

During the past two decades, at least, the greatest increase in rifle accuracy has been through bullet improvement — made possible by jewel-like swaging dies held to unbelievably close tolerances. Here's how they are made. . . .

By JIM GILMORE

TELL ME IN 25 WORDS or less how you build a set of bullet-making dies." It was no time to be talking about custom dies, or anything else for that matter. We were sitting at the firing line at a big bench rest match, waiting for the range officer's imminent "commence fire." The shooter to whom I directed my comment — one of the leading custom die manufacturers in the country — knew I was putting him on, but a master of dry humor, he countered with a comeback that left me wishing I'd never broached the question.

"Nothing to it," he quipped, without a trace of a smile. "You just start with one piece of steel for each die and remove the metal you don't need." When you stop to think about it, he's right. But the intricacies of "removing the metal you don't need" involve considerably more detail than his comment implied.

Don J. Rorschach wasn't the man I questioned that day on the range, but if anyone could answer that question, he

could. He has spent seven years perfecting machining techniques used in producing super-precision bullet-making dies; and to his growing group of fans, he is "the man" among the handful of specialists producing custom bullet dies on a commercial basis for competition bench shooters and varmint hunters who are satisfied with nothing less than the best.

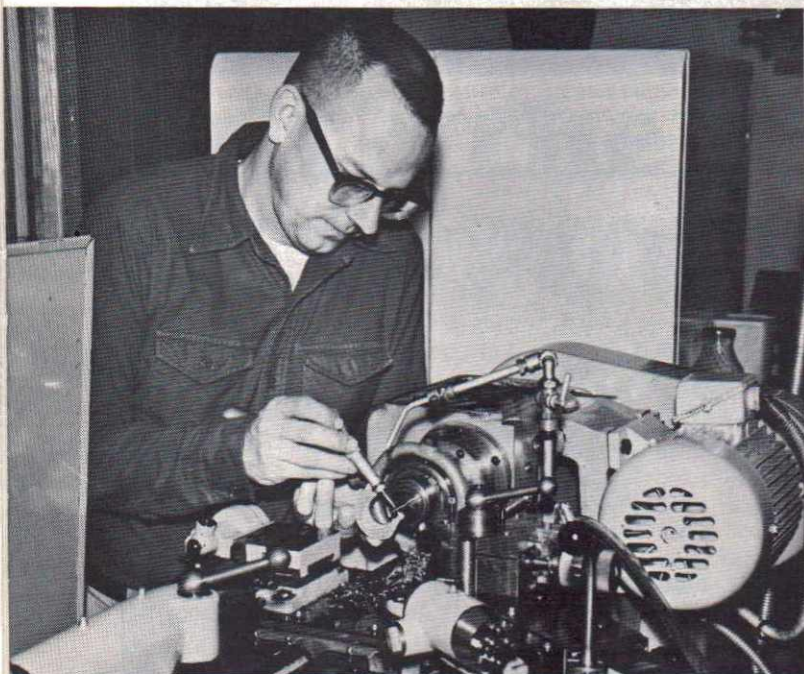
Like many other "name" manufacturers of precision shooting equipment, Rorschach started his business as a hobby, working in a modestly equipped home shop with little technical knowledge. But that was seven years ago. He's still working in the garage of his home, and as a sideline — he's city attorney at Irving, Texas — but today he's producing dies of unsurpassed quality in a machine shop packed — literally — with some of the finest precision machinery modern technology can produce.

His equipment inventory includes: two lathes — a brand-new Hardinge toolroom model (with a value equal to

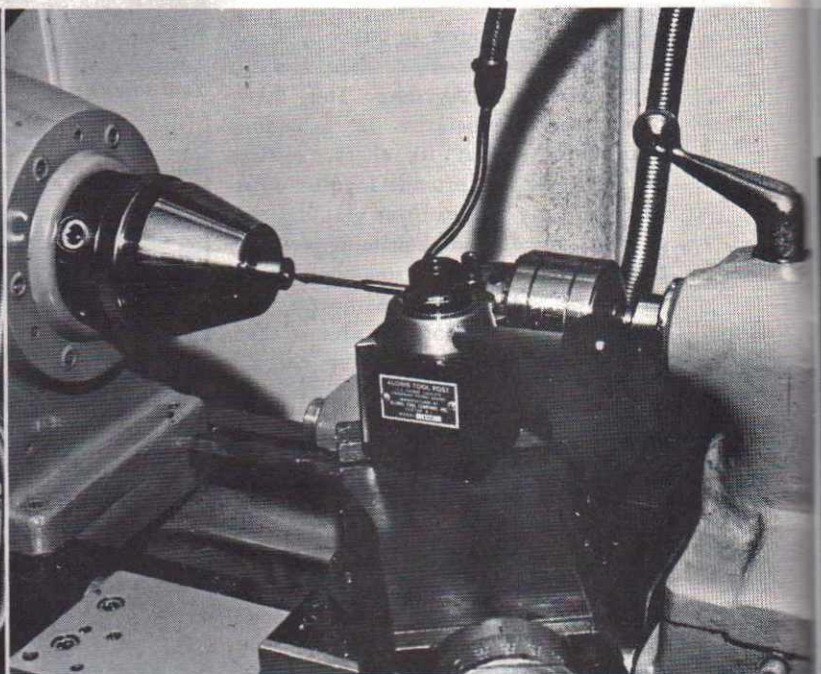
that of about 35 new 40XB Remington rifles) and a precision British tracer lathe (which is no longer produced because the manufacturer found his company was losing money in selling the units for \$5,000 a copy); a Brown & Sharpe universal tool and cutter grinder; a Sunnen hone; a super-accurate air-gauging system; a small but stable heat-treating furnace; a drill press; and scads of conventional measuring tools (dial indicators, comparator micrometers, etc.).

Why so much equipment? Just one reason — tolerances. Even a non-benchrester is well aware that bullets won't shoot winning groups unless the tolerances are acceptable, and the tolerances Rorschach considers acceptable are, indeed, quite acceptable. As a matter of fact, they're almost unbelievable.

Three dies are required for producing custom bullets, and all three are actually "inserts," screwed into a larger die body which supports both the die and its ejector assembly. The die body has an external 7/8-14 thread. It's screwed into



Most difficult part in bullet-making dies to machine is the swage die, which shapes the ogive of the bullet. In the right photo the cavity is being rough cut with a hollow-ground split reamer, which cuts the die



to within about .003-inch of final size. The die is brought to finish size by a series of 42 three-inch steel laps, such as Rorschach is shown checking as it is made on the hydraulic tracer lathe (left.)

CUSTOM BULLET DIES

the die "station" of a conventional bench-mounted reloading press.

The first die in the series is the core-forming, or "squirt" die, into which small cylinders cut from rolls of lead wire are swaged into uniformly shaped cores varying no more than one-tenth of a grain in weight. (Excess lead is extruded through three .010-inch "bleed" holes in the die).

In the second die — the core-seater — the previously formed lead core is pressed firmly into a hollow copper bullet jacket, and the outside diameter is expanded to the exact size of the final bullet diameter, or as much as .0001 of an inch undersize.

Final die in the series is the swage, which forms the ogive (pronounce it *owe-jive*), or rounded portion of the bullet, and the hollow point. This die is the most difficult of the series to machine accurately, because of the curving ogive area.

The die sets are machined from Timken Graph-Mo tool steel, but before

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THE ULTIMATE IN PRECISION MACHINING



Don Rorschach's bullet-making dies are held to tolerances which could not be measured only a few years ago. From left are the core-forming, final swaging and core-seating dies, threaded 7/8-14 for use in standard heavy duty reloading presses.



Rorschach, left photo, hones the "bores" of core-forming and core-seating dies to within 50 millionths of an inch of final size in a series of operations, then takes the last .00005 with a wood lap and 60,000



micron diamond paste. At right, Rorschach uses a comparator micrometer to measure the pressure ring on the heel of a finished bullet made in a new set of dies. Looking on is A. G. (Jerry) Rogers.

Editorial

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state conservation department coffers. All told, hunters and fishermen contributed well over a quarter-billion dollars directly to conservation programs and agencies in 1971 — a figure that we need to have on the tip of our tongues whenever someone starts making nasty remarks about "rapacious hunters and fishermen."

And though it might seem incongruous, we hope that the Cleveland Amorys and Alice Herringtons of this world keep on calling for "open season on hunters" and the forbidding of all commercial and sport fishing — for though these people anger us, they also serve to stir our apathetic fellow sportsmen to action. And they make the general public aware of just how kooky they are. — Neal Knox

Custom Bullet Dies

(Continued from Page 27)

the actual die-making process begins, Rorschach also has to build his tooling. Chucking 6-inch lengths of annealed drill rod in his hydraulic tracer lathe, he machines the external dimensions of the reamers used for cutting the "rough" die cavity. He then hardens the reamers to 67 Rockwell (C) and uses the cylindrical grinder to hollow-grind the cutting edge, leaving a "split" reamer which cuts the swage die cavity about .003-inch smaller than the finished size.

After the outside diameter of the die is turned and threaded it's hardened to 65R(C) and drawn back to about 64R(C). The remaining metal inside the die cavity is carefully removed by hand-lapping — an old, time-consuming process which is used only in metalwork where the highest degree of accuracy is absolutely essential.

In fact, the key to the ultra-precision Rorschach dies is the series of 42 laps he uses to finish the swage die. Rorschach machines the laps from cold-rolled steel, turning them on the hydraulic tracer lathe. (A lap, in this instance, is a 3-inch steel rod, one end of which is shaped exactly like the finished bullet). Each lap in the series is a different size, with diameters increasing in increments of one ten-thousandth of an inch from one lap to the next. Oddly, varying the lap dimensions by exactly .0001 of an inch in successive laps is no problem at all —

it's all done automatically.

"I discovered by accident," Rorschach explained, "that during the first 20 minutes or so, my tracer lathe won't turn out duplicate workpieces. They vary in size by .0001 of an inch, which just happens to be exactly right for my purposes." (The variation is caused by the unstable temperature of the hydraulic fluid, which is warming up during this time). "Finally, however, the temperature stabilizes and then the lathe won't give me the .0001 variation anymore — it just makes 'em all the same, so I have to turn it off and do something else for a while," he said.

Using titanium carbide tooling exclusively, Rorschach turns the lap stock at 4,500 rpm, attaining a surface finish of approximately 8rms, which in layman's language might be defined as "very, very smooth."

The lapping process itself is the most difficult part of the manufacturing sequence. It requires 12 to 18 hours of tedious work, and it's the only aspect of Rorschach's die-making operation that he considers proprietary. There's more to the operation, he emphasizes, than simply squirting a little lapping compound on the lap and rotating it inside the die cavity. Developing a technique for producing a close-tolerance cavity in which the ogive portion is almost perfectly concentric with the straight section took him about 2½ years.

In conjunction with the steel laps, Rorschach uses diamond lapping compound in various grades of "coarseness," finishing with 60,000-micron (theoretical sieve size) diamond paste, which is packaged in a syringe-like tube and appears no more abrasive than ordinary toothpaste. It removes an infinitesimal portion of the hardened steel wall, leaving a concentric cavity with a glass-smooth surface finish of about ½rms. The super-hard diamond lapping compound removes the amorphous surface film which remains after machining and heat-treating and does not create the burnished surface often produced by conventional lapping compounds. Burnished surfaces are undesirable, Rorschach says, because they wear rapidly under high-pressure loads. (Note: The "burnished" surface to which we refer here should not be confused with a roller-burnished surface, which is work-hardened, smooth, and highly wear-resistant.)

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absolutely square with its shank (straight section) Rorschach makes the swage cavity deep enough that the cored jacket and a portion of the punch are well supported in the die before the point-forming operation begins.

Because the core-forming and core-seating dies have no ogive, they're much easier to build than the swage. Rorschach drills and reams each die, then rough-hones (to remove reamer marks) the holes with a precision internal hone. After hardening and drawing the dies to 64RC, he again "rough-hones" the cavity to within .0005 of an inch of the final dimensions. (For .2240 dies, the inside diameter of the squirt die is .191 and the core-seater is .2238 to .2239-inch.) A finishing stone removes an additional .00045 of an inch of metal, leaving a surface finish of 1-1.5rms. A remaining 50 millionths of an inch of metal is polished out using a wood lap and 60,000-micron diamond.

The stubby steel punches which force the cores and jacketed cores into the dies are lathe-turned and finished to a concentricity of 20 millionths of an inch. Punches and ejectors, which push the semi-finished and finished bullets out of the dies are custom-fitted, because in order to function properly, they must fit properly. (Rorschach considers a diameter tolerance of plus-or-minus 50 millionths of an inch a "proper" fit.) Since conventional measuring tools are incapable of resolving such close tolerances, he uses a system of sophisticated air gauges accurate to within 10 millionths of an inch.

Rorschach's punch holder, which is incorporated in the modified ram of a reloading press (typically, an RCBS Rock chucker) insures that the punches are centered within the die cavities, compensating for any misalignment in the press itself. He grinds a precision half-ball base for the punches, enabling them to automatically align with the die cavity as they are inserted.

Rorschach bullet-making dies are available only in .224 and .243 caliber, but since they're produced on a semi-custom basis, the customer may specify final bullet diameter to the nearest .0001 of an inch. Delivery is usually about two months following receipt of the order. Considering the cost of the equipment with which precision bullet dies must be made, and the time and skill it takes to make them, their high cost is understandable. Rorschach charges about \$275 for a set of his dies, yet he's on the low end of the custom die cost scale. And he and the other better makers usually stay several orders behind.

One thing is obvious — the buyers aren't ordering their dies with any hope of saving money, for even with a set of dies paid for, the cost of pure lead wire and good-quality jackets almost equals the cost of factory bullets, and it takes a lot of time and care to make the perfect bullets that high-quality dies can produce.

Although the Texas diemaker's tool-steel units can produce about 50,000 bullets before any wear is measurable, he's experimenting now with die inserts made from high-grade tungsten carbide, which resists wear far better than steel. "If I can hold the same tolerances with carbide," he explained, "you could almost say that these dies will last forever."

And that's about as long as most of us plan to shoot.

Jim Gilmore

Muzzle Flashes

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is starting to roll." I think we gave it a little push.

Try as we might, we can't seem to keep the gremlins away from the magazines. There was a dandy goof in my accuracy/velocity article in the May-June issue; the table on page 40 has compound errors. First, the Remington and CCI primer heads are transposed; second, the final block of data for 21.4 grains of Reloder 7 was also transposed. If you will write in these corrections the table will make more sense when compared to the comments in the article.

The article brought a letter, then a phone call, from Ken Oehler (designer of the chronograph system I was using) who said he thought I'd gone way out on a limb with my comment that I thought I could get "a good load, possibly the best load" solely on the basis of minimum shot-to-shot variation in velocity. But I'll stick by what I said, for as I told Ken, I now have more evidence.

The week after I wrote that article I used the chronograph to develop a load for Jim Carmichel's new, previously unfired 6x47 40X with 21-inch A&M barrel and Brown fiber-glass stock. Because of a shortage of time, I was able to get the rifle to the range twice, each time for only a little over an hour. Both days the wind was blowing much too hard for reliable accuracy testing.

On the first day I tried three powders with charges that had given good results in another 6x47 (.222 Magnum necked up to 6mm) with the same 60-grain McMillan bullets and Remington 7 1/2 primers. Five rounds of 26.8 IMR-4895 gave 2,995 fps average velocity with a 94 fps spread; ten rounds of 27.3 IMR-4895 gave 3,032 fps with a 58 fps spread. Nine rounds of 23.5 IMR-4198 gave 3,155 fps and a 107 fps spread. Nine rounds of 23.5 RL-7 gave 3,187 fps and a 51 fps spread.

Because it gave higher velocity with good uniformity, all of the test loads tried the second day were with RL-7. Five rounds with 22.9 grains gave 3,122 average and 86 fps spread; ten rounds of 23.2 gave 3,168 and 60 fps spread; ten rounds of 23.5 gave 3,197 and 62 fps spread; ten rounds of 23.8 gave 3,219 average and 101 fps spread. These

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