SUSSEX BELL-FRAMES

By George P. Elphick

The bell-frame, or bell-cage as it is sometimes called, strangely enough seems to have escaped the attention of the archaeologist. It is difficult to say why; certainly not for its lack of interest. Its very development shows how the carpenters of long ago faced and solved the many problems which it presented at each turn of its journey to its present form. Surely it is not to be said that men were unwilling to enter into the gloom and dirt of a belfry to seek knowledge? For it is this entering into strange places that gives 'steeple-chasing', or 'bell-hunting', the thrill of all true adventure. The difficulties that have to be overcome—the begging, borrowing, but not quite stealing of ladders to gain access to a tower or diminutive bell-cote; the making of notes and sketches with rough-hewn timber for a pad, hands and paper soiled with the dust of centuries and, of course, with oil and grease with which ill-fitting bearings have been anointed, and which have penetrated everywhere except where the steeple-keeper intended—these only add zest to the game. But there is another side which the old saying truthfully records, 'Out of sight, out of mind'. It is only too true, for sometimes it requires an effort to realize that one is in the 'House of God' when in the towers and bell-cotes containing the smaller rings of bells. The crunch of the bones of birds, the stench of rotting guano and pellets deposited by owls, not to mention the sticks and rubbish deposited by the birds! With regret it must be recorded that some Sussex belfries are in a disgraceful condition. Is it asking too much for every incumbent to visit his belfry and make it worthy of his church? The best preservative for timber is cleanliness and fresh air, which is free for the taking; iron and steel frames require a coat of paint every five years, which, by the way, does cost money.

Bell-frames are structures that convey the dynamical forces set up by the swinging bells to the walls of the tower or church. They may be either of wood, cast iron, rolled steel, stone or brick piers, or reinforced concrete. It is with

the development of the timber bell-frame, which consists of two trusses between which the bell swings, that this paper is chiefly concerned.

Before the bell-frames we ought briefly to consider the towers that contain them. It is generally agreed that the tower is a development of the porch, the room above being used for a variety of purposes and fulfilling the function of the narthex of the early Christian Church.[1] Their use as belfries came at a rather later date in the history of the Church. Belfries do not appear to have become part of the structure of churches until the seventh or eighth century.[2] Their development was gradual, mainly along the line of heavier bells requiring stronger towers to contain them. Our cathedral at Chichester tells a story of how men built the spire for inspiration and not for strength; consequently our cathedral possesses the only detached bell-tower among all the English cathedrals, though there was one at Salisbury until the architect Wyatt destroyed it at the end of the eighteenth century. There are several detached bell-towers in England, but they are far more common in southern Europe. In the writer's alphabetical list of Sussex churches[3] the dates of the towers are given in order to indicate when bells may have been installed, and it is surprising to find that a high percentage of the frames are inaccessible.

A slight knowledge of bell-hanging and methods of ringing is a great advantage in tracing the development of the frame. Bells are hung from and fastened to a horizontal baulk of timber known as the 'headstock', often referred to as the stock. This has fixed at the lower part of each end an iron or steel spindle called a 'gudgeon'. The gudgeons rest in bearings known as 'brasses', which are fastened to the top member of the bell-frame. Bells are swung by means of wheels or levers fastened to the headstock. A bell when normally at rest has its mouth in a downward position; to make it speak, or sound, it is swung through an arc. There are many varying factors that determine how far it has to swing before the clapper strikes the bell; this is usually after it swings through an arc of about 10°. The clapper continues to strike only on one side until the bell swings through an arc of about 100°

[1] *Sussex County Magazine*, v. 346.
[2] Rev. G. S. Tyack, *A Book about Bells*, p. 131.
[3] A copy of this list has been deposited by the writer in the Society's Library at Barbican House.

or more, when it commences to strike on either side alternately. It is then said to be rung to half-pulls; that is, it speaks twice for every pull of the rope attached to the wheel. If the bell is swung still higher it becomes possible to cause the bell to speak once every time the rope is pulled. This is known as whole-pull ringing. The bell is swung through an arc of 360°; from a position of rest with its mouth up it is pulled off the balance, swings down one side, underneath and up the other side on to the balance again. A bell stresses a frame to its greatest extent when it is rung to whole pulls, the stress amounting approximately to twice the bell's weight in a horizontal direction and four times the bell's weight in a vertical direction.

The dating of bell-frames presents a much more complex problem than that of dating medieval bells, for many points have to be borne in mind. Dated frames do not seem to appear before the early seventeenth century. The earliest dated frame known to me is at West Hanney, Berks, dated 1605.[1] There are sixteen dated frames in Sussex, including one with a mass of dates indicating some repairs, and not counting dates cut by the mischief of idle boys. The earliest is at Westfield in 1617, and there are three others of seventeenth-century date. The eighteenth, nineteenth, and twentieth centuries provide four examples apiece. The only other safe guide is when the frame timbers are built into the tower walls; the period in which the tower was built will then give the date of the frame. A point to be borne in mind about towers is that the addition of later buttresses may indicate when the number of bells was increased. A frame may have been altered to fit a tower when it was rebuilt, for some frames are older than the towers that contain them. Westfield is an example. Moulded frames can be approximately dated from the mouldings in vogue at different periods, on beams and other examples of the carpenter's work. It must always be remembered that the frames were constructed by the local carpenters, and they would use principles of construction with which they were familiar. In some cases the frame will be of similar type to a preceding one, only the sections of the members and the proportions of size will be different, the carpenter using his own judgement. In most cases the carpenter would have noticed where

[1] F. Sharpe, *The Church Bells of Berkshire*, pt. v. 80.

the old frame failed and would try to rectify the weakness in the new one, usually by using more braces and ties. The joints used do not give much help except when the heads are dovetailed into the end-frame heads. This usually indicates nineteenth-century workmanship. Joint marks are cut on the members to make certain that when the frame is taken apart on the ground, where it was fitted, to be fixed together in the tower, the right members will be fastened together. These marks are not of much assistance, except that as a general rule gouge marks are of earlier date than chisel marks, and that tally marks are usually earlier than Roman numerals. Brace-ties or the housings for them on the braces indicate that at one time the trusses were of either I, J, K, or L types, Fig. I. Curved braces are a sure sign of an earlier date than straight ones, except in very early frames. From this it will be noticed that most end-frames are of later date than the trusses themselves. When there is no evidence that the width of the pits has been altered, and there are marks in the clearance grooves of the bell rubbing the frame, a frame can sometimes be placed by the long-waistedness of the lip marks, which usually means thirteenth-century. Frames are often composed of various types of trusses; this may indicate the addition of new bells to the old ring. It should also be borne in mind that most of the types of trusses overlap each other by considerable periods. The roping of the bells, that is, the position of the rope in the pit within which the bell swings, may provide a clue; but first check whether the bells have been rehung, by looking for old rope holes in the floor boards and beams of the belfry floor. The next floor usually is not of much help, for often the ropes are pulled out of upright so that they fall in a good circle in the ringing chamber. The direction of the grooves that are worn by the rope, sometimes found on the arch over a door opening in ground-floor ringing chambers—caused by the sexton trying to toll the knell and keep his eye on the parson as well—may show if the roping has been altered. Whole-pull ringing was practised by the sixteenth century,[1] consequently by this period frames became more massive and were braced to a greater extent than formerly.

The use of bells in the Christian Church was confined to small handbells in its early days. In the course of time men

[1] A. H. Cocks, *The Church Bells of Buckinghamshire*, p. 83.

began to cast larger bells, and this involved the question of hanging them. The methods adopted can be divided into two branches: one where they are 'hung dead', or fixed, and are chimed by a hammer, and the other where they are swung and struck by a clapper. It is with the frames that carry the

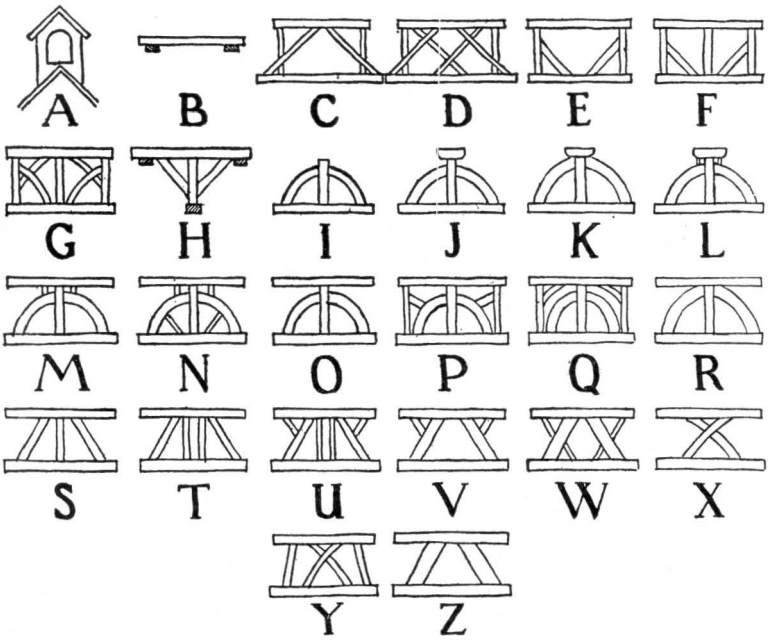

FIG. I. TYPES OF TRUSSES

Variants

B. As above, supported by plates, padstones, or studs of bell-cote. B 1. Supported by independent posts at ends. B 2. Supported by post in centre. B 3. Beams braced to walls. B 4. Beams braced to wall-posts. B 5. Beams braced to studs. B 6. Beams braced to independent posts. B 7. Brace-ties. B 8. Brace-ties strutted and braced. B 9. Head-struts vertical. B 10. Head-struts incline toward top of centre-post. B 11. Head-struts incline away from top of centre-post. B 12. End-frame head above truss head. B 13. End-frame head below truss head. B 14. End-frame head a return of the truss head. B 15. Sills above plates. B 16. Sills below plates. B 17. Sills returned in place of plates. B 18. End-posts to trusses. B 19. Corner posts to frame.

latter group that this paper is concerned. The simplest and no doubt one of the earliest methods was to hang the bell between stone or brick piers, which for convenience may be called an A-type frame (see Fig. I). Of the 406 churches covered in this survey, about 12 per cent. are of A type, which is often known as a 'bell-gable'. Usually the stone piers are a continuation of the gable wall at the west end of the church, the

piers being surmounted by an arch, and above this a stone-pitched roof is built (see Fig. II). It is usual for bells so hung to be tolled by a lever to prevent them being swung through too wide an arc, and so over-stressing the wall. There is one great disadvantage in this method: the bearings never get

Fig. II. Selham

any attention, yet being exposed to all weathers they need more attention than a bell hung inside a tower. The most elaborate bell-gable in the county is at Staplefield Common, containing five bells. What probably was the most massive was at West Chiltington, where previously to the building of the present bell-cote the chancel arch appears to have been carried above the roof to form an A-type frame. This probably was cut down to its present level in 1602, when the bell-cote appears to have been constructed. Didling, Rumboldswyke, Selham, and Woolavington may be some of the

oldest in the county. There are two or three examples of timber A frames in Sussex. At East Wittering is one of early-nineteenth-century date, consisting of two four-by-four posts, with clearance grooves cut $2\frac{1}{2}$ in. deep. Another is at Lindfield, where the tenor to the old ring of five was

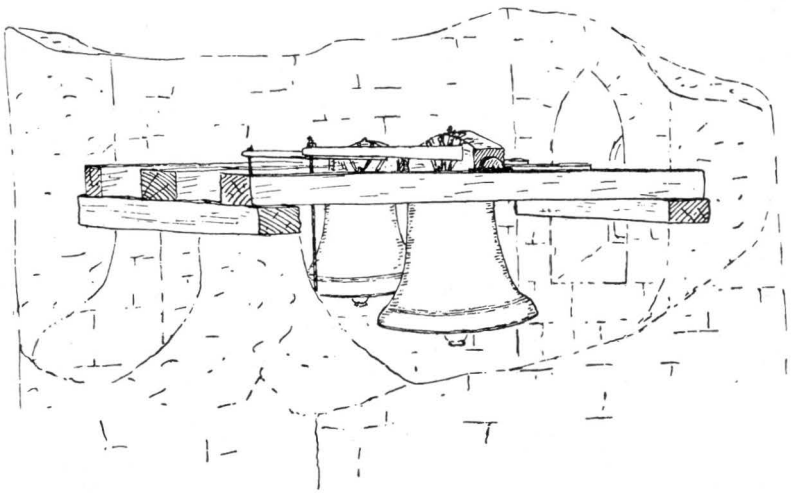

FIG. III. LYNCHMERE

(probably in 1887) hung between two ten-by-ten posts, as the clock hour bell.

As the founders became more proficient they attempted heavier castings, and towers were required in which to hang them. The most natural method would be to hang them from beams, the beams taking the place of the stone piers of an A frame. A B-type frame, Fig. I, is primarily two beams between which the bell swings. The ends of the beams may rest on timber plates, resting on the walls, on padstones, or they may be supported by the angle posts or studding of a timber-framed bell-cote. The tie-beams at the base of spires are often used for B-type frames, of which there are several variations. Probably the earliest example we have of a plain B-type frame is at Lynchmere, which I consider coeval with the late-thirteenth-century bell it contains. This is represented in Fig. III.[1] The present tower at Lynchmere appears

[1] It ought to be borne in mind that all illustrations of frames in this paper have been drawn from rough sketches made, on the average, five years ago. The drawings of bells, wheels, and fittings are not claimed as exact representations of them in the particular frame under review.

to have been built in 1665, and at first sight this would seem to be the date of the frame, for it is built into the tower walls. On closer examination the portion of the plates that is buried in the walls of the tower shows signs of exposure and age to the same degree as the parts that cross the present

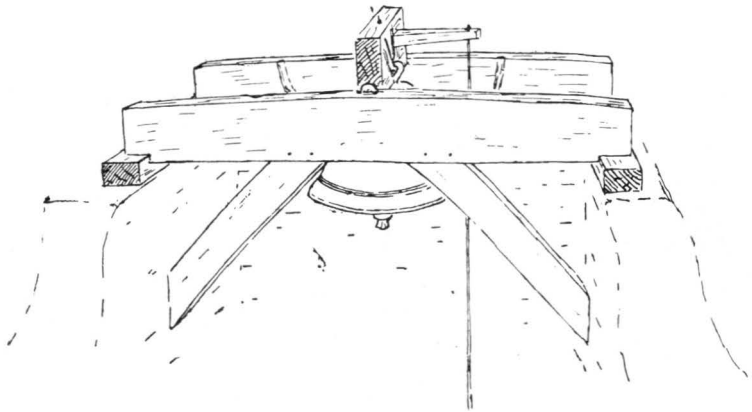

FIG. IV. NEWHAVEN, PART OF OLD FRAME RECONSTRUCTED

louvre windows, proving that they were in that condition when the present tower was built. The sections of the beams on which the bells hang show that by experience the early carpenters had found that beams on edge are stronger than beams of the same section laid on the flat, and that the central beams have to carry twice the load that the end ones do, and also that wall-plates should be laid on the flat to distribute the load over a greater area. The size of a tower was governed by the sizes of the timbers obtainable for the use of beams and B-type frames. It was soon discovered that the long beams necessary for B-frames were not rigid enough; so posts and braces were introduced to stiffen them, which subdivide the B type into two main branches and several slightly different forms. B 1 types (see Fig. I) are at Parham, Horsham St. Mark, and Middleton. Examples of B 2 trusses with a central post are to be found at Bramber, Framfield, Friston, and North Stoke. A combination of these types is at St. Mark's, Brighton, also the eighteenth-century frame at East Chiltington with the addition of braces. One of the earliest methods to stiffen B trusses was to brace the beams to the walls, the tops of the braces often

being one-third the beams' span apart. Of these B 3 trusses there are examples at East Chiltington (mid-twelfth century), Heyshott, and Newhaven (Fig. IV); examples at Ewhurst and West Grinstead have had their braces removed. The Newhaven example shows two improvements over the

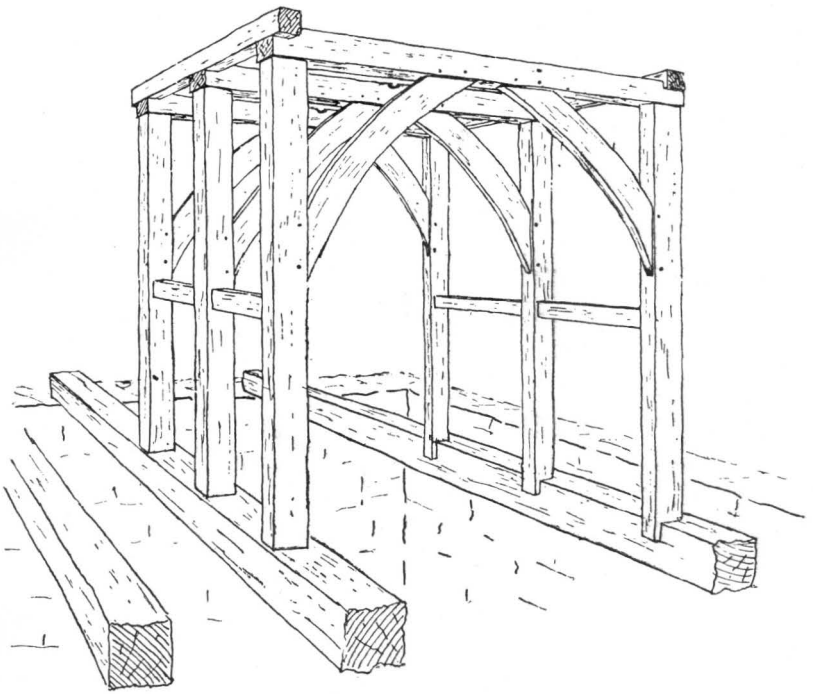

FIG. V. BECKLEY, OLD FRAME IN SPIRE

parallel beams usually used for B frames. The beams are higher in the centre than at the ends, the lower edge being straight; this has the effect of lightening the beams without detracting from their strength. The carpenters also had found out that the shorter the headstock the more efficient it became when driven-in gudgeons were employed; so vertical clearance grooves were cut in the beams to allow the beams to be of less distance apart than the diameter of the bell's mouth, the lip of the bell being able to swing through the clearance grooves (Fig. IV). A variation at Slaugham had a central post down to the floor. B 4 trusses and frames have the improvement of vertical wall-pieces or posts to

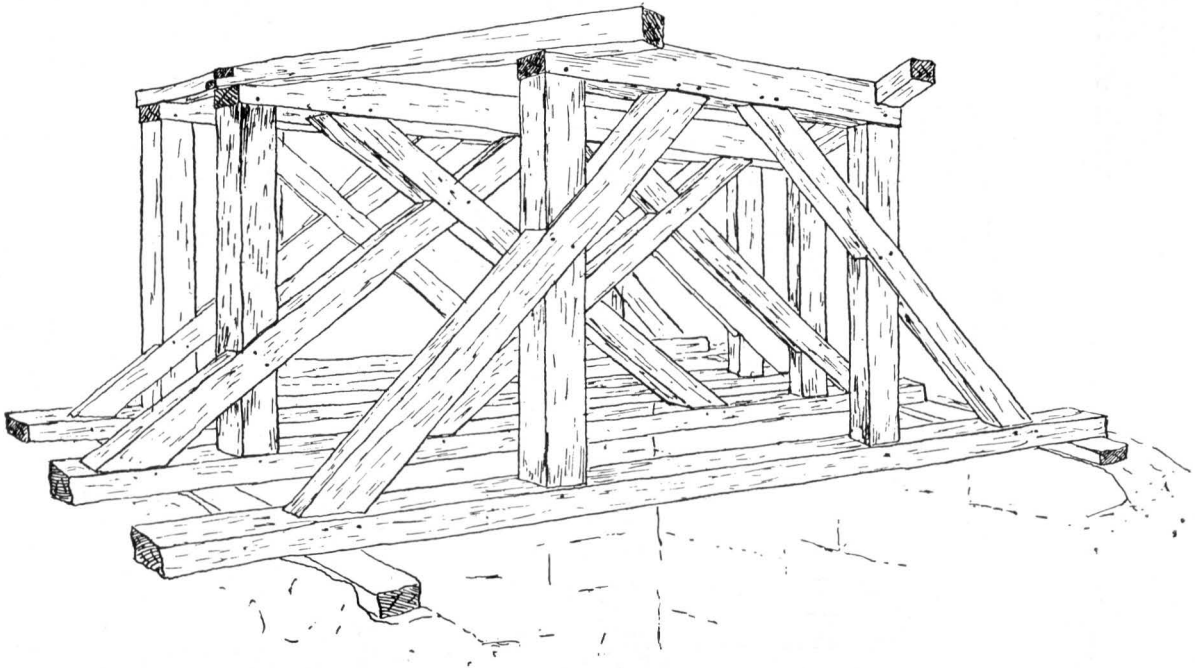

FIG. VI. WISBOROUGH GREEN, OLD FRAME IN SPIRE

distribute the thrust of the braces over a greater area. Fletching and Lurgashall B 4 frames are formed by the tie-beams of their spires. The old B 1.6.12 frame (explanations of figures, Fig. I) in the spire at Beckley (Fig. V) is a fine example of its type. It is 10 ft. high and is built off the tie-beams of the spire at a time when men endeavoured to hang their bells as high as possible. Examples at the normal height of frame are to be found at Burton and Apuldram. The B-type frame and its variations cover approximately 25 per cent. of Sussex bell-frames.

In the spire at Wisborough Green is a development of the B frame that is, as far as I know, unique. It is a frame for three, consisting of two trusses of C type and two central trusses of D type; they are lattice-braced, the braces being halved where they cross, the purlins of the spire forming the end-frame heads (Fig. VI). At Iping is an E-type frame, another variation of the B frame, the end posts being braced to the sill instead of the head, which is the more usual method. Another variation is the addition of a centre-post, making an F-type frame. Ashurst, Fletching—the truss for the treble pits—and Sutton are examples. The frame at Poling is the only example of a G-type frame in the county (see Fig. I). It is rather doubtful, in spite of their appearance, if these frames have developed so directly from the B frame. It is more likely that they are variations of the trusses known as the braced centre-post group, such as types I to R, Fig. I. If they are direct developments of the B frame, it is interesting to notice how they have shrunk from the span of the tower to independent structures resting on the beams carrying the belfry floor. The other main branch of the B frame developed into the bell-frame as the term is generally understood—a trussed timber frame. These types of frames were constructed from the experience men had gained from roofs and floors, to which they are closely allied. For the roof truss, like the bell-frame, has to contend with both vertical and horizontal thrusts. Up to the end of the twelfth century the carpenters were rather masonry-minded; it was in the late twelfth and early thirteenth centuries that trusses were probably conceived.[1]

The H-type frame (Fig. I) is the first member of this branch. It consists of beams or 'heads', as they will be

[1] *Illustrated Carpenter and Builder*, xx. 750.

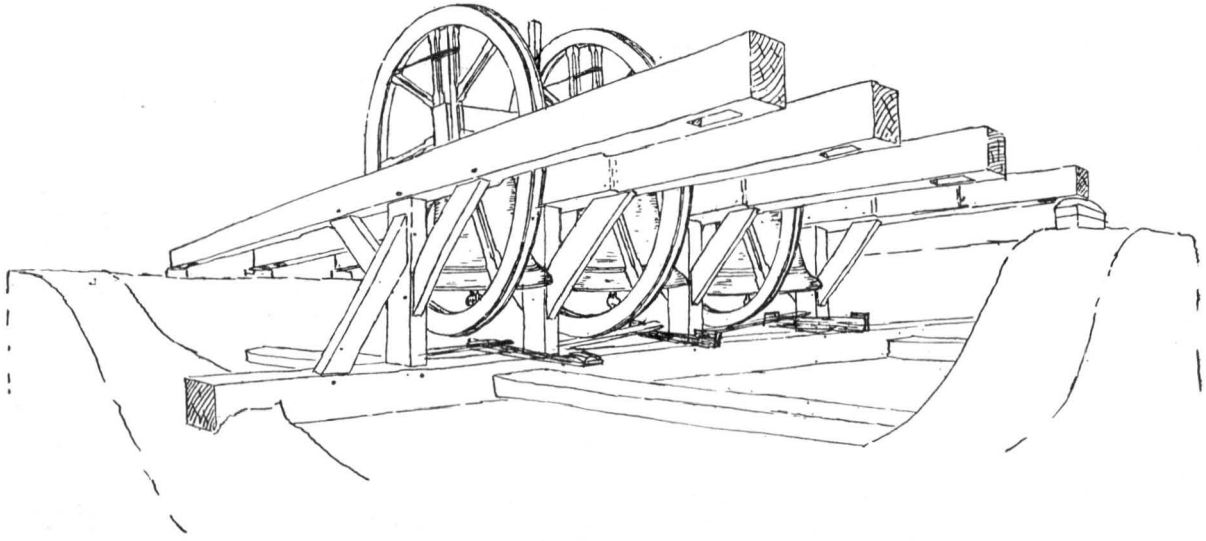

Fig. VII. Cold Waltham

called, on which the bells hang; below these heads is a beam lying in the opposite direction low enough to allow the bells to swing clear; the heads and lower beam are connected by short posts which are braced to the heads. It is in fact the construction of a floor, the posts and braces being borrowed from the roof truss. The Cold Waltham frame is an excellent example of this group (Fig. VII). An improvement on the previous types is shown in the shaping of the heads. The carpenters had found out that once a vertical cut or groove was made in the side of a beam, the timber between it and the nearest wall was not taking any strain; in fact, it was an unnecessary weight in the structure; so in their endeavour to obtain the maximum strength for weight of structure they cut it off and produced what will be called a 'reduced head'. The Cold Waltham frame has lip marks in the treble pit of a long-waisted bell; coupled with this, the fact that the lower beam is built into the tower walls is double proof of thirteenth-century date.

In the next type the carpenters have broken right away from the tradition of hanging bells on beams. Whether the I type (Fig. I) is an invert of the H type or whether it came direct from the roof truss is open to doubt, though the latter seems the more probable. There are I frames at East Blatchington, Guestling, Southease, Tarring Neville, and Telscombe. Now the strange thing about this group is that they are all in the Ouse valley, except Guestling, which is the only modern example, dating from 1890, probably a reconstruction of an earlier frame. Southease is no doubt the earliest in type, for the centre post of the spire is used for one side of an A frame with I trusses either side; the plates being halved show that strength was not the main consideration. The way the braces are fixed gives one the impression that they are second thoughts; if this is so, the I type is a descendant of the A frame and not from the H type after all. East Blatchington and Telscombe come next, both having brace-ties, i.e. horizontal members to keep the braces equal distances apart, probably a later addition. Both frames have straight braces, no doubt indicating the influence of straight principal rafters in the roof truss. Both have the posts, or centre-posts as they will be called, reduced after the manner of the central Cold Waltham heads. Tarring Neville is the last example of this group, and the great

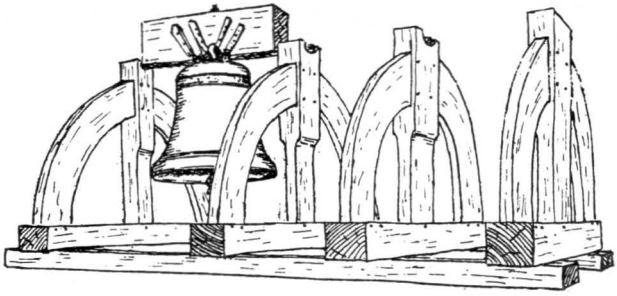

FIG. VIII. TARRING NEVILLE

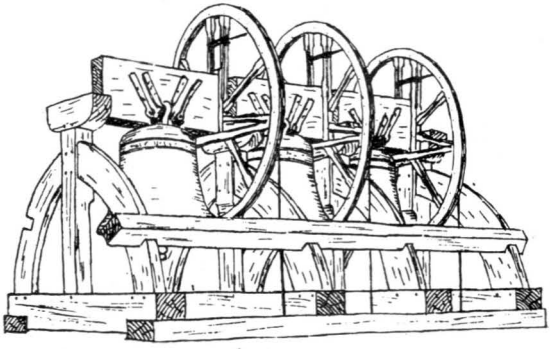

FIG. IX. CHALVINGTON

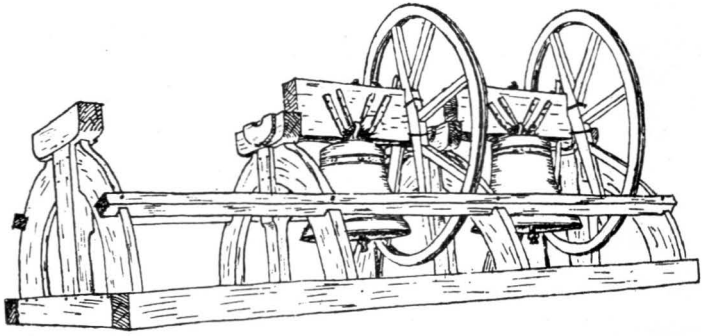

FIG. X. BIRDHAM

difference is the curved braces (Fig. VIII). The carpenters apparently thought that a curved brace would direct a horizontal force into a vertical direction. This is an example of one of man's inspirations which unfortunately does not work out in practice. This conception of directing forces by curved braces runs through the development of the bell-frame for over four and a half centuries, and it was not until after the late seventeenth century that straight braces became the general rule. These last three examples of I frames also show another improvement—the use of plates at the ends of and under the sills, the sills being the horizontal members into which the centre-post and braces are fastened. In this group the brasses are let into the end grain of the centre-post. This proved to be a source of weakness, for the carpenters found it difficult to fasten the brasses securely, so short heads were introduced to provide a fixing in the long grain. Newtimber and Chalvington (Fig. IX) are two Sussex examples of J-type frames. In solving the problem of fixing the brasses they created another—that of preventing the heads rocking on the centre-posts. This was the great problem that baffled the wits of the bell-hangers for centuries, and was only finally solved by discarding the centre-post altogether. First in the K type (Fig. I), of which Birdham (Fig. X) is an example, they moved the braces up to the head and fastened the tenons on the ends of the braces into both head and centre-post. A good idea, but in practice it did not work, for the cross-grain of the head was more subject to shrinkage than the long-grain of the centre-post. In the L type the braces were lowered and short posts known as 'head-struts' were introduced between the heads and the braces; Alciston, Lancing St. James, and West Wittering (Fig. XI) are examples of this type. The earlier examples have the head-struts vertical, the later examples have them inclined, to assist in directing, as was considered, the horizontal forces to the curved braces; see 9, 10, and 11 of Fig. I. The next problem to be solved was to prevent the frame from whipping. This was attempted by bracing the brace-ties to inclined struts between the braces and the sills. These struts later became the 'jack-braces' of the N, U, V, and W type frames (Fig. I). The three Sussex examples are at Lancing St. James, Plumpton St. Michael, and West Wittering. The head-struts at Plumpton are stop-chamfered,

an early attempt to ornament a frame. West Wittering is the tallest and most elaborate example (see Fig. XI). An interesting point about this frame is that the sill is cambered 2 in., consequently throwing the centre-post into greater tension, and proving that by this time the carpenters had

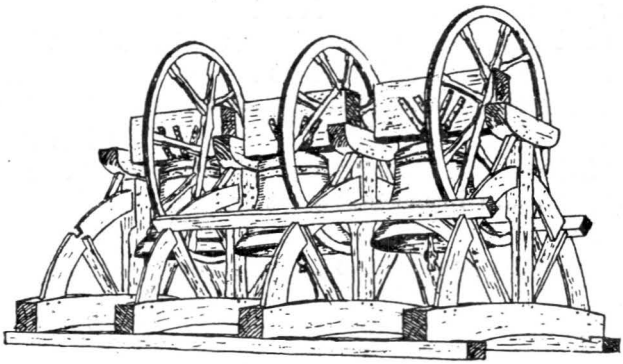

FIG. XI. WEST WITTERING

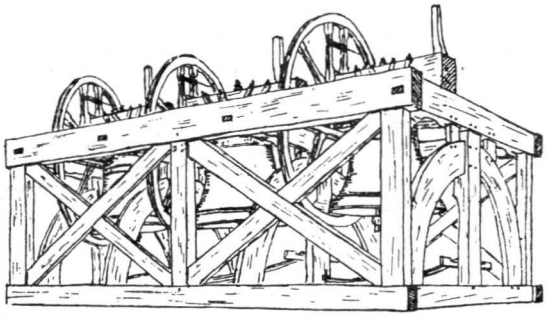

FIG. XII. WESTFIELD

thoroughly mastered the principles of the king-post roof truss. A noticeable feature is the height of these frames as compared with earlier examples. From now on, as a general rule, they get lower and lower, until by the end of the nineteenth century they were so low that it was almost impossible to give the clapper any attention that it may have required.

The method of bracing the brace-ties to prevent the frame from whipping did not prove too satisfactory; so long heads

were introduced to have greater leverage in preventing the heads from tipping, their ends being connected by return heads, known as end-frame heads (see 12, 13, and 14, Fig. I). The M-type frame is simply an L frame with a long head substituted for the short one and without brace-ties. These

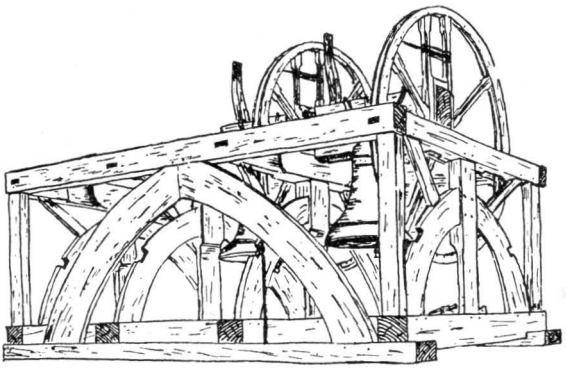

FIG. XIII. CLAYTON

frames account for about 5 per cent. of the frames in the county. There is an example at Westfield dated 1617 (Fig. XII). Some of these frames retain their brace-ties, showing that previously they had short heads; for example, Lewes All Saints, whilst Lewes St. Thomas-a-Becket plainly shows the transition from L to M types, it having both brace-ties and a head half-way in length between long and short heads; this frame appears to have been constructed from an earlier frame of the same type. The Clayton frame, like Cold Waltham, has an interesting point in that the end truss heads have clearance grooves and are not reduced like the central trusses (see Fig. XIII). In an effort to obtain still greater stability the braces were next braced to the sills, forming an N-type frame. The present frame at Pagham was a member of this class until it was reconstructed into a Q-type frame. The mortices for the braces of the earlier N frame are shown in Fig. XIV. From now on the carpenters alternated between types having many braces and struts, and types having as few as possible, still endeavouring to keep the heads from moving. Many braces meant plenty of joints that could not only work loose but also complicate the structure. The O type (Fig. I) is but the

earlier J type with long heads and without brace-ties; simplicity was the keynote—a few simple joints well constructed. These frames form 10 per cent. of the total in the county. East Dean, near Chichester, and Newick (Fig. XV) are dated examples, 1655 and 1682 respectively. These

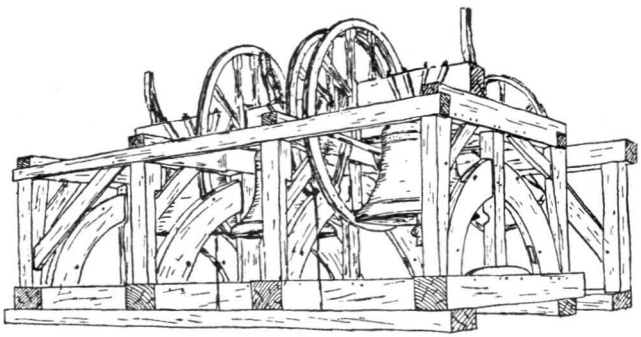

FIG. XIV. PAGHAM

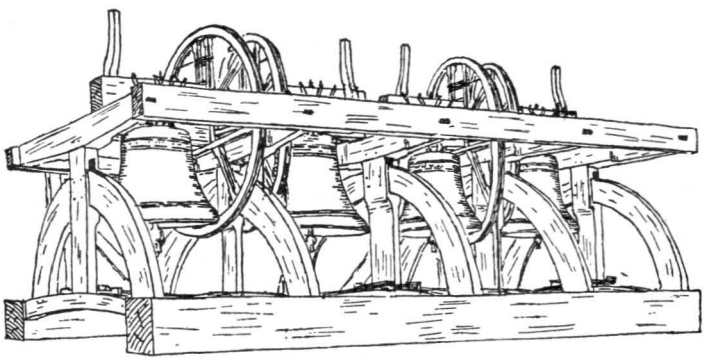

FIG. XV. NEWICK

frames appear to be generally of sixteenth- and seventeenth-century date, and are often moulded. The Newick example shows the sills, which are cambered, framed into the plates, the beginning of the end-frame sill. The moulded frames of this type are at Clapham, Findon, Kingston, Newick, and South Malling (see Fig. XVI for details). The frame at South Malling (Fig. XVII) is most elaborately moulded. It will be noticed that the most usual form of moulding is an ovolo. The earliest dated example of an O frame known to

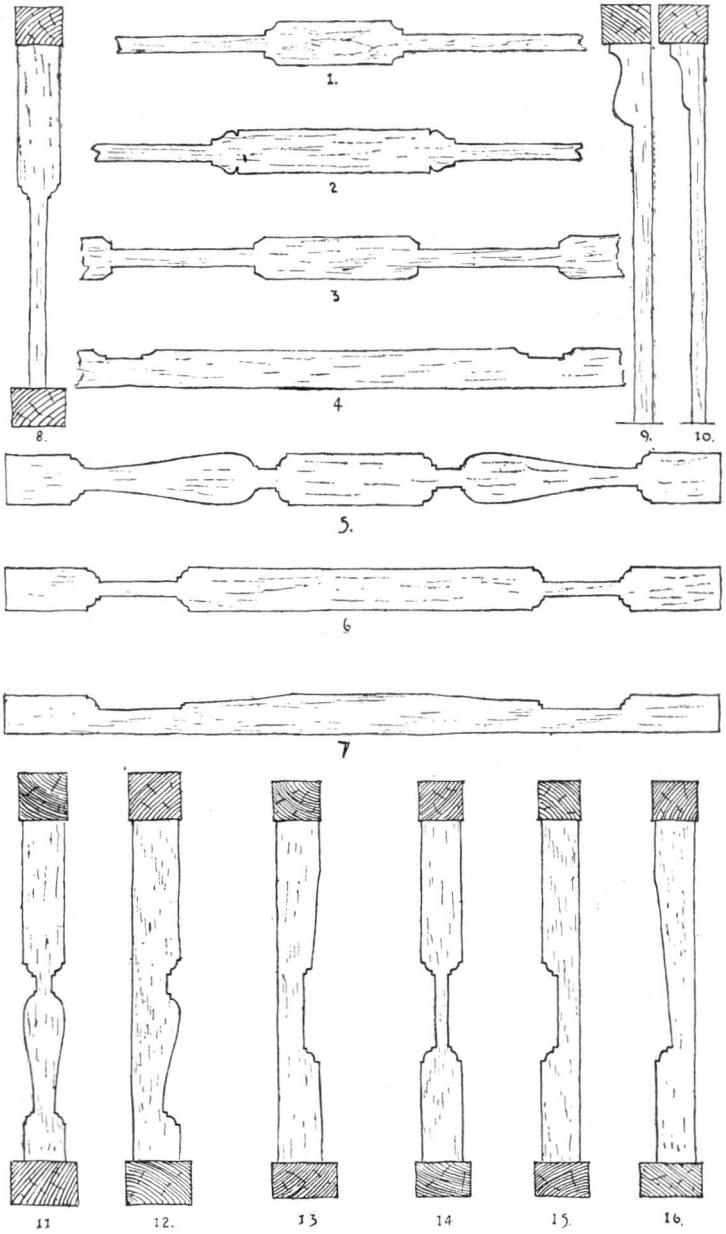

FIG. XVI. PLANS OF HEADS: 1. Newick; 2. Portslade; 3. West Grinstead; 4. Ripe; 5. South Malling; 6. Findon; 7 Kingston.

ELEVATIONS OF CENTRE-POSTS: 8. Findon; 9 and 10. Wilmington; 11 and 12. South Malling; 13–16. Kingston.

me is at Dilhorn, Staffs., dated 1652.[1] Secondary braces were then added from the main braces to the end posts—which by now had become part of the end-frame and were often braced in a variety of ways, making a P-type frame. The frame at Rustington is of this type and is dated 1671

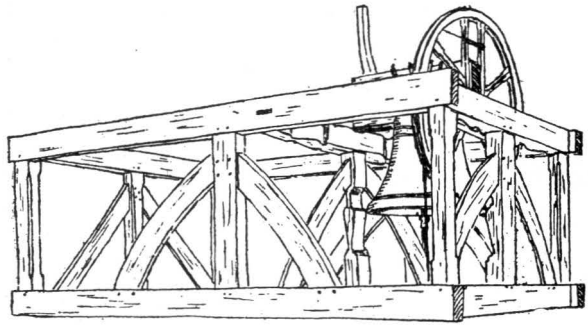

FIG. XVII. SOUTH MALLING

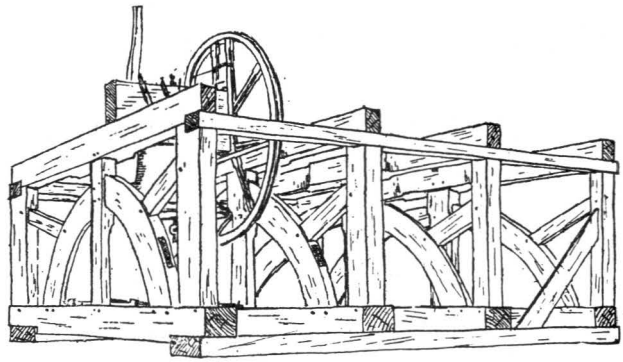

FIG. XVIII. RUSTINGTON

(see Fig. XVIII). Crowhurst and Icklesham are later in date, and of P type in part.

The system of bracing employed in the P frames did not solve the problem, so a different system was used, as, for example, the present frame at Pagham (Fig. XIV) known as Q-type frame. There is a group of these frames in Berkshire, dated examples being at West Hanney, dated 1605,[2] Lockinge, 1620, and East Hendred, 1631.[3] There was formerly a frame

[1] C. Lynam, *The Church Bells of the County of Stafford*, Plate xxxvi.
[2] F. Sharpe, *The Church Bells of Berkshire*, pt. v. 80. [3] Ibid., p. 79.

of this type dated 1603 at Aston Tirrold, Berks.[1] The carpenters next tried raising the braces to the head, as in the R type, of which Botolphs is a good example (Fig. XIX). The end-frame braces at Botolphs and the truss braces at Sullington are of rather unusual shape; it seems as if the

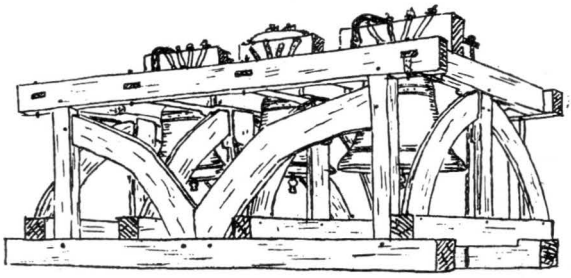

FIG. XIX. BOTOLPHS

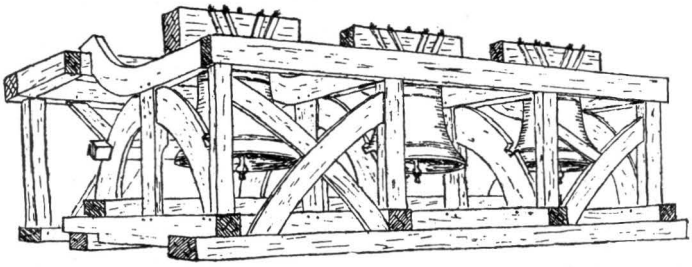

FIG. XX. FUNTINGTON

carpenters dimly realized that the curved brace did not direct the forces as expected, and that they were trying another form, which eventually became the straight brace. The frame at Funtington of this type (Fig. XX) is unique in my experience, the heads of the frame for three being raised at one end to join the head of a truss for carrying a bourdon bell. We often find mentioned in early wills bequests to the 'great bell', which usually means the tenor bell; seldom is it a bourdon. A dated example of this type is at Blewbury, Berks., 1640.[2] The carpenters in the S type (Fig. I) made a bold move; they braced the heads direct to the sills. It was a great step forward in the development of the bell-frame, for it led to the modern frame which is the simplest practical

[1] Ibid., pt. I. 86. [2] Ibid., p. 97.

form of a triangulated truss. Mid Lavant is an example of an S-type frame. At Mountfield one of the trusses has two centre-posts forming a T-type truss. This is usually employed for chiming hammers. The U-type frame at Ninfield has the addition of upper jack braces. In the next type, V,

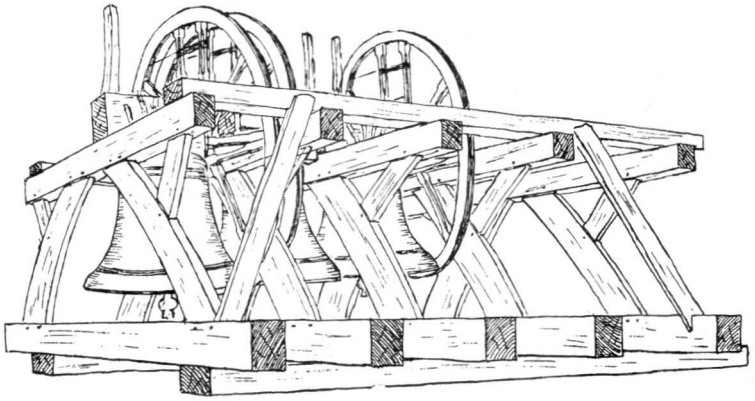

FIG. XXI. BURY

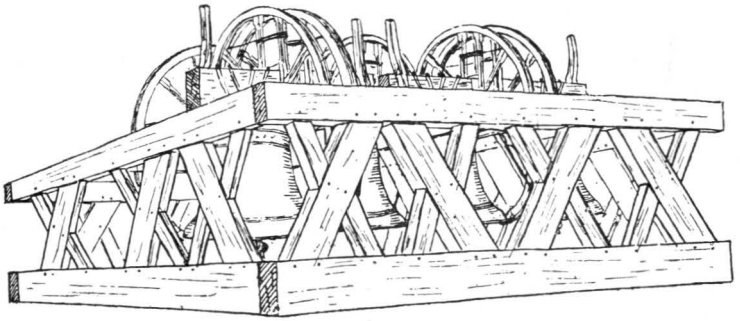

FIG. XXII. SHIPLEY

the carpenters took the final step and discarded the centre-post. There is a dated example at Beddingham, 1709. Figure XXI shows the V-type frame at Bury. The W-type frame, of which there is an example at Chichester Cathedral, dated 1731, was the type in general use during the eighteenth and early nineteenth centuries. It consisted of a V truss to which was added another set of jack braces from the main braces to the sills. Figure XXII shows the W frame at

Shipley, dated 1893. These frames form about 5 per cent. of the total in the county. There is a possibility that the X-type truss is a development of the D truss (Fig. I), or it may be merely half a W truss. There is much to be said for the view that the early examples such as Cuckfield (old

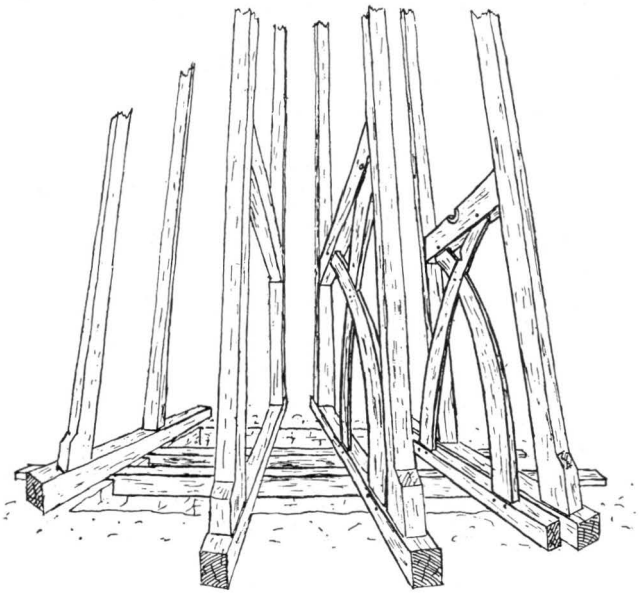

FIG. XXIII. CUCKFIELD

frame in the spire) and Rudgwick evolved from the D truss, and the later examples at Iden and Tillington from the W truss. Figure XXIII illustrates the old frame for one in the spire at Cuckfield. The Y-type trusses at Hastings, St. Clements, are a variation of the X truss. We have now arrived at the final stage in the development of the timber bell-frame: the Z-type truss. These form over 20 per cent. of the total of Sussex timber bell-frames. Figure XXIV illustrates the Z frame for one at Streat with an additional Z truss to carry a chime of two fixed bells. These frames are in fact W frames without the jack-braces, it being found as in the earlier types of N, P, and Q trusses that many joints were a source of weakness. The final step was to bolt the heads to the sills with long vertical bolts, known as 'tie-bolts'; these bolts usually pass through the braces. The

draw-bore pin, by which all the members of the framed trusses that we have considered were fastened together, was at last displaced. When the tie-bolts are kept tight, the present Z timber frame is one of the most rigid examples of the carpenter's craft.

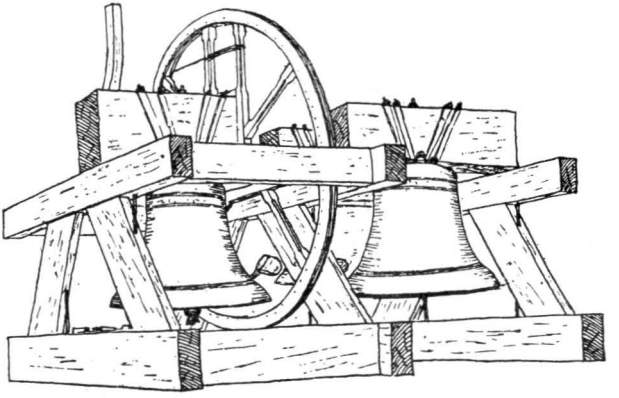

FIG. XXIV. STREAT

Towards the close of the nineteenth century a slight weakness of the Z truss became apparent when unseasoned English timber was employed for the very wide braces used in these frames. When the braces shrank, the angle of their shoulders was altered, and consequently they did not fit the heads and sills properly, although the tie-bolts were tight. This was the reason why iron and steel were introduced into bell-frames. It is considered by many as a retrograde step, for it is extremely doubtful if the modern iron and steel frame will last as long as its counterpart in wood. If a parallel is drawn from the filthy condition into which many timber frames are allowed to get, the iron and steel frame is seldom likely to get its coat of paint every five years. Its insidious enemy—rust—will then get a foothold, which will be the beginning of the end. Claims that iron frames are fireproof are often put forward, it often being forgotten that the distortion of the frame caused by the heat of a fire means that most of it will have to be replaced after such a calamity. Composite frames, that is to say, those composed of both wood and iron or steel, were first used to overcome the weakness caused by the shrinking of timber braces. At first both

heads and sills were of wood, with either cast-iron or rolled steel joists or channel iron braces bolted to the woodwork at either end. Examples of these are to be found at Lindfield, 1887, Hastings, Christ Church Blacklands, 1890, and Aldrington, 1891. From an engineering point of view an improve-

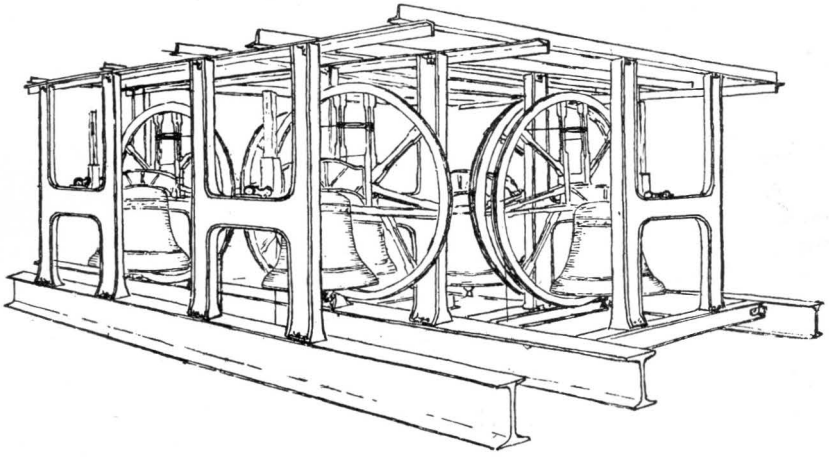

Fig. XXV. Thakeham

ment is shown in the frame at Christ Church, St. Leonards-on-Sea, 1894, with channel iron heads, and, better still, at Mayfield with heads, braces, and a top set of jack braces (like a V timber truss) in a single casting of iron, probably in 1898. In both of these cases timber sills are employed owing to the high cost and weight of cast-iron sills. Cast-iron is weak in tensile strength compared with steel, but this latter material was not used owing to its tendency to corrode. In composite frames the bell-hangers solved one problem, that of providing a good bearing area at the ends of the braces, and created another, that of fixing the ends of the braces, the many bolts used seldom receiving the attention they require. This was overcome at Mayfield by using iron castings for the trusses. Rolled steel joists were used later for sills and plates, these forming a grillage displacing the timber beams and floor used for carrying timber frames, and so the iron frame arrived in our Sussex towers. The iron and steel frames can be divided into two main branches: the 'H' frame and the side-frame. The 'H' frame (Fig. XXV)

is similar to a B-type timber frame, the bearings being fastened to a cast-iron beam supported by two cast-iron posts. The trusses are tied together at the top by angle irons, and the bases of the trusses rest on rolled steel joists. Danehill and Pulborough are both of this type, being the earliest

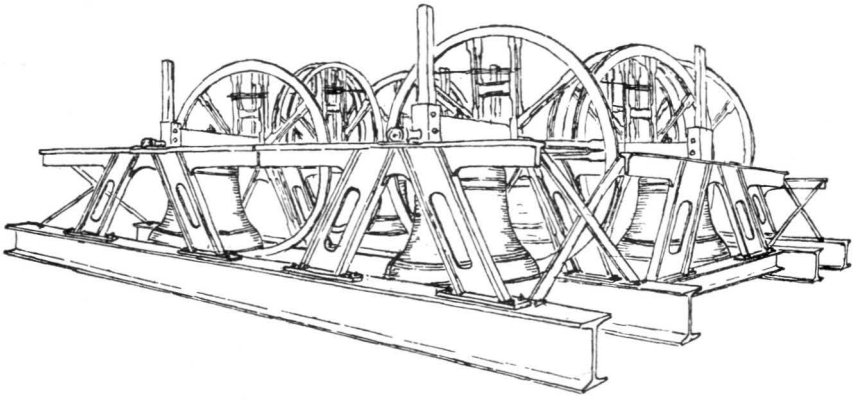

FIG. XXVI. BRIGHTLING

I have traced in Sussex. Both came from the Loughborough foundry; Pulborough in 1897. The side frame (Fig. XXVI) is either like V or Z timber frames. The castings usually have ribs to stiffen them, and often the webs (especially the later examples) are lightened by having some of the metal removed from their centres. Uckfield in 1905 appears to be the earliest example of a side-frame in this county, the trusses being similar to V timber trusses. The 'H' and side-frames are roughly in equal proportions, and account for about 10 per cent. of the total number of Sussex bell-frames. Two exceptions are at Lindfield and Westham. The lower frame at Lindfield is formed by cast-iron trusses of 'A' shape, the bells hanging from the bar. Milland also has this type of frame, the bells being hung in two tiers. The frame at Westham is composed entirely of rolled steel joists and flat steel braces. The trusses are similar in type to the timber T-type truss.

The modern bell-frame appears to be on the eve of a further stage in its development, if the reinforced-concrete frame installed at Liverpool Cathedral is a sign of things to come. If this comes to pass, the development of the bell-

frame will have completed a circle. Starting from stone piers forming A frames, it will have passed through wood, iron, and steel in their varied forms, and back again to man-made artificial stone piers. This concludes a survey of the development of the bell-frame, a subject which it has by no means exhausted; in fact, it has barely touched the fringe. Much remains also to be done in the allied subject of medieval bell-hanging.