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# British Color Case Hardening

Case hardening is sometimes called a “black art.”  
It is not.

Case hardening is a scientific—if low-tech—process that has been practiced for many centuries. It is a method of giving low-carbon steel a glass-hard surface to prevent wear and corrosion while also preserving the metal’s tough ductile core, which provides strength and the ability to absorb shock and stress.

Historically, this has been achieved by packing the steel into a carburizing agent—that is, into animal bone meal, wood charcoal, leather, horn or another high-carbon material—then heating the “pack” to a critical temperature so that carbon transfers to the metal and is then set in the latter’s surface layers by a quench in liquid, usually water or oil. Though there are many formulas for the carbon pack and heat treatment (depending on the purpose of the object being hardened), all follow proven metallurgical principles.

Where black art and alchemy spill into the science of metallurgy occurs in the craft of color case hardening fine guns. Naturally, there are similarities between case hardening for industrial applications and for firearms—the processes must always ensure that the end products are durable and wear-resistant—but there are critical differences too. Distortions in metal caused by heat that might be acceptable in some industrial applications of grosser scale would be no more welcome in the mechanism of a fine gun than they would be in a Swiss watch. And the term “color case hardening” highlights an essential difference in the process from that of industrial case hardening: In the former, producing gemlike colors to tease the eye is a coterminous goal with proper hardening.

The set of skills needed to harden a gun while simultaneously showcasing attractively arranged colors, all with minimal metal distortion, have been hard earned enough to make most masters of the process very secretive about their techniques—so furtive, in fact, that



*Gunmaker Robin Brown, of A.A. Brown & Sons, is one of the few craftsmen in Britain who color-hardens his own guns.*

(Matthew Brown/Orange Media Photography)

they lend the process an air of mystery, even magic, especially in Britain. Author Rich Grozik, in his book *Game Gun*, writes: “. . . to this day English casehardening evokes images of occult-like rituals, gurgling caldrons, and cryptic formulas applied to gun steel behind closed doors.” Grozik goes on to mention rumors of old-time practitioners using human bones and urine to achieve extra-lustrous colors.

This secrecy noted, there is little to suggest witchcraft or worse at the factory of British gunmaker A.A. Brown & Sons, where I visited owner Robin Brown in November 2008 to discuss his color case-hardening techniques.

Robin, now 63, is the fourth generation of Browns to make guns in

and around Birmingham, and he has practiced color case hardening going on a half-century. Brown's is one of the few English gunmakers to not only make its own guns but also harden them in-house. (Most British gunmakers today send traditional color-case work to commercial hardening specialist Richard St. Ledger, on Price Street in the truncated remains of Birmingham's old Gun Quarter.)

Robin is an old friend, and in the nearly 20 years I've known him he has been unfailingly generous in sharing a lifetime's knowledge learned on the bench as one of England's finest gunmakers—including revealing his very traditional techniques for color case hardening. "I came into the trade in an era when you walked into a craftsman's workshop he would drop a cloth over his vise so you couldn't see what he was working on," Robin recalled as we sat in Brown's small factory in Alvechurch, south of Birmingham. "I've never liked that sort of secrecy. I think it sad to see skills developed over generations get lost."

In the era after the Second World War there were two principal color hardeners to the Birmingham trade: Billy Woodward and the Century Polishing & Hardening Co. Both were metal polishers and hardeners, the polishing of components being a critical last step before the gun was engraved prior to hardening. Woodward went on to train renowned Ray St. Ledger, father of aforementioned Richard. Robin Brown, on the other hand, was tutored by Ted Stokes, an elderly craftsman who had spent most of his career at Century Polishing. "Ted was probably in his late sixties when Century went down as the Birmingham trade contracted," Brown recalled. "We hired him to polish components and harden for us two days a week."

In stark contrast to much of the British trade, A.A. Brown & Sons was expanding when Robin joined the firm in 1961 as a 15-year-old apprentice. Under the leadership of Robin's uncle, Albert, and father, Sidney, and by dint of will and skill, the Browns pursued a growth strategy of bringing as many gunmaking processes as possible under one roof—machining, lockmaking and hardening being notable examples. By the early '60s, Brown's had become one of Birmingham's most important gunmakers to the post-war trade and employed nine full-time craftsmen, building some 200 to 250 guns per year, many for companies such as Holland & Holland, Churchill's and Westley Richards. Although Robin also was apprenticed as a stocker, Stokes



*Robin Brown, age 17, two years into his apprenticeship with his family's gunmaking firm. He is holding a Brown-made, scaled-frame smallbore sidelock.*

took him under his wing. By the late '60s, Robin was working closely with Stokes hardening guns.

Traditional color case hardening consists of four major steps: bone-meal preparation, the arrangement of the components in the carbon pack, the heat cycle and the quench. "The first thing Ted taught me was to prepare the bone meal," Robin explained. "It wasn't ready to use when you bought it; you had to condition it first."

Conditioning meant heating the meal in a furnace to about 500° C to burn off excess fat, grease and other contaminants invariably present in the meal of the day. As the meal was being heated, Robin was taught to rake it continuously, ensuring that the fat was burned off and also preventing it from scorching, which would de-carbonize the material. He remembers the odor—"an abattoir smell"—but stresses the importance of the process. "If there was any fat or grease left in the meal when you hardened, it would cause ugly flaking on the surface.

"Whenever we got in a fresh batch of meal, we'd first experiment by color hardening different pieces of metal to make sure we were going to get the results we wanted. We never knew exactly where the meal came from or the sorts of contaminants we'd find in it.

“The level of flaking we’d see in those experiments told us how much meal prep we needed to do before hardening actual gun components. The quality of the meal back then was not predictable and was the grayest area of the whole process.”

This has changed for the better, as these days Robin is able to obtain the same bone charcoal that Scotch distilleries use to filter whisky. “There is much less grease in it,” Robin said. “Consequently, preparation is now easier and quicker.”

Unlike some American color-case recipes that call for additional carburizing agents such as wood charcoal and leather, Stokes’ recipe employed bone charcoal alone. “Pure bone meal, just animal bone,” Brown said. “Nothing exotic was added, I’m afraid—no magic powder, no old shoes, no human bone.”

And urine?

“Certainly not. We always had good results with animal bone alone.”

Color case hardening is one of the last stages of craft gunmaking—at this point the gun is mechanically complete and fully engraved. Components traditionally hardened are the action (or frame), various pins (screws), the triggerplate, the triggers, the forend tip and decorative furniture and, in the case of a sidelock, the lockplates and lock bridles. Some English gunmakers have used a higher-carbon steel for their forend irons that obviates the need for case hardening, but Brown’s typically used the same mild (or low-carbon) steel for their forends as for their frames and consequently case hardened these, too.

After the gun was disassembled, components had to be thoroughly degreased. “Cleanliness is *everything* in color case hardening,” Robin said. “Just the oil from your fingertips left on the metal would cause flaking if it wasn’t removed before hardening.

“In those days Ted and I boiled off the components in soda water to remove any traces of grease, then rinsed them again in clean boiling water to get rid of the traces of soda.”

Next came the process of “packing the pots”—carefully arranging the components in layers of prepared bone meal in their “pots,” which at the time were rectangular cast-iron boxes with loose-fitting lids. There were two sizes: for one gun or a pair.

Stokes taught Robin not only how correctly positioning the components in the meal influenced proper carbon absorption and conse-



*A pair of 12-bore Churchill Imperials made for the London firm by A.A. Brown & Sons, in Birmingham, in 1963. Craftsman Ted Stokes color-hardened the guns assisted by then-apprentice Robin Brown. The original finish remains pristine. (Courtesy of Gavin Gardiner, Ltd.)*

quent hardening for each piece, but also how specific arrangements could minimize distortion and affect coloration. “You didn’t just jumble the bits in,” Robin said.

The action, for example, was always put in the center surrounded by a maximum amount of meal, and to encourage additional carburization it also was placed in the upper portion of the pot. “The top of the pots got hotter than the bottom, so you packed them in such a way that each piece was getting the correct heat.” No major parts were allowed to touch each other, although Stokes sometimes wired specially shaped blocks of steel to the backs of lockplates and triggerplates to enhance colors—especially blues. “The slower a piece cools, the more blue it will have,” Robin said, “so wiring metal in effect gave these pieces greater thickness, which helped retain heat.”

Temperature and time at heat along with the nature of the carburizing material determine the depth of carbon penetration into mild steel—and thereby the latter’s surface hardness once quenched. Higher temperatures and longer heating times make components harder but also increase the risk of metal distorting or becoming too brittle. Traditional color case hardening always has been a balancing act between aesthetics and achieving correct hardness.

Heated metal glows at different colors depending on its temperature, and Stokes had learned his craft in the first decades of the 20th Century, when many gun-trade practices were still more akin to medieval blacksmithing than the scientific processes of a mature Industrial Age. The act of balancing was more difficult then.

“Ted learned to harden before gas furnaces were used in the trade and before any means for accurately measuring temperature were available,” Robin said. “He would harden by putting the pot directly into a fire. Temperature control was done purely by eye—by looking at the color of the pot. He had to move the pot around the fire to keep it at the critical temperature. And the ambient light of the day would make a difference in how the pot looked as it glowed. On a cloudy day he’d have to adjust to how it should look on a bright day.

“The skills of these men were immense then. Most of the guns they color hardened came out perfectly, but I remember stories of occasional mistakes.” By the time Stokes was teaching Robin during the ’60s, Brown’s was located in Westley Richards’ factory complex in Bournbrook and had access to Westley’s pyrometer-equipped gas





*Gun No. 19288, an easy-opening Westley Richards sidelock built in 1966 by Brown's when the latter's workshops were sited in Westley's Bournbrook factory. Made for J.P. Morgan Jr. (a descendent of the J.P. Morgan Jr. discussed in Chapter XXII), the gun was fitted with a Brown-variant, Baker-type single trigger with a rare barrel-selector slide located on the lockplate. Robin Brown and Ted Stokes color-hardened it, and its finish remains in original condition. (Richard Rogers)*



furnaces, making temperature control easier and more accurate than observing an open fire.

Although the gas-fired furnaces at Westley Richards in those days had automatic temperature settings, they lacked real precision. “We’d set them for the temperature we wanted,” Robin said, “but in reality the range of heat was drifting up and down on either side of our setting. I found the high peaks caused more distortion.”

Careful packing of components, as noted earlier, helped minimize these dangers, but experience has since taught Robin that *exact* temperature control is equally critical for quality results.

Robin walked me to the machine-tool room that houses Brown’s furnace—a natural-gas-fired muffle furnace custom made in 1974. Today Robin eschews auto-controls; instead he manually sets for a certain temperature—between 750° C and 775° C, depending on the characteristics of the bone charcoal on hand—and carefully monitors the pyrometer to ensure “absolutely stable” temperatures. “You can’t go off and brew a pot of tea and forget about it,” he said.

The heat cycle lasts about three hours from when Robin places the pot in the pre-heated furnace to the time when he removes it. During the final 20 minutes, Robin drops the temperature by 10° C. “I found this decreases distortion,” he said. Before tipping the contents into the quench, Robin rests the pot outside the furnace an additional two minutes. “The steadying of the bone-meal temperature prior to tip seems to ‘bind’ the parcel of gun parts and bone meal during the drop from pot to water,” Robin explained. “That way the tip seems less explosive and more predictable.”

If a gun’s hardness—and subsequent durability—is influenced by heat, then the quench helps dictate its beauty. Case colors—comprised basically of iron oxide—are formed as a chemical reaction during rapid cooling as red-hot metal and surrounding bone meal interact with water. Preventing components from “flashing”—that is, from coming into contact with open air during their fall from the pot to the liquid—was (and remains) critical. A “flashed” component would be hard but also gray and devoid of desired colors due to oxidation.

A good “tip” was key to preventing this. “The tipping technique was partly black art,” Robin said. “You had to tip in such a way that everything remained in an envelope of bone charcoal as it passed into the water.”

Robin demonstrated a practice tip: Using a long set of tongs to lift a pot from the factory furnace, he walked out back to where a tub of water would have stood had this been a genuine operation. With his lead hand grasping the underside of the tongs and rear hand nestled over the top, he flicked the pot upside down with a swift, deft turn, and then quickly scuttled backward like a scalded crab. “There would be a mini-explosion of hot bone meal hitting water—sparks flying up in the air, and a great *whoosh* of steam and burnt-off bone meal,” Robin said. “Under modern safety rules, if you were to subject an employee to this process today you’d have to dress him as if he were going into a volcano.”

“We never did that,” Robin added, “and I still have one or two scars to prove it.”

You occasionally will see discussions of some practitioners adding ingredients—secret or otherwise—to the quench to enliven colors, or guidelines for holding water at a certain optimum temperature to affect same. Robin’s approach is decidedly elemental: “We just use cool water, fresh out of the tap.”

Standard procedure does recommend oxygenating quench water for better colors, a procedure Robin follows. “We use a hose to create turbulence, which increases oxygen content,” he said. “But I personally don’t think you should have air bubbles floating in the water at the time of the tip. There is an increased risk of flashing, I think, and you get colors that just don’t look ‘right’ on a traditional English gun—too many bright pinks and oranges.”

Three-quarters down the tub a sieve would have caught the components as they sank through the water and cooled, with the leftover meal settling to the bottom.

“We’d then remove the parts and examine them with interest,” Robin said, “gasping if the colors were especially good, cursing if not . . . .”

Components were then put back into the pot—still hot from the furnace—to dry, and afterward they were quickly lacquered and oiled to resist any rust. Then it was on to the finisher for reassembly and final regulation and freeing any parts with minor distortion.

Although Robin has modified—even modernized—many of the techniques he learned from Stokes, he recalls his mentor with great fondness. “Ted was a very kind man, absolutely charming,” Robin said. “His color hardening was an art and a real craft, and he passed

all of it on to me at a time when a lot of people in the trade were very precious about what they knew and didn't want to share their skills.

"For all of that, Ted never made much money. What he earned he drank away. That seemed to be his life in his last years; his wife had died, but he still had a dog he loved. He didn't aspire to anything other than to come in to our factory and mix with the craftsmen, do his job and then go have a few pints with his friends after work. One

## Colors on Brown Guns

In recent years talented practitioners—such as America's Doug Turnbull and the late Dr. Oscar Gaddy and his disciples—have evolved a number of techniques that have been immensely consequential to the development of, and reproducibility of, colors and color patterns. These include any number of jigs, blocks, shields and mechanical fixtures that either retain heat or keep the carbon material close to the metal as it is quenched. The most vivid colors seem to come when components cool more slowly as they quench and also when the carbon pack remains enveloped around the metal as it falls through the quench.

Robin Brown's methods remain almost alchemical by contrast and rely on his skill in "packing the pot"—that is, his placement of components within the carbon pack and pot—to achieve desired colors and hardness. "The way in which I arrange the components affects the amount of heat they receive, how much carbon is absorbed and how fast the bone meal is washed away in the quench," he said. Since being tutored by Ted Stokes, Robin has eschewed

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*Facing page: A recently made 20-bore Supreme De Luxe before and after color hardening. It showcases some of Robin Brown's aesthetic preferences: The darker colors are concentrated nearer the center, with the lighter tones radiating to the edges. This highlights the engraving (by Keith Thomas) while also framing the lighter edges against the browns of the stock. Note the evolution of the action shape from Brown's earlier days of making guns for the trade.*

day he was walking up the steps of his local pub, and he just fell down dead, with his little dog at his side.

“And that,” Brown said, trailing off, “was the end of Ted Stokes . . . .”

Life is a fleeting thing, and one lived as obscurely as Ted Stokes’ seems but a nanosecond measured against the infinity of time. Yet great guncraft is timeless—and in the thousands of guns he hardened and in the techniques he passed along, the legacy and skills of Ted Stokes live on.



wiring extra metal to components to increase coloration. “I found this can increase distortion.”

The latitude of permissible techniques and materials (as well as personal tricks of the trade) means that almost every hardener has a signature coloring style—or *styles* in the case of commercial hardeners like Turnbull, who works with a wide variety of guns of different makes, models and designs and from many countries. Robin’s methods, by contrast, have evolved for essentially one gun—the Supreme De Luxe, Brown’s easy-opening best sidelock of modified Holland & Holland design—although he also re-hardens sidelocks and boxlocks from other British makers when he restores them.

Robin smiles as he speaks of the “joy of colors” on a gun he has correctly colored, and for him correctness follows certain principles of pattern, placement and color. On Supreme De Luxe lockplates, for example, the darker colors—the blues and related permutations—will be nearer the centers, with grays, browns and tans radiating outward, the lightest shades predominating at the edges. A form of framing, this highlights the bolder colors and sets them off against the chocolate hues of the stock.

Aesthetics are, of course, only half the equation in color case hardening; the carbon skin and its protective qualities will matter to the shooter long after colors have faded. Colors on a gun a century old may have rubbed off through use, but a properly hardened case will keep the metal largely unsullied by wear.

The case itself seems surprisingly thin. Robin estimates that his are about .002" deep. “This is plenty thick to prevent wear,” he said. “If you go much deeper, I’ve found you run the risk of metal distortion.” Brown’s guns, it should be noted, are rarely built as “closet queens”—or collectors’ pieces—but instead are commissioned by a clientele that tends to shoot them hard and incessantly at driven game year after year. I have seen any number of Supreme De Luxes with their stocks in tatters but their metalwork invariably as pristine as the blade of Excalibur.

British sculptor Eric Gill was quoted as saying, “Art is skill. That is the first meaning of the word.” That art—and those guncraft skills—are exemplified in Robin Brown’s color case hardening.