NOTES ON BELLS, BELL HANGING, BELL RINGING AND BELL RESTORATION

Church bells:

Bells have featured in worship in the Christian Church since the 5th century when Italian monks revived the ancient knowledge of bell founding that had been developed in China as early as 2000BC. Today, bells are cast in the same bronze alloy of copper and tin as then in the approximate ratio of 4:1. This is a significantly higher tin content than is found in any other application and yields a metal with sufficient hardness to withstand repeated blows of the clapper, corrosion resistance and richness of tone.

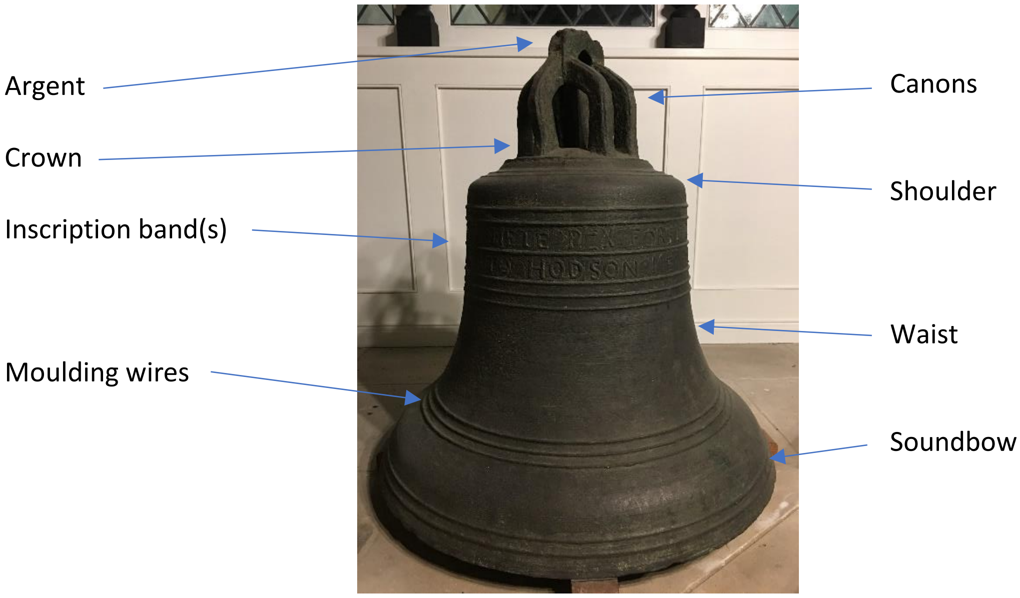

Fig. 1. Close-up of a bell

Bells come in a very wide variety of sizes, ranging from handbells weighing less than a pound to bourdon bells of several tons (the bell ringing fraternity clings tenaciously to the imperial system of weights and measures). Distinctive shapes have evolved in different parts of the world to satisfy the varying tastes for their harmonics. In the Western world, profiles have remained largely unchanged for several centuries. The oldest known bell in Lichfield Diocese dates from circa 1200 and, though longer in the waist (measured from top to bottom) than modern bells, is of a shape that is instantly recognisable.

Bells of this age are rare. Many were destroyed during the reformation and others were broken up to be re-cast into armaments, principally cannon, at times of strife. Of those which survived into the 17th century, many were re-cast as engineering technology developed and it became possible to produce bells of greater size. Improved means of transport also allowed dedicated foundries to be established in fixed locations from where they could be shipped to their destination, where previously it had been more practical for itinerant founders to assemble the necessary materials on site and set up temporary foundries in churchyards.

Canon Law has long contained statements on bells and the current 7th edition, amended by General Synod in 2010, includes the following:

"F8. Of church bells

1. In every church and chapel there shall be provided at least one bell to ring the people to divine service.

2. No bell in any church or chapel shall be rung contrary to the direction of the minister."

Bell hanging:

The smallest bells can be carried in the hand, but larger bells must be hung with appropriate fittings, usually in elevated positions, to permit them to be rung by the action of pulling on a rope from below.

Fig. 2. A stone turret above a gable end, a flèche midway along a roof apex and a massive masonry tower

Many bells are rung by being chimed. Here the bell swings back and forth through an arc of, usually, less than 180^0. If the rope is pulled with a smooth action, then bell and clapper swing synchronously and will not chime. The ringer must 'check' or 'jerk' the rope in order to force an unnatural swing of the bell such that it is struck by the unconstrained clapper.

In such cases the bell must be fixed to a headstock, originally of wood but now in steel, from the ends of which project gudgeons (bearing pins) to rest in bearings on fixed mountings. Early bearings were of the plain type but, since the early 20^{th} century, double-row self-aligning ball bearings (protected in cast iron housings) have been the preferred choice as they will accommodate slight mis-alignment in the bearing mountings.

The headstock must be fitted with a projecting lever to which the rope can be attached. This rope then falls to ground level, often through a small opening in the roof for transition to indoors. Ringing a bell in this manner is somewhat haphazard. The dynamics of the bell's movement is dictated by its weight, the radius from the bearing centres to its centre of gravity and any friction in the system. Where two or more bells are rung by this method, they chime in a random and uncoordinated manner. Ringing of this nature is widespread throughout, e.g. most European countries.

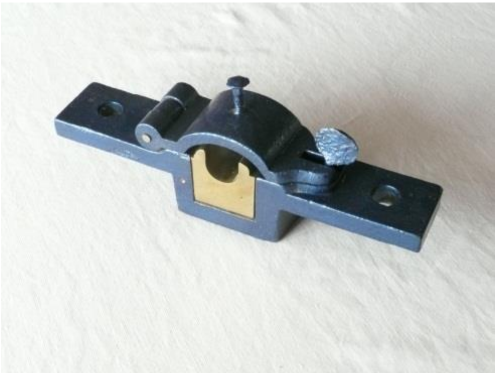

Fig. 3. A plain bearing with brass insert in a steel housing and a double-row self-aligning ball bearing

English change-ringing:

In the 17th century, ringers began experimenting with means to control a swinging bell more accurately. Levers on headstocks were replaced with quarter, then half and finally full wheels. Bells could now be swung backwards and forwards through a full circle, during which the clappers would strike once at the same precise moment each time. Pausing the bell's movement briefly at the point of balance allowed sufficient control to dictate the sequence in which the bells would strike and to change the sequence at will. Such ringing required the bells first to be raised, i.e. swung progressively higher, and additional fittings allowed them to be parked in the 'up' position between episodes of ringing. Ringing in this way requires a surprisingly small amount of effort. The ringer has only to pull gently at each end of the bell's swing in order to send it on its next rotation. It is an activity that requires development of the 'knack' and which usually takes many weeks of practice to perfect.

The changes of sequences were, at first, generated by a conductor making occasional calls to vary the order but this soon developed into 'scientific' ringing, where changes occurred at each pull of the rope following an ordered pattern. Bell ringers' ambitions were sustained as churches acquired more bells and began paying ringers for their services. It became a matter of civic pride, for town and city churches in particular, to have greater numbers of heavier bells with ringers of sufficient competence to acquit themselves well in the prize competitions which became a feature of the ringing scene. Many foundries were established across the country to meet the demand, particularly during the 18th and 19th centuries, but today only two companies casting new bells remain in the UK. Competition ringing remains, but with friendly rivalry the only motive.

Scientific ringing, today referred to as 'method' ringing, developed rapidly, as did the number and variety of the ordered patterns of changes – 'methods'. There are today literally thousands of such methods, ranging from the relatively simple to the extremely complex, often with names which reflect the places where they were first rung, e.g. Cambridge, Kent, London, Norwich, etc. Those who practice change-ringing refer to themselves as bell ringers and shun the use of the word 'campanology', this being a more embracing term which encompasses the much wider range of issues associated with bells and ringing of all styles, customs and traditions.

The Church of England has some 16,000 churches, of which approximately one-third have between four and 12 bells hung for full-circle change-ringing. As the name implies, it is largely confined to England, with far fewer to be found in Ireland, Scotland and Wales. It was exported in small quantities and a few ringing towers exist in the former colonies in Australasia and the South African and North American continents.

Fig. 4. A ring of six bells at rest and rung up in readiness for change-ringing

Inscriptions:

Many bells bear inscriptions cast in raised relief, usually just below the shoulder but often also on the waist, and these can tell us much about the social history of the time. One is tempted to wonder, for example, if the inscription:

“GOD SAVE HIS CHURCH OUR KING AND REALM”

on a bell cast in 1634, i.e. in the years leading up to the English Civil War, was in part a statement of political affiliation.

Foundry workers of earlier centuries were probably ill-educated, barely literate even, and it is not unusual to find evidence of this in the form of e.g. the letters “N” and “S” being reversed or upside-down.

The inclusion of the suffixes against the names of the four churchwardens in this bell from 1717 tell us something about their standing in the wider social environment:

“RICH^{D} LLOYD ESQ^{R} RICH^{D} OWEN G^{NT} HUM^{P} KYNASTON G^{NT} NAT^{H} PRICE G^{NT}”

Some founders habitually included inscriptions that were probably not specifically requested by a parish, as the same wording is found on their bells in many different towers:

“PEACE AND GOOD NEIGHBOURHOOD”

“PROSPERITY TO ALL OUR BENEFACTORS”

“I TO THE CHURCH THE LIVING CALL AND TO THE GRAVE DO SUMMON ALL”

There are bells which have been designated as WWI War Memorials by virtue of the commemorative inscriptions which they bear.

Some parishes were evidently willing to ‘go an extra mile’ by commissioning elaborate decoration between the lettering on the inscription band and/or around the shoulder and soundbow.

The historical significance of inscriptions has long been recognised and, where bells have had to be re-cast for some reason, it is not unusual for impressions to have been taken and the inscriptions recreated on their replacements.

Fig. 5. Oak-leaf decoration between lettering and a 1632 inscription recreated in a 1959 re-casting

Structural issues:

Bell hangers learned very quickly that large forces are exerted as bells swing through a full circle. A widely used rule-of-thumb gives that each bell exerts peak vertical and horizontal forces equivalent to four times and two times its weight respectively. The design of timber bell-frames of massive construction evolved and these had to be securely anchored into the tower walls. Steel has now almost completely replaced timber for new frames and achieves similar strength and stiffness with far more slender proportions. The need for secure anchoring remains.

Any ringer who travels widely will have stories about towers that sway during ringing – visible to the eye perhaps only by the movement of picture frames hanging in ringing rooms, but enough to be felt when standing against a wall.

Other means of sounding bells:

Change ringing requires one person for each bell that is being rung. In times past, and even more so today, finding sufficient ringers can be difficult. Bell hangers have devised two methods to overcome this.

An Ellacombe chime system operates with bells hung stationary and with a hammer beneath each bell that rises and strikes on tugging a rope (Fig. 6). Unlike full-circle ringing, where the diameter of the bell wheel produces a large excursion of the rope, the movement here is minimal. Ellacombe ropes can be routed to descend to a compact rack where they are within easy reach of one individual. It is not unusual to find Ellacombe racks in towers with bells hung for full-circle ringing, thus offering the option of either technique. It is this author's experience that these are very little used.

Fig. 6. An Ellacombe hammer and rack (here for 10 bells)

Ringing bells in this way is tiring and, as the momentum of moving parts is relatively low, the sound level generated is much lower than with full-circle ringing.

Modern developments in other technologies also allows bells to be struck by electro-magnetically operated hammers. These can be mounted on the frame alongside the bells (Fig. 7) or hung inside the bells to replace conventional clappers. Electronic control systems allow choices of ringing style at the push of a button, e.g. changes on all of the bells, slow tolling for a funeral, hour striking (with or without the presence of a clock), Angelus and Sanctus bells. As with Ellacombe hammers, the volume of the sound produced is relatively low.

Fig. 7. An electro-magnetic hammer and a micro-processor controller

BELL RECORDINGS: The Church Buildings Council (CBC) observes that:

Mechanical, electrical, or electronic imitations of bells are strongly deprecated.

The Lichfield Diocesan Advisory Committee (DAC) takes the view that, where a church has three or more existing bells, the matter of authenticity should take priority and that it is these bells which should be heard. In such cases it will therefore usually recommend against the installation of systems which broadcast bell recordings.

Refurbishing old bells:

In this context, 'old' bells are those cast more than 100 years ago. Refurbishment work is likely to require a Faculty and, in making recommendations to the Chancellor, the DAC will usually adhere to CBC guidance, extracts of which are quoted here in *italics*.

CLAPPER SUSPENSION: Clappers, usually of wrought iron, are suspended inside bells. Until the late 19th century this was achieved by inserting an iron 'staple' into the mould prior to pouring the molten bronze. On solidification, part of the staple was embedded in the crown and part exposed on the underside from which a clapper could be hung. Iron corrodes to iron oxide (rust) which occupies a greater volume than the parent metal. This expansion due to corrosion is widely held to be the commonest cause of cracks in the crowns of bells. Whenever old bells are refurbished, it is normal practice to follow the CBC advice that:

"… it is desirable to remove as much of the iron stumps (by drilling them out) *as possible to avoid future trouble*".

Exceptions to this may be made in cases of the very oldest of bells. It can reasonably be argued that, if cracks have not formed from this cause after several centuries, the bell is probably immune to the problem. Such exemption permits the preservation intact of the oldest examples of the bell-founders craft.

TURNING BELLS: Repeated blows of the clapper (or external hammer) at the same point on the soundbow (inside or outside) of a bell give rise to depressions forming in the bronze. If these advance to …

… 10% or more of the unworn thickness, turning the bell or moving the hammer is necessary to reduce the risk of cracking. When a bell is rehung, the clapper and any hammer should strike upon an unworn thickness of the soundbow and preferably at 45° from any welded crack.

WELDING CRACKED BELLS: Cracks may be repaired by welding. Given the peculiar composition of bell metal, this is a highly specialised task and there is currently only one company offering a commercial service in the UK.

REMOVAL OF CANONS: Canons are bronze loops once incorporated into the crown of a bell by which they could be fixed with iron straps to wooden headstocks. When steel replaced wood for the latter, bells were then cast with flat tops to be bolted directly to the headstock. When re-hanging old bells, it may be appropriate to remove the canons to create a flat top or to provide a steel canon-retaining headstock.

As a general principle, canons should not be removed. This general rule may be relaxed only if the bell is not identified as of historic significance, cast after 1700 and to be hung for full-circle ringing. Particularly fine or unusual canons should be retained regardless of the bell's age, and others should be retained where it would help balance bells in a ring which includes other bells with canons.

Fig. 8. Canons, iron straps and wooden headstock and a steel canon-retaining headstock

TUNING: Bells have a fixed pitch and do not go out of tune. However, and in common with all other musical instruments, they produce a complex sound made up of the nominal note and a series of harmonics. These are produced at different points in the bell's profile and are closely linked to the various diameters.

A ring of bells will normally yield a diatonic scale (in the Western world, sometimes called a 'natural' scale). However, prior to the late 19th century, the tone of an individual bell and the relative pitch of each one in a ring was largely the product of the founder's artisanship. Bell profiles which delivered accurate pitch were arrived at by an iterative process and some foundries were notably more successful than others in achieving satisfactory results.

Digital measurement of the frequencies produced and an understand of their optimum relationship now allows tuning by machining, usually of the inner surface, which can lower the pitch of the partials by up to a semitone. The process can be applied to bring the tuning of a ring of old bells into better alignment with one another and to improve their tone. Some past founders habitually cast bells with greater thickness of metal, rendering them more amenable to modern tuning techniques.

Tuning usually involves adjustments to all the bells within a set. Where the set consists of only three or fewer bells, tuning is rarely worthwhile.

The aim should be to conserve listed bells and other bells deemed worthy of preservation in as near their original state as possible. In such cases, tuning should be undertaken only when essential.

BELL FRAMES: Church bells are often not seen by their listeners, but at least they are heard. Bell frames are very much ‘out of sight, out of mind’ and belfries are visited by very few, often not even by the incumbents and churchwardens who have the primary responsibility for their care. Nevertheless, they often reveal the craft, ingenuity and sheer determination of their makers and lead us to marvel at the achievements of our forebears, given the crude tools (by today’s standards) available to them.

Old timber frames can create difficulties for change-ringers and, in severe cases, cause damage to tower masonry. If the joints between sections have loosened, then the frame will distort during full-circle ringing. This acts to dissipate some of the energy expended by the ringers, who must work harder as a consequence. It is not unknown for the heavier bells in a ring to cause sudden ‘shifting’ of elements of the frame. Such movement is, typically, measured in only small fractions of an inch but may be sufficient to disturb the swinging of the lighter bells. Ringers strive to exert precise control in order to produce regular striking, but a ‘mobile’ frame can make this very difficult to achieve. In the most severe cases, and where the perimeter of a frame lies close to the tower walls, movement of a frame can effectively turn it into a ‘battering ram’ with consequent damage to masonry.

Bell installations often illustrate the ‘cutting edge’ technology of their day and very old bell frames, together with those having interesting or unique features, are well-deserving of conservation. This is sometimes seen as ‘inconvenient’ by enthusiastic ringers who lament their structural under-performance by comparison with modern frames. Nevertheless, where it is judged that timber frames of historic interest are no longer ‘fit for purpose’ and cannot be adequately strengthened by the addition of steelwork, they may have to be retained in the tower and space found for the insertion of a new steel frame.

Peter Woollam,
Lichfield DAC Bell Adviser
February 2018