the edge.

"With dendtritic steel, the toothy virgin carbide microstructures are at maximum abrasiveness, fully bonded and rooted, and do not pop out," Boye explains. "Therefore, a different kind of cutting edge and a new kind of cutting action are produced.

"In dendritic metallurgy, hard structures throughout the steel reinforce the matrix and produce more rigid mass; there is less willingness to deform, therefore less flattening at the blade apex.

"With forged steel, hardness decreases distortion and wear and retains carbides at the edge better. Thus, higher hardness produces better edge retention and cutting stamina," Boye declares.

"With dendritic steel, the bite derives from hard structures within the steel, and we have theorized that a softer matrix might result in greater differential in hardness between matrix and tooth," the Arizona cutler says. "I believe dendritic steel, to some degree, can in a way pseudo-sharpen itself, as the softest matrix wears away and exposes more tooth."

David Boye supports his concept with the 3000 pieces of 1-inch hemp rope he cut without resharpening the blade of that particular knife.

"To measure cutting performance, I mentally counted the number of lateral strokes it required to complete each cut. The edge was a Moran grind; that is, the sides of the knife came together right at the cutting edge, which was stropped with a buffing wheel and acid-etched to maximize exposed carbides.

"At first, the blade would cut the rope in one slice, without problem, but performance went downhill noticeably. After about 500 cuts, the blade was cutting in about four strokes. At around 1500 cuts, we were at around seven strokes. At 2000, we were at around nine strokes. At 3000, I was lucky to cut the rope in less than fifteen strokes.

"During the actual cutting," Boye recalls, "I had the feeling that the knife was not much duller during five hours of continuous cutting from around 500 almost to 1500 or so. My theory is that the matrix was wearing down a little faster than the tooth. Thus, the edge still may have been getting 'toothier' and duller at about the same rate, and thus performance was maintained."

Boye reports that at around 2500 cuts, he began to notice a more rapid loss of effect and attributed this to general wear on the edge, making it wide (translate, "dull"). After 3000 cuts, he says, "it was not fun to cut the rope." The total test, incidentally, required three five-hour cutting sessions.

Boye theorizes that had the blade been harder—perhaps 61 instead of RC 58—the wear of the steel might have been less and the tooth might have been exposed at a slower rate, resulting in lower performance."

But what about RC 52? Would this be even more aggressive? Boye says that, "until it is thoroughly tested, there is only opinion as to the ultimate effect hardness has on performance with dendritic material.

Today, Boye is aided by his daughter, Rachel, and an apprentice. His knives are available by mail order or they can be obtained from the Boye Knives Gallery in Davenport, California, a community about ten miles north of Santa Cruz. Copies of Boye's knifemaking book also are available at the latter site.

Expanding his efforts, Boye now is selling his dendritic steel to other knifemakers, either as billets or unfinished blades. It's been a long, sometimes rough road from that first kitchen knife fashioned from a used-up saw blade.

Through this entire essay, some readers have been asking, "What the hell is dendritic steel?"

Well, the molten steel is cast to the desired shape in a mould, and a network of chrome-carbide crystals are formed throughout the material. As Boye explains it, these crystals appear in branchlike patterns that resemble trees or ferns.

The name, dendritic, is derived from *dendron,* the Greek word for tree.