# Computers and composition in change ringing

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**Programs have been written to produce touches of Plain Bob Minor in a systematic way. One is designed for short touches while the others use Q-set rules to produce extents of 720 changes.**

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Change ringing is usually performed on a set of church or hand bells tuned to a chromatic scale. If there are six bells in a ring then they are numbered down the scale from 1 to 6 and bells rung in this order are said to be ringing 'rounds'. One of the aims of change ringing composers is to produce 'touches' or blocks of changes which begin and end with rounds but which otherwise contain no repetition of changes. This is done using 'methods' which obey certain rules. (Papworth, 1960.) These methods can be classified and several programs have been written to enumerate the methods in certain classes of interest to ringers (Hudson and McClenahan, 1963; Cooper-Bailey, 1967). However, the basic method does not provide all the changes or permutations if there are five or more bells, so the composer uses further rules to extend the basic method to give the the number of changes required. Papworth (1960) described these rules as applied to Plain Bob Major and wrote a program to produce touches in this method in a random fashion.

If a systematic generation of touches is to be attempted, then in order to bring the problem within the scope of modern computing techniques the touches generated must be restricted in some way. In order to simplify the problem as much as possible this paper is devoted to Plain Bob Minor, the Plain Bob method on six bells, though the results are directly applicable to other similar methods and point the way to a similar generation of touches in more complicated methods. In practical change ringing one of the lengths of interest is 5040 changes. This is a 'peal' length on six bells and takes about three hours to ring. On 6 bells it is obtained by ringing seven extents of 720 changes. Also of interest are quarter-peals of 1260 changes, usually consisting of an extent plus a touch of 540 changes. In addition short touches of up to 360 changes are required for practice. Thus the problem can be split into two parts, the production of extents and the production of touches of up to 540 changes. These two can be approached separately and in different ways.

## Short touches

The basis of the technique used here is the same as that used by Papworth (1960) except that the bobs and singles are not used in a random fashion but are inserted logically. A touch which is known to be true is given to the computer (this can be the final touch from a previous run) which then tests the final lead-end to determine whether it was a plain lead or whether a bob or single was used. If it was a plain lead a bob is used instead and the resulting lead head and lead end are tested to see whether either of them are false against the other lead heads and lead ends of the touch. The method of proof used here is the same as described by Papworth (1960). If a bob was used a single is substituted and again the resulting rows are tested for falseness. Finally if a single was used the program goes back to the preceding lead and examines that in the same way. If the new lead produced is true, plain leads are added until the touch runs false when again bobs and singles are substituted for plain leads as before. When rounds are produced the touch is printed out and the program continues looking for new touches until it has produced the required number. A cut off is imposed so that only touches up to a set maximum length are composed. This program written in Fortran IV for the Bath University, ICL. 4–50 computer generates touches at the rate of about 40 a minute.

## Q-sets

When a call (bob or single) is made in Plain Bob it only affects the three bells in positions 2, 3 and 4 at the lead end. Thus at any lead, irrespective of whether a call is made or not, the two bells in 5, 6 are unaffected. The 60 leads of Plain Bob Minor can thus be grouped into 10 sets of six leads in which each member of the set has the same two bells in 5, 6. Such a set is known as a Q-set and these have some interesting properties which are of great relevance to the composition of true extents where all 60 leads must be used. A typical set of six lead ends/lead heads is shown in the first row of **Table 1** where the lead ends and leads heads are joined by plain leads. Subsequent rows show the same lead ends and lead heads connected by bobs and singles.

Looking at **Table 1** it can be seen that by plaining the lead end 32546 the lead head 35264 is produced, but this same lead head can be produced by bobbing the lead end 53246. Thus if the lead end 32546 is plained, the lead end 53246 cannot be bobbed because the row 35246 will occur twice and the touch will run false. By looking at the in-course members of the Q-set it is found that these members must be either all bobbed or all plained if the truth of the touch is to be maintained. A similar rule holds for the out of course members. Note also that if a bob or a plain lead is used the nature of the rows is not altered, so that by using bobs and plain leads only a maximum of 360 changes can be obtained, which is half the extent of 720 changes. The call that alters the nature of the rows is the single so that if we can compose 360's using bobs only, these can be joined in pairs, using two singles, to produce true extents.

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**Table 1**

**The Q-set 4, 6. The lead ends and lead heads are shown with the nature of the rows, in-course (+) or out of course (—). The Treble bell (1) is conventionally omitted as it is always at the beginning of the row.**

| | | | | | | |
|---|---|---|---|---|---|---|
| 32546+ | 23546— | 25346+ | 52346— | 53246+ | 35246— | Plain |
| 35264+ | 25364— | 23564+ | 53264— | 52364+ | 32564— | |
| 32546+ | 23546— | 25346+ | 52346— | 53246+ | 35246— | Bob |
| 23564+ | 32564— | 52364+ | 25364— | 35264+ | 53264— | |
| 32546+ | 23546— | 25346+ | 52346— | 53246+ | 35246— | Single |
| 32564— | 23564+ | 25364— | 52364+ | 53264— | 35264+ | |

A similar analysis can be performed on the singled Q-set. In this case it is found that pairs of leads must be treated alike to avoid falseness one such pair being 23546 and 25346. Thus with singles, touches of 240 can be composed which can then be linked with three bobs to produce extents, though this has to be done more carefully than before since there is a mixture of odd and even rows in each pair of leads.

There is yet another way in which the members of the Q-set can be grouped so as to avoid falseness. **Table 2** shows the heterogeneous Q-set 4, 6 in which those members of the set in which the 3 makes 2nds are plained, those in which it makes 3rds are singled and those in which it makes 4ths are bobbed. If any Q-sets are used in this way a one-part extent results.

**Table 2**

**The heterogeneous Q-set 4, 6**

| *Plain* | *Bob* | *Single* |
|---|---|---|
| 32546 | 25346 | 23546 |
| 35246 | 52364 | 23564 |
| 35246 | 52346 | 53246 |
| 32564 | 25364 | 53264 |

### Composition of extents on the computer

Three programs have been written. Each of these uses the Q-sets in one of the ways set out in the preceding section. These should produce a good selection of extents, though there still remain those which use Q-sets in all three ways for future investigation. In contrast to the program for composing short touches, where a new lead is produced and then proved, these programs utilise the Q-set rules to say what type of lead should be added. As an example of how the Q-set rules are used a description is given of how the program using bobbed Q-sets only works.

A true touch is given as data, and the final lead is tested to see how it was used. If it was a bob, the computer goes to the preceding lead and examines that. If a plain lead was used, the computer finds out whether the lead is the only member in the touch of the Q-set to which it belongs. In the event of another member of the Q-set appearing in the touch, the lead cannot be bobbed since all members of the Q-set must be treated alike. Thus in this case the preceding lead is again examined. If, however, the last lead is the only member of the Q-set present then a bob can be substituted for a plain lead. The new lead end that is generated is now a member of another Q-set so the computer looks to see whether any members of this Q-set have been used before. Having sorted out any other leads belonging to the same Q-set the computer decides whether the new lead is false against any of the others and whether the others were bobbed or plained. The new lead is then bobbed or plained accordingly and the new rows generated are tested. If the lead end belongs to a Q-set, none of whose members have occurred before, then a plain lead is added. Finally if any lead end is false the program examines the preceding lead as before. When rounds occur the number of leads is checked and if the touch is 360 changes the result is printed out. The program then repeats the process until the required number of touches have been produced. The resulting blocks of 360 changes can then easily be joined by pairs of singles to give a variety of true extents.

### Conclusion

The work described here constitutes the first steps towards providing a systematic production of compositions for change ringers. The programs developed are for use with methods of the Plain Bob group and, with only minor programming changes, other groups of Plain Minor methods. Shortly, it is hoped to develop programs for other more complicated methods, though some of the problems are formidable.

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### References

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