

<b>Derby Diocesan Association of Church Bellringers Consultant's Report</b>	<b>Report no. DDACB 11/003</b>
<b>Analysis of Bell Dynamic Characteristics at All Saints' Church, Mugginton</b>	<b>Issue date: 2/09/003</b>

## 1.0 Introduction

Use of an Odd Struckness Meter at Mugginton had indicated that:

- bells 1 and 2 were apparently odd struck,
- bell 3's swing time was a little slow,
- bell 3's mean clapper time was fast,
- bell 5's mean clapper time was slow.

It was decided to take the opportunity to understand the dynamics of the bells in more detail and a comprehensive set of parameters was recorded. Analysis and interpretation used a range of established criteria and also a computer programme called "SPEED" which simulates bell dynamic behaviour.

## 2.0 Parameters Recorded

The parameters and their recorded values are shown in Table 1.

## 3.0 Derived Parameters

The following parameters have been derived for each bell and are shown on Table 2.

- Bell aspect ratio (ratio of internal height to lip diameter)
- $T_b$  - the bell swing time (for one oscillation over a small arc) averaged from three sets of timings over twenty swings
- $T_c$  - the clapper swing time (for one oscillation over a small arc) averaged from three sets of timings over twenty swings
- $L_b$  – the length of a simple pendulum having the same swing time as the bell
- $L_c$  - the length of a simple pendulum having the same swing time as the clapper
- $h$  – the distance between the centre of gravity of the bell (+ headstock + wheel + stay) and its axis of rotation
- $k$  – the radius of gyration of the bell (+ headstock + wheel + stay)
- Clapper throw (distance between clapper pin and bell axis of rotation)
- Clapper half angle (half the angle moved by the clapper relative to the bell when it swings between the strike points)
- Strike angle of bell (derived from "SPEED" programme).

## 4.0 Background

The bells are a mixture having been cast by several bell founders spanning a considerable period of time as shown in the table.

Bell	Diameter mm	Weight Kg	Aspect Ratio	Founder	Date
1	690	241	0.73	Taylors	1987
2	712	245	0.74	Taylors	1987
3	760	241	0.68	William Noone	1721
4	790	269	0.72	George I Oldfield	1659
5	840	304	0.72	Mellours	1500
6	905	392	0.71	Mellours	1500

The low aspect ratio for bell 3 has resulted in a diameter which fits with its neighbours but with a weight equal to the treble.

Bells 5 and 6 have retained their canons; bells 1,2,3 and 4 have no canons.

## 5.0 Analysis of Results

5.1 All clappers appear to be central between their strike points to within +/- 5 mm and so there is no obvious reason for any bell to be noticeably odd struck.

5.2 The swing times for the bells do not fall on an entirely smooth curve; ideally they should. Bell 3 is confirmed to be slow and bell 5 marginally slow.

5.3 The low aspect ratio for bell 3 has resulted in its centre of gravity being relatively closer to its lip than is the case for the centres of gravity for the other bells.

5.4 The bell hanger seems to have hung the bells based broadly on two criteria:

- a hang, i.e. distance from lip to axis of rotation, of  $(D/2 + 216)$  mm (where D is the bell diameter)
- and a clapper half angle of about 29°.

The hang on bell 5 deviates slightly and it is tucked in too far by 19 mm.

5.5 The high pull down distance for bell 5 compared with bells 4 and 6 and the low value of clapper throw indicates this bell is tucked in too far.

5.6 The low value of h/k for bell 5 confirms that bell 5 is tucked in too far.

5.7 The ratio  $T_c/T_b$  should generally have a value of 0.9 +/- 0.05 for satisfactory clapping. Where this ratio is at the lower end of this range, the bell strikes more quickly and is prone to double clapping. All of the

Mugginton clappers are at or below this lower limit with bell 3 having a very low ratio of 0.81. (Using data taken for bell 3 in the “SPEED” computer programme resulted in double clapping).

5.8 When raising a bell, for the bell to go up “right” the amplitude of the clapper must exceed that of the bell. It can be shown that the ratio  $(L_c + \text{throw})/L_b$  must be greater than unity for this to happen. This ratio is less than unity for all of the Mugginton bells and bell 5 is the worst with a value of 0.80.

5.9 Another yardstick for assessing clapping is a graph produced by Thelfall and McClenhan in 1965 which defines areas in which a clapper would always ring right, always ring wrong, and an intermediate area where it would ring either right or wrong depending on how it was initiated. All of the Mugginton clappers are in the intermediate area.

5.10 The ideal design of clapper would have its centre of percussion positioned at the centre of the ball – this would ensure that all of the force of the clapper occurred at the ball. The centre of percussion actually occurs at a distance  $L_c$  from the pivot and inspection of the results shows this to be typically 0.81 of the distance between pivot and ball. This indicates that the clapper profiles are far from ideal – typical of many SG cast iron clappers. From this we can conclude that:

- a part of the clapper blow load will always be felt at the pivot points (hence resilient mountings)
- the clappers swing faster than their ideal equivalents.

## 6.0 Effects of Hanging Bell 5 Further Out

If the hang of bell 5 is increased by 19 mm it will:

- achieve a hang of  $(D/2 + 216)$  mm which brings it in line with the other bells
- the value of  $(L_c + \text{throw})/L_b$  increases to 0.83 reducing its tendency to go up wrong and bringing it in line with bell 6
- according to “SPEED” the clapper strikes earlier ( $-5^\circ$  of bell angle)
- the swing time for the bell is reduced by a very small amount (from 1.704 to 1.700 sec)

## 7.0 Bell 3

The hang on bell 3 cannot be reduced since it has a cast resin pad on its crown. It may be possible to alter the swing time by addition of weights to the wheel; given more time this could be determined by calculation.

## 8.0 Discussion

The oddstruckness meter provides a quick insight into the dynamic behaviour of bells and provides a datum from which decisions on further investigation can be made. However dynamic behaviour of bells is relatively complex and

so care must be taken in arriving at conclusions from information given by the meter.

The clappers on all bells were reasonably well centred and so there was no apparent reason for oddstruckness measured by the meter on bells 1 and 2. The more detailed analysis contained in this report does find that the bells are probably prone to double clapping and experiments revealed that this is the case for bell 2 on one stroke only. Has the meter registered the second blow on this stroke and so indicated odd struckness? More work is necessary perhaps paying particular attention to the microphone sensitivity adjustment on the meter.

Mike Banks

Bell Consultant to Derby Diocesan Association of Church Bellringers.

MUGGINTON BELL NUMBER	1	2	3	4	5	6
Bell Diameter	690	712	760	790	840	905
Weight (cwts)	4.75	4.82	4.75	5.30	5.99	7.71
Wheel Radius at Rope	680	698	716	728	750	791
Pull Down	496	484	475	443	454	342
Hang	560	570	600	613	617	670
Bell Time (20 swings)	1 30.54	1 30.93	1 32.16	1 32.83	1 34.20	1 35.17
	2 30.66	2 31.00	2 32.22	2 32.65	2 34.04	2 35.16
	3 30.60	3 31.02	3 32.17	3 32.69	3 34.00	3 35.14
Clapper Time (20 swings)	1 25.76	1 26.60	1 26.25	1 27.40	1 28.25	1 29.49
	2 25.84	2 26.31	2 26.10	2 27.55	2 28.24	2 29.54
	3 25.81	3 26.27	3 26.07	3 27.42	3 27.94	3 29.73
Ball to Bell Strike Points (Rope side)	240	255	260	287	295	340
Ball to Bell Strike Points (Non rope side)	250	260	270	290	295	345
Sally Height (bell down)	1550	1540	1560	1555	1530	1480
Sally Height (bell up)	1675	1670	1675	1535	1520	1620
Clapper Pin to Lip	453	453	450	510	533	570
Clapper Pin to Ball	510	520	520	590	600	670
Clapper Ball Width	100	100	100	100	100	110
Lip to Strike Point	28/33	30/33	40/43	28/30	39/39	34/32
Distance between Strike Points	540	575	585	630	650	750
Lip to inside of Crown	504	524	520	571	602	645

Pull down weight: 72 kgs

**TABLE 1 MEASURED PARAMETERS**

**TABLE 2 DERIVED PARAMETERS**

<b>MUGGINTON BELL NUMBER</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
<b>Bell Aspect Ratio</b>	0.73	0.74	0.68	0.72	0.72	0.71
<b>Tb</b>	1.530	1.549	1.609	1.636	1.704	1.758
<b>Tc</b>	1.290	1.320	1.307	1.373	1.407	1.480
<b>Lb</b>	582.0	596.7	643.8	665.6	721.9	768.2
<b>Lc</b>	413.8	433.0	424.7	468.5	492.3	544.0
<b>h</b>	304.5	321.0	346.9	340.6	312.0	347
<b>k</b>	290.7	297.5	320.9	332.7	357.6	382.3
<b>(D/2 + 216)</b>	561	572	596	611	636	669
<b>Throw</b>	107	117	150	103	84	100
<b>(Lc+throw)/Lb</b>	0.895	0.922	0.893	0.859	0.798	0.838
<b>throw/Lc</b>	0.259	0.270	0.353	0.220	0.171	0.184
<b>Lb/Lc</b>	1.406	1.378	1.516	1.421	1.466	1.412
<b>Tc/Tb</b>	0.843	0.852	0.812	0.839	0.826	0.842
<b>Strike Angle from "SPEED"</b>	110	110	101/124	115	120	119