Lock, Stock & Barrel

The Newsletter of the Worshipful Company of Gunmakers Issue 21 Summer 2009

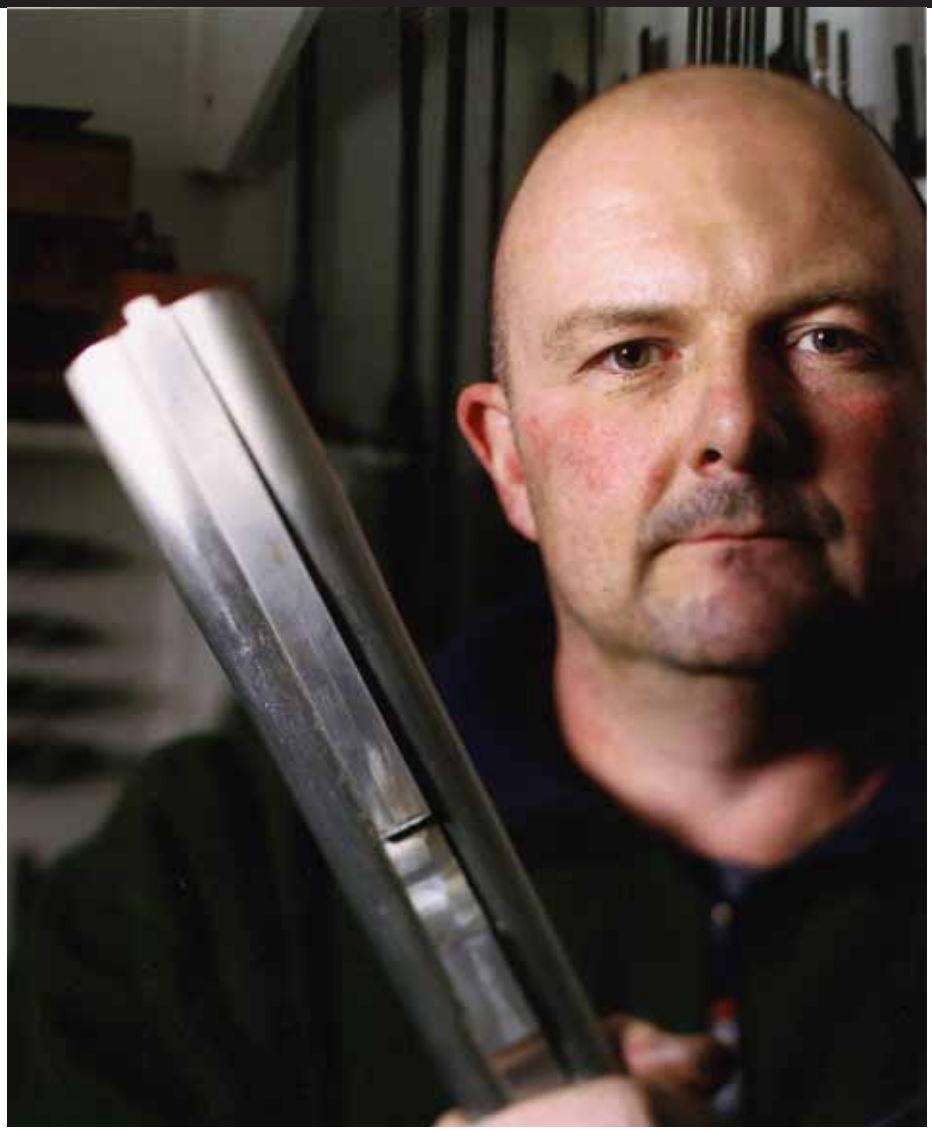
Interlivery Shoot 2009

May sunshine, and a rain of clay targets greeted the 24 liverymen who descended on the Holland & Holland shooting ground on 20 May for the annual Interlivery Clay Shoot. Divided into six teams, we competed against 92 other livery teams. While we didn't win everything, we did emerge with our share of honours.

Gunmakers' A, shooting hammer guns, was the top side-by-side team. Congratulations to John Farmer, Derek Stimpson and John Gregson – and double congratulations to Nigel Brown, who also took the prize for top individual score with a side-by-side. Gunmakers' D – Arthur Chamberlain, Chris Batha, Nick Measham and John Browning – shot the high score in the flush and placed second overall, behind the Horners.

As in previous years, the event was beautifully organised by Chris Parr of the Environmental Cleaners. The hog roast lunch was unusually tender, the queues for bacon butties at breakfast were unusually short, and the bacon crispy. Thousands were raised for a variety of charities, and a good time was had by all. What better way to spend a day out?

Side-by-side winners: (from left): Derek Stimpson, John Farmer, Nigel Brown and John Gregson.



Bill Blacker. Barrel-maker.

When one thinks about topend guns and rifles, one tends to think about actions and engraving and stocks. A dazzling piece of walnut or an exquisitely executed game scene is what grabs the eye. The barrels seem to be little more than the black bit on the front. And yet it is the barrels which define the thing as a weapon. Without the barrels a gun is no more than a club; or perhaps a bat. And on closer consideration there is far more to the barrels than a pair of tubes.

Bill Blacker is a barrel-maker at the top of his profession. He began his career in 1976, aged sixteen, as an apprentice at Holland & Holland. The first year was spent making the tools of his trade and one day a week was passed at Willesden Technical College undertaking Mechanical Craft Studies.

By his second year Bill knew where his inclinations lay and moved into Holland's barrel shop where he was mentored by the late Percy Batchelor for the remainder of his ap-

prenticeship. In 1981 he moved onto the senior bench in the workshop.

In these days of spark erosion and computer-aided design it is important to recall that the Holland & Holland factory at that time, a little over 30 years ago, was largely mechanical. Lathes were belt driven and the rest of the barrel work was done in the time honoured fashion of filing with a succession of finer and finer tools.

"The barrel shop had something of a blacksmithing feel to it," he chuckles, "when compared to the work on the action benches, for example. Fine blacksmithing, to be sure, but smithing for all that." Fine work indeed. Filing down a barrel wall to the few tens of thousandths of an inch tolerance required is only the first insight one gains, in chatting to Bill, into the almost alchemical mastery of the barrel-making art.

Making barrels sing

After the initial filing there comes the customisation. When you consider the proportion of the overall weight of a fine gun that is contained in the barrels what becomes immediately apparent is the effect that the distribution of that weight can have on the balance of the finished gun. By adjusting that weight forwards towards the muzzles or back towards the breeches it is possible to achieve significant differences in the handling and feel. When top flight game shots refer to "fast" guns, what they mean – but seldom understand – is that some of the barrel weight has been eased back to the breech end in order to shift the point of balance towards the action. "A good swinging gun" that some great shots prefer for the highest pheasants in the kingdom will have more muzzle-heavy tubes to achieve that stable, momentum-laden swing.

Which is why, when Bill is rebarrelling old guns for discerning customers today he likes to have the old barrels in order to study the original dimensions, and to discuss with the customer what feel the finished replacements should have.

Then there is the conformation and combination with the ribs. Different makers, and indeed, different owners desire and require that their guns pattern in particular ways. The degree of convergence of barrels from breech to muzzle, the width of the rib, will determine at what distance the shot patterns will begin to overlap. A pair of 28-inch barrels will have forty thousandths of an inch between them at the muzzle to converge the patterns at a standard distance. An extra thou either way will add or subtract from that distance. So it is the case that a properly discriminating customer, working with a truly talented barrel-maker, can design a gun for a specific quarry or a specific style of shooting. Flat ribs, concave ribs, raised ribs. Take your pick but each will have an effect of your sight line and an impact on your point of aim. Here again a thousandth at the shooter's end means a foot or more at the target end. This is the barrel-makers art.

After which we can move inside the barrels and consider chokes and cones. The arguments for this choke and that are the stock in trade of shooting lunches all over the world but the shaving of a thousandth here and there by a master craftsman is what delivers a perfect killing pattern. Though it remains the role of the shooter to deliver it where required. The barrel-maker's magic only extends so far, sadly.

The value of tradition

In 1983 Bill went to Purdey where he honed and refined his skills in their barrel shop. He went freelance three years later but continues to do considerable work with and for Purdey whose guns he esteems some of the finest examples of the gunmaker's craft.

A good deal of the modern fascination with forcing cones and porting however, are in Bill's view, mere fashion. Much as the Edwardians were led by the examples of the great Shots of their time. If it's good enough for Lord Walsingham or the Prince of Wales it'll do for me. As a matter of fact, Bill's view is that if it was good enough for the Edwardians it will probably work today. "I don't think that the guns made around that time can be much improved upon," he avers, "except in very modest ways." It is a view he endorses in his own choices. "I don't shoot very much myself, just with friends really but when I do I'll take the side-by-side Woodward. It's a hundred years old but it works just as well now as when it was made. I'd be interested to see whether top-end guns are very different in another hundred years. I doubt they will be."

His particular pleasure is building big rifles. The .500s and .600s. The minute technical requirements relating to sights fascinate him and the need for precise accuracy over long distances delivers a provocative challenge for him as a craftsman. "Mark you," he says, laughing, "you know when you've been working on those big guns. Hefting those great tubes about takes a toll on your shoulders. A bit like letting them off, I shouldn't wonder." More laughter.

There is plenty of work finding its way to his Essex workshop for the time being. He's creating replacement tubes for a pair of triple barrelled Dickson 20 bores just now. Where else do you go for a project like that, I wonder?

He's rising fifty now and his son Matthew is apprenticed to him so Bill's skills and talents will find their way to another generation. However the diminishing skill base is a source of concern to Bill. "We have to find a way of ensuring that these skills are preserved. Once they're gone, they're gone." he says. "That's the real challenge for us as gunmakers today."

Hear. Hear. — *Giles Catchpole*

Gunmakers' Company Charitable Trust

Our company charity is dedicated to helping to maintain and hone gunmaking skills. We now support two apprentices: one at Watson Brothers in London (whose progress was recently featured in *The Shooting Gazette*) and one at Westley Richards in Birmingham. It is pleasing to report that the trust received donations of £30,100 in 2008, bringing unrestricted funds to just over £112,000.

We have supported the Lord Mayor's Appeal which was for Well Being for Women and Orbis (for blind children). In addition the Trust has made grants to the Gun & Allied Trades Benevolent Society, and Mudchute Farm and Barts. We thank all liverymen for their generous support, and hope that it will continue.

Recess at rifles

On the 21st April, Gunmakers and their guests gathered at Bisley, home of the National Rifle Association (NRA) for a day's shooting across various, and very diverse, disciplines. The day was organized by past-Master Stewart Urry and Court Assistant John Jackman, former chairman of the NRA, under the auspices of the Gunmakers' Social Committee. Entry was open to all liverymen and their guests. On the day, 16 attended to shoot a smörgåsbord of what the NRA has to offer: target rifle at 900 yards, running deer, gallery rifle, and, for a special treat, flintlock pistol.

The 900-yard target is what Bisley is famous for: just over half a mile from rifle to target, undertaken with 7.62mm target rifles, without the aid of telescopic sights. The targets are six-foot square overall, with a bulls-eye 10 inches across. They look a long way away from the aiming mat. At that range, a gentle breeze can push the bullet a foot or three to the left or right – and, to add to the challenge, the flags on the Stickledown range showed unpredictable and varying gusts. But with the aid of wind coaches Stuart Card and Charles Perry to adjust the sights, even those who had never shot at such range managed to put respectable numbers into the black. None, however, seriously rivaled the accuracy of the Company Chaplain, David Cooper, who, in addition to his spiritual duties, also wrote the sniper's manual for the British Army.

Running deer proved a completely different challenge: only 100 yards from rifle to the target, which is more or less the shape of a stag, and shot standing rather than prone. In the "Swedish" version of the discipline that we shot, the first shot is taken at a stationery target. But as soon as the shot is fired, the target starts moving across the track. The challenge is to reload and place a second shot into the scoring area before the target disappears off the other end of the track. Repeat six times. Here Arthur Chamberlain's African game-shooting experience brought him to the fore.

Riflemen assembled for tea at the North London Rifle Club, after an enjoyable day's shooting.

Jonathan Irby clears the decks for boarding with his flintlock pistol.

Gallery rifle took many participants back to their youths, before health and safety eliminated guns and shooting from fairgrounds. Shot with a .22 semi-automatic, the trick was to put ten shots into the bull at 25 yards. Just to add a bit of pressure, on the second attempt, the target moved towards the gun, which put a 13 second time limit on the exercise. Derek Stimpson took home the metaphorical stuffed bunny.

Last but not least, came the buccaneer's special: flintlock pistol. The pistols (all modelled on English duelling pistols) were muzzle-loaded with black powder by by members of the Muzzle Loaders Association of Great Britain: David Spittles, Jeff Tanner and David Brigden. Then they were then fired amid great gouts of smoke by Gunmakers and their guests at targets 25 yards distant (roughly double traditional duelling distance). Jonathan Irby channelled his inner pirate to snatch victory.

From the first bacon roll to a rather sumptuous tea at the North London Gun Club, a good time was had by all – particularly as it didn't rain. The hope is to repeat the event next year, so that new participants might try rifle disciplines they might not otherwise be able to shoot, and old ones might see if they might manage to improve. — *Derek Stimpson*

Legends in our lunchtime

On Thursday 5th February Liveryman Diana Keith Neal gave a lunch in the Court Room for friends and family in memory of her father, Past Master William Keith Neal. Diana asked the Master to act as host on her behalf while Past Master and Providitor Roger Mitchell chose the wines from the Company's cellar, and the Honorary Chaplain, the Reverend David Cooper, said Grace.

Superintendent Richard Mabbitt gave an excellent talk on the work of the Proof House. Proof Assistant and Beadle Jeff Darbon carried out test firings – though Nicholas Soames MP, former Minister for the Armed Forces, insisted on pulling the trigger.

In the Keith Neal cabinet, considerable interest was shown in the feats of Colonel Peter Hawker with his personal sporting weapons, and also the pair of duelling pistols used by Captain Horatio Ross to shoot ten brace of swallows on the wing for a wager, with a pistol and single ball, which he achieved before breakfast.

Lunch guests (from left): Nicholas Soames, MP, the Duke of Westminster and Master Richard Purdey.

During lunch, the Master spoke about the work of the Company and current projects, its fledgling trainee scheme through the charitable trust, and the success in repurchasing the old Gunmakers' Hall. For a very generous contribution to its re-acquisition, the Master was able to thank one guest in particular, the Duke of Westminster, former head of the Territorial Army, and a liveryman of the Company for twenty five years.

Afterwards, Nicholas Soames told Diana: "It has been the most wonderful and fascinating visit to this unique building, a great thrill to see guns being tested, and to see part of the magical Keith Neal collection."

Yet another tragic sporting heartbreak

So here is a question. Who is Ali Bin Nasser? No idea? Well… Bin Nasser was the referee who never saw Maradonna's Hand of God Goal. The point of all this, is not to arm you with useless sporting trivia for your next pub quiz but to hint that this years Interlivery Pancake Tossing Competition will be remembered for its officials as much as for its result.

So where to start? Well, as is only right, we should turn our focus to the race run by our Master. Resplendent in his robes, he chose to pin back his ermine by wearing his embroidered apron over the top of his gown. This technical manoeuvre liberated his arms for a better sprinting technique and was soon copied by many. Laces tied with a double bow, chef's hat fixed, white gloves tight across his skilled hands, he stood at the start. Like a boxer eyeballing his opposition at the weigh-in, he cast his eye along the line. Nothing to fear in this race!

And how right he was, nothing to fear – except perhaps the laws of the sport. Law XII, Paragraph 3, subsection 4 states that the "tosser" must toss the pancake on both the outward and return lap of his race. Sadly our Master ignored his statutory toss on the return sprint. The result: a disqualification, and pain, frustration and unyielding sorrow scrawled lividly across his brow and etched deep in his clear eyes.

So who next? Liveryman Jonathan Irby. Having last year been beaten in the heats by the eventual winner, would this year be any better? Could our Liveryman make the semi-final? Gloved and robed as befitting his status within the company, he started well, but not fastest. But a dextrous flick of pan and canny use of bulk saw him take the lead at the turn. But no, the field were upon him. But wait, the deployment of the topple-flip manoeuvre saw him lose no momentum and overtake his competitors during the return toss. Victory, what joy! The semis awaited his presence.

Pray silence for our Lady Liveryman, Lynne Moore. With elegant skirt measured to neatly below the knee, as required by the laws of the games, she betrayed no sign of nerves. Instead, buoyed by her secret diet of chocolate that morning, she crouched, gazelle-like on the start. So keen was she to do well for us all that she snuck in a false start. Called back to restart, this initial burst of energy had left her drained. She leapt to the sound of the gun for the real race and was gliding down her lane like a speed skater. Low angled body, free swinging arm turning her through the tight turn. But sadly it was just not to be. The eventual winner of the ladies competition proved to strong for our novice. With granite eyes, she laid down her pan and declared that surely it was time to have a G&T.

Blithely unaware of what would follow, our pancake-racers pause for inspiration before the first toss: (from left) Master Richard Purdey, Sally Traverse-Healey, Lynne Moore and Jonathan Irby.

Now to the Novelty Class. Who within the company is worthy of such a title? In truth there are many names that can fit this description. But within the Pancake Race it was Sally Traverse-Healy. As our fancy dress entrant Sally was resplendent in her Dolly Parton outfit. She set off in her heat at a cracking pace. A sharp turn (despite her cowboy boots) and she was in the lead. But then we realised, her heat had men in it. No chivalry here! They soon used their longer legs to catch her up and this pressure lead to every tossers nightmare, a slipped pancake! Sally was now juggling pan, pancake and momentum and it all became too much. She finished a creditable third but frustration was clear for all to see.

Now to the semi-final. Mr Irby, with apron fastened over the top of his beaver-trimmed gown, his nerves were as bad as those he felt during his under-fives three-legged race at primary school. The gun sounded, and the race was on. First to the outward toss, second to the turn. Three yards behind as they approached the second toss. And my, what and a toss – one long to be admired in slow-motion replay. This freed his bulk to carry him to the line just ahead of a younger, taller but less virile opponent from the Remembrancers. A classic victory for technique over speed. But forget not Ali Bin Nasser, the official who failed to see what was clear to the all others? History was repeating itself. As Irby was stretching, to keep in perfect form for the final, the tannoy barked loathsome words.

The referee did not see the Gunmakers toss on the return leg. A five second penalty. Just how high does a pancake have to be for it to be seen? Just how long must it stay airborne? All questions that raced through all of our minds. But with good grace and bitten lips we accepted the judgment. The official had not seen what everybody else had. He had missed one of the sport's finest tosses. But that is the great sport of pancake-racing. We dusted ourselves off, disrobed and left the field of play, our heads held high and our pride resplendent in the knowledge that we had been robbed!

— *Jonathan Irby*

How to make a good bullet

Rarely in the realm of weapons design has so much innovation been concentrated in such a small space as in rifle and pistol ammunition. Bullets come in a bewildering variety of sizes and shapes. All do the same basic job: deliver a wallop of energy to a target. But each takes a slightly different approach, determined by the designers' views on how best to balance weight, shape and velocity in order to deliver the most energy, most accurately. For sporting weapons, the key concerns are accuracy and power. In the military, an additional factor applies – the weight of the ammunition, which determines how much a soldier can carry. Though the variations are myriad, the same basic laws of physics determine the design.

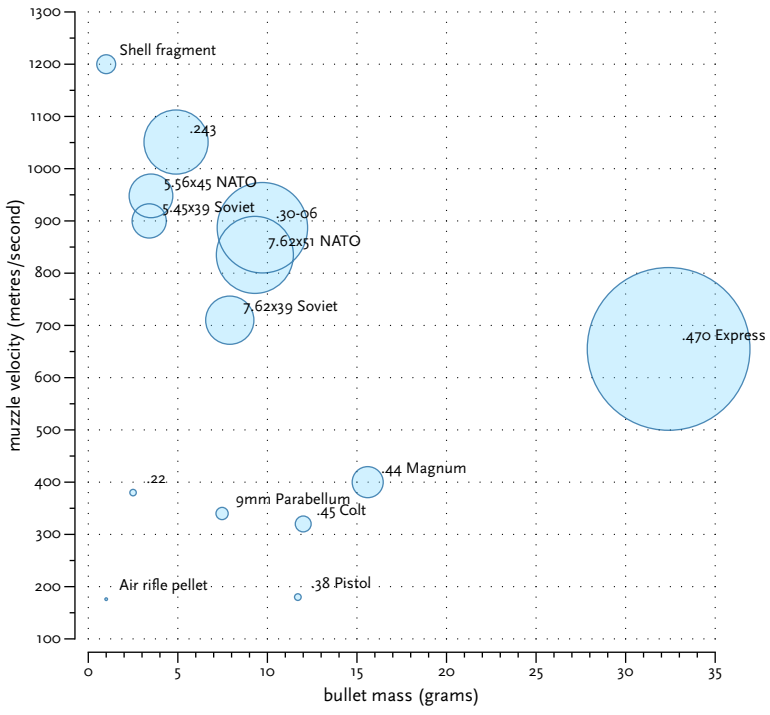
Much of the physics underlying bullet design was worked out in the mid-nineteenth century by Gaspard-Gustave Coriolis and William Thomson, later Lord Kelvin. They built a mathematical understanding of kinetic energy, which describes how much energy is carried by an object in motion. Kinetic energy is a function of both mass and velocity, according to the equation $K = \frac{1}{2}mv^2$. That is to say, the energy carried by a bullet varies with the mass and the square of the velocity. The result is measured in joules, which describe the amount of energy transferred by a force acting over distance (eg, a bullet striking a target).

So how much energy is needed to do a bullet's job? In the late 1880s, studies were undertaken in Germany by General Rohne who concluded that it was sufficient for a soft lead bullet to have an energy of about 80 joules and went on to report work by the French Army that concluded 185 joules was enough to put a horse out of action. The British army published "Notes on Artillery Material and Experiments", (HMSO) in 1903, which gave a minimum striking energy of 81.6 joules. By comparison, the maximum legally permitted energy for an air rifle is 16 joules.

That said, the energy concept is somewhat misleading since the penetrating power also depends on the shape (and cross sectional area) of the projectile. Not many people are killed by cricket balls or, for our American brethren, baseballs – despite them having energies over 120 joules. They may hurt but they don't penetrate. Riot control baton rounds are designed to deliver under than 40 joules and are claimed to be "less than lethal". However, there is a different response between a little old lady bystander and a 200lb rioter standing next to her!

In modern practice, all commonly used ammunition delivers much more than the minimum energies specified by nineteenth century militaries. A .22 rifle delivers just over 180 joules – and whatever the French might have said about horses, modern hunters consider that far too little to humanely dispatch a deer. A common calibre for smaller deer, the .243, delivers about 2,600 joules, and the 30-06 delivers about 3,800. The chart below left shows the weight and velocity of a variety of popular ammunition, and the diameter of the circle by each calibre is proportional to the energy delivered in joules.

Bullets by calibre: mass, velocity and energy



Smaller, faster, better

The general trend over time has been to use lighter bullets, but to deliver more energy by getting them to go faster. Faster also means straighter, for the simple reason that the bullet travels more quickly to the target and is thus subject to the force of gravity for a shorter period. A straighter trajectory, in turn, means less need to adjust the aiming point for differences in the distance to the target. A heavier bullet will be less subject to crosswind effects and drag from air resistance.

Historically, the 30-06 (or, in Europe's metric parlance the 7.62x63), has been the ammunition of choice. It was used in both world wars, Korea and even into Vietnam. It is still the most popular big-game cartridge in America. The name derives from the fact that it is a .30 calibre bullet, and the cartridge shape was introduced into the United States Army in 1906. It was used in the bolt-action M1903 Springfield rifle, the bolt-action M1917 Enfield rifle, the semi-automatic M1 Garand, the Browning Automatic Rifle (BAR), and numerous machine guns, including the Browning M1919 series.

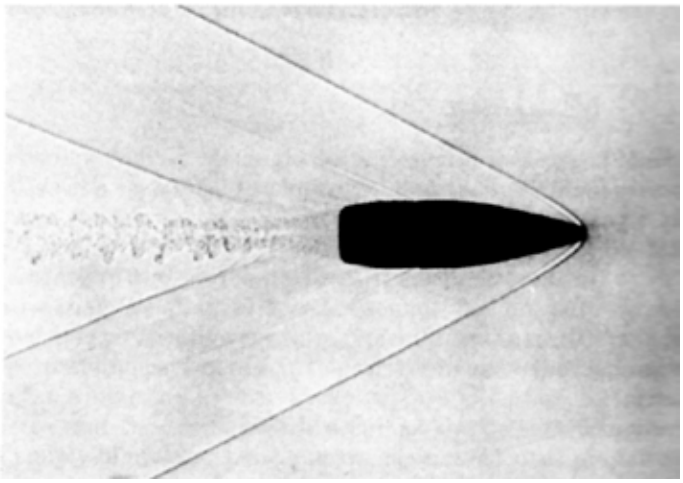
Today's armies, however, have standardised on slightly lighter ammunition. Exactly what type depends on the tactical doctrine of the relevant armies, and there are interesting variations. NATO's 7.62x51 ammunition is designed to defeat steel helmets and body armour at relatively long range, out to about 600 metres. This makes it somewhat heavier than the standard Soviet 7.62x39 ammunition. But the Soviet battle philosophy focused on short-range engagements with plenty of men and firepower. So they were willing to trade range and penetration in order to increase the amount of ammunition each soldier could carry.

The basic design of ammunition for game has undergone relatively less evolution than that for military use – witness the continued popularity of the 30-06. One of the most powerful ammunitions still in common use, the .470 Nitro Express, was developed by Joseph Lang in the first decade of the twentieth century. It shoots a massive bullet,

nearly four times the weight of the 30-06. But it propels the bullet more slowly – in part to reduce recoil and in part because engagement with the animals it was designed to shoot, mostly cape buffalo and elephant, typically occurs at distances of 100 metres or less, making bullet drop less of a worry. Combine slower speed with a heavy double rifle, and the resulting recoil is more of a steady push than a bruising jolt. And the energy delivered to the target, at nearly 7,000 joules, is still about double that of a 30-06.

Shape matters

Though weight and speed are the key determinants of how much energy a bullet delivers, shape also influences how much of that energy is transferred to the target. Pointy-nosed, missile-shaped bullets travel through the air with a minimum of drag. But – unless they tumble within the target – they tend to keep on going, straight through the target, taking much of their energy with them. Round-nosed bullets, by contrast, are slowed by the air. But when they hit, they flatten and transfer more – if



A bullet in flight. Note the front and rear shock waves, and the spiralling eddy behind the base.

not all – of their energy to the target, causing maximum damage.

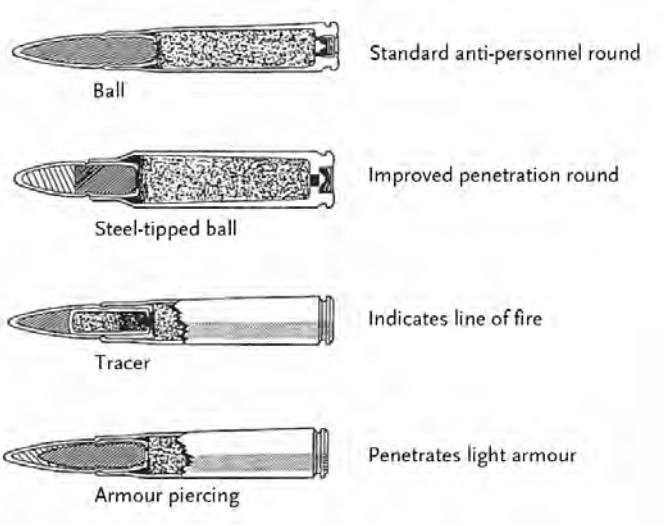
Trading off these concerns has resulted in a variety of bullet shapes. Pistol bullets, as befits a weapon designed for use at short range, often to stop an advancing foe, are usually stubby and round. Rifle bullets are more varied. Lead or lead/antimony amalgam is still used as the basis of bullets because it is soft enough to deform in the barrel and engage in the rifling to provide a gas tight seal. In order to prevent melting lead from fouling the barrel, a problem which became more severe as the muzzle velocity increased, the jacketed bullet was developed. The jacket is typically made from cupro-nickel alloy but latterly cheaper gilding metal (90% copper, 10% zinc) or gilding-metal-clad mild steel is used.

The jacket does not cover the core completely but leaves some lead exposed at the base to allow for "set-up", which is bullet base expansion to improve gas sealing. For high velocity bullets, the rear of the bullet is also boat-tailed to reduce base drag. Snag: the more boat-tailed the bullet, the less efficient the set-up in barrel. A similar trade-off concerns the tapering of the bullet. The ideal aerodynamic design tapers smoothly and steadily to a point. But in the barrel the bullet needs a length of straight side to guide it through the barrel without "balloting", or rocking back and forth.

A further constraint on bullet shape is the need to achieve just the right amount of spin for stable flight. Spin is imparted by the spiral of rifling in the barrel, and thus proportional to the length of the bullet on which the rifling can act. Too little spin, and the bullet may tumble. Too much and it will be overstabilised, keeping its nose at the same angle as it left the barrel even as its trajectory arcs. This too creates drag and instability in flight. Trial and a fair amount of error has shown that the maximum ratio of length to diameter to achieve proper spin is about 6:1. In practice, most bullets are designed with a ratio between 3.5:1 and 4.5:1.

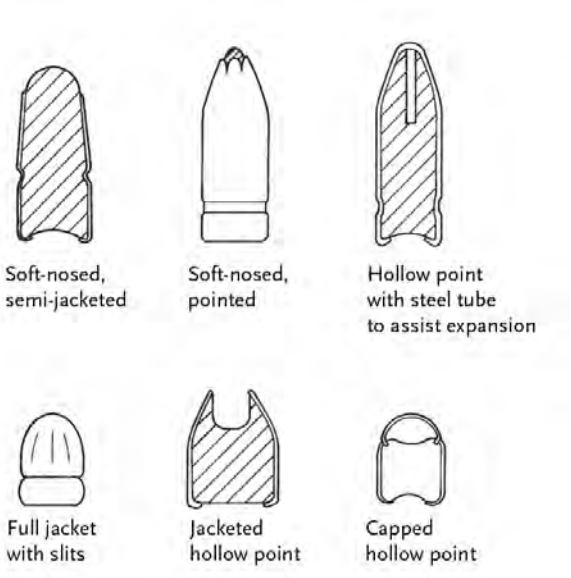
Interestingly, these ratios apply over a range of bullet sizes. Smaller, lighter bullets are more easily turned by the air, and so require higher spin rates for stability. A 155mm shell is stable at 16,500 revolutions a second, a 7.62mm bullet at 167,000, while a 5.56mm bullet requires 334,000. But smaller, lighter bullets also more easily take up spin from the rifling. So the ratios hold. When it is impossible to achieve a stabilising spin rate, ie in an air rifle, an alternative is to add a flare skirt to the pellet. But this adds drag. The shadowgraph to left shows the profile of a typical 7.62mm bullet in flight, and the shock waves and eddy created as it moves through the air.

Given a specific shape, there are also refinements that can be made to the internal structure of a bullet that change its behaviour on impact (see below for examples). To penetrate armour, the tip of the bullet can be made of steel, to give the momentum carried by the heavy lead something hard to push against in driving through a barrier. To provide a visible trail to aid in sighting, bullets can also contain a chamber at the rear, which contains a combustible material which leaks light out of the back while burning in flight and reduces base drag. In earlier times, tracer bullets also proved effective against zeppelins. Normal bullets caused a slow leak; tracers ignited the hydrogen gas which kept airships aloft.



Form follows function. The construction of a bullet is the key to its impact on the target, or lack thereof.

To cause maximum wounding, bullets can also be designed to mushroom, tumble and/or fragment upon impact by creating a soft spot or hollow in the tip of the bullet. Expansion increases both energy transfer to the target and the size of the cavity caused by the hydrostatic waves created when the bullet penetrates flesh, which is 80% water. This cavity is many times larger than the diameter of the projectile, and, though it collapses back to the size of the wound track after a few milliseconds, the power of the shock waves can be strong enough to destroy organs or break bones. Expanding designs were first used in the 1890s for .303 bullets by the British Dum Dum arsenal in



Dum and dummer. Though banned in the military, dum-dum bullets still have a variety of shapes and uses in other areas.

India – hence the common nickname, "dum-dum" bullets. Modern variations include various techniques for shaping the jacket over the point, or even a steel rod in the point to speed expansion. (See illustration above for examples. There is a short video clip which demonstrates the effect of expanding bullets on cavitation at *www.youtube.com/watch?v=gin5bLllNG4*.) For military use, expanding bullets were banned almost as soon as they were invented, by the Hague Declaration of 1899. But they can still be used on animals and, more surprisingly, civilians.

Cartridges: the back half of the solution

Though the bullet is certainly the sharp end of ammunition, there is also another half of the design problem: the cartridge. There are three key features of cartridge design.

- Thick base to withstand the pressure of propellant gases and to transmit forces efficiently to the gun receiver, without rupture.
- Thin walls for the shaft and bullet-end to expand under pressure to form a tight seal.
- Overall shape which will enable the cartridge to be positioned quickly and accurately in the chamber – which is particularly important for automatic weapons which must use simple machinery to load and eject cartridges quickly.

For many cartridges, there is an additional factor: the need to pack in enough propellant to achieve the desired muzzle velocity. For relatively low-velocity rifles, and pistols, the required charge can be conveniently held in a cartridge the diameter of the bullet. But high velocity rifles require more oomph. Adding more powder by lengthening the cartridge can create an ungainly shape, and one that is impossible to eject in an automatic weapon and difficult even with a bolt action. So the base of the cartridge is typically made wider than that of the bullet it fires. Typically, the diameter of the base of the cartridge is about double that of the bullet it fires. Cartridges have been made wider, but there are decreasing returns to size. In a very wide cartridge, much of the extra energy of more powder doesn't make it out of the bullet-end of the cartridge, and instead simply stresses the base of the case, like a sort of mini-bomb. In any event, the transition from wide base to narrow opening creates additional stress points and machining issues for the cartridge.

Given these requirements, only a limited number of materials can do the job. Probably the best is also one of the least used: carbon steel. Its key advantage is that it can withstand more stress than the most commonly used material, brass. So steel cartridges can be made thinner and lighter. Its disadvantage is corrosion. Without a special finish, steel cartridges rust and weaken rapidly. Special finishes are expensive. So most cartridges are made of brass. Brass is so corrosion-resistant that most cartridges can be recycled – though clearly this is more easily achieved for sporting rounds than military cartridges fired in the heat of battle.

There are other alternatives for some special situations. Aluminium alloy cases are used for the 30mm chain gun mounted on Apache helicopters. Though tricky and expensive to shape, aluminium's overwhelming advantage for aircraft is its lightness. Some tank guns, by contrast, use a combustible paper cartridge impregnated with nitro cellulose, which is burnt up during firing. These have significant disadvantages for civilian use including safety and environmental protection. While designers have looked at plastics, such as are used in shotgun cartridges, as a lightweight, easy-to-manufacture alternative to brass, plastic unfortunately isn't up to the temperatures and stresses of rifle fire.

For military weapons, the radical alternative is to do away with cartridges altogether. In theory, caseless ammunition would be both much lighter than conventional brass and capable of doubling the rate of fire in automatic weapons by eliminating the need to eject a spent cartridge. In practice, Heckler and Koch developed a completely caseless small-arms ammunition in the 1970s in response to a NATO request. While it did work, the gun required was complex. Perhaps biased by not having invented it, the English called it a cuckoo clock, and pointed out that it held so many springs that field stripping could end with an abrupt twang that spread its many components across the ground. The gun was never adopted.

That said, the search for alternatives to brass casing goes on. If nothing else, the raw materials of brass, copper and zinc, are difficult to come by. Over 80% of the world supply comes from only six countries, and half of that is in the USA and Russia. So it should not be too surprising that Germany still leads the way in research into steel-cased and caseless ammunition – just in case. — *David Izod*

Clerk's Notes

Clerk's Assistant. There have been further minor changes in my office. Ruth Streeter has reduced her hours and Sue Hobbs has correspondingly increased hers. Sue now works Mondays to Thursdays and Ruth only works on Fridays.

Dinners. This year's Midsummer Banquet at Vintners' Hall is imminent (Tuesday 9th June) and may have happened by the time you read this. The next big event is the Nomination Dinner at Stationers' Hall on Tuesday 3rd November. Please make every effort to attend. – don't forget it is free for Liverymen!

Livery Lunches. The programme of Livery Lunches continues and grows in popularity. They are always enjoyed by those attending, visitors and Liverymen alike. I am glad to be able to report a wider spread of attendance across the Livery. The remaining lunches for this year are fairly well booked up but people do drop out, so it is still worth enquiring if you are interested. The lunches provide a good opportunity for Liverymen and their friends to see what goes on at the Proof House and to learn more about the Company's raison d'être. Dates for next year's lunches will be announced later in the year. Vacancies are allocated nearer the event. To avoid potential embrassment for all concerned, please do not assume you are attending unless you have received confirmation from me.

City of London Briefings. Attendance at City of London Briefings by Gunmakers has improved but should be better. I once again urge more of you to try to go on one. As Liverymen and electors, you should learn something about your City and how it is governed. The briefings are aimed particularly at newcomers but Liverymen and Freemen of longer standing are encouraged to attend as well. They are interesting, good fun and give you the chance to meet Liverymen and Freemen from other Companies. Wives, husbands and partners are welcome too. Details are in the enclosed leaflet. Applications should be submitted direct. From June it will be possible to book online at *www.livery committecourses.org.uk*. There will in future be a charge of £10 per head to cover catering costs.

Ties. Two types of tie are available for purchase from the Proof House. The new Livery tie in silk features the Company's arms and the London Proof Mark in a vertically repeating pattern in a diamond grid. It is in two colours – blue with a grid of red lines and green with a grid of white lines. It may be worn only by Liverymen of the Company. The sale price is £15. Samples will be on display at forthcoming dinners and livery lunches. Ties for general wear, in polyester, feature the London Proof Mark, also in a repeating pattern, on a background of green or blue, and cost £12. Enquiries to the Clerk's Assistant on 020 7481 2695 Option 4.

Wines. The Company's principal wine merchants, Berry Bros & Rudd, have increased the discount offered to Liverymen to 12.5% on unmixed cases of wine. If you wish to take advantage of this discount, you should place an order by telephoning Lance Jefferson direct on 020 7396 9605. The discount is unlikely to be available if you try to buy wines direct from their premises in St James's Street without speaking to Lance first.

Lord Mayor's Book. Past Lord Mayor Alderman Sir John Stuttard has published recently a fascinating and erudite book about the Office of Lord Mayor: *Whittington to London Financial Centre – The City of London and its Lord Mayor.* A flyer and order form are included.

Social Committee. There are still places available for the Company wine tasting at Berry Bros & Rudd in the evening of 23 September. If you'd like to taste some lovely and/or unusual wines with other liverymen, please email *pa@gunmakers.org.uk*.

Admissions to the Company

	Freemen	Liverymen
26 February	The Earl of Shrewsbury	The Earl of Shrewsbury
	Raymond Watson	Carl Steven Langton
		John Steven Martin Rowe
		John Algernon Martin Rowe
23 April	John Joseph Batty	
	John Jeremy George Mackenzie	
	Stephen Morant	
	Paul Christopher Ridge	
	Geoffrey de Jager	

Best thank-you note ever? Diana Keith Neal received this one for a lunch at Proof House. There is much to be said for the disappearing art of doodling...