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BRITISH BRICK SOCIETY

INFORMATION 53

JULY 1991

CONTENTS

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EDITORIAL:

BRICK BRIDGES THE GAP

Brick viaducts stalk the land wherever railways cross a river valley. Each week, I travel from Norwich to London over the River Yare: the walls of the Roman town at Caister St Edmund come into view shortly after the river crossing. Railways were both major users and major producers of brick; however, brick as the building material for bridges is much older than the 1820s and 1830s. I have been shown photographs of fourteenth-century brick bridges in Iran, contemporary with brick-built mosques. In Britain, brick as the material favoured by bridge builders is current among canal builders: the second of the papers in this issue of Information includes some canal bridges before looking at some early railway viaducts and the reasons why brick was chosen by railway builders for their bridges.

The idea of a special issue of Information is not new. Terence Smith used Information 37 to gather together material submitted about brick in churches. The submission by Martin Hammond of the long paper on 'Masonry Skew-Arch Bridges' coupled with some preliminary thoughts which grew into the second item presented here led to the idea of an issue devoted to brick in bridges. Due to pressures of space in Information and time available for writing, an article on early brick bridges and moated sites was not completed; other subjects have been suggested for another special issue devoted to brick in bridges. More warning than was given for Information 53 will be forthcoming for another topic issue, either the suggestion of another devoted to bridges or one on the use of brick and terracotta in watertowers.

The society's A.G.M. was held on Saturday 15 June 1991 at the Ibstock Design Centre, London, and our thanks are due to Andrew McEwan of Ibstock-Johnson for arranging the splendid setting both of accommodation in the meeting room and the most welcome coffee when we arrived, not to mention the lunch. The afternoon visit to south London and Docklands was illuminating in its variety of brickwork. The society's secretary, Michael Hammett acquired yet another role as the courier and guide on the coach trip.

A number of items arising from the A.G.M. are noted in this issue of Information under British Brick Society News.

Some material is to hand for Information 54; that which is available will be set during October 1991 and proofs of the longer items sent for checking. But there is a little space available. Submissions if possible early rather than late.

David H. Kennett
Editor

OBITUARY:
SIDNEY BEADLE

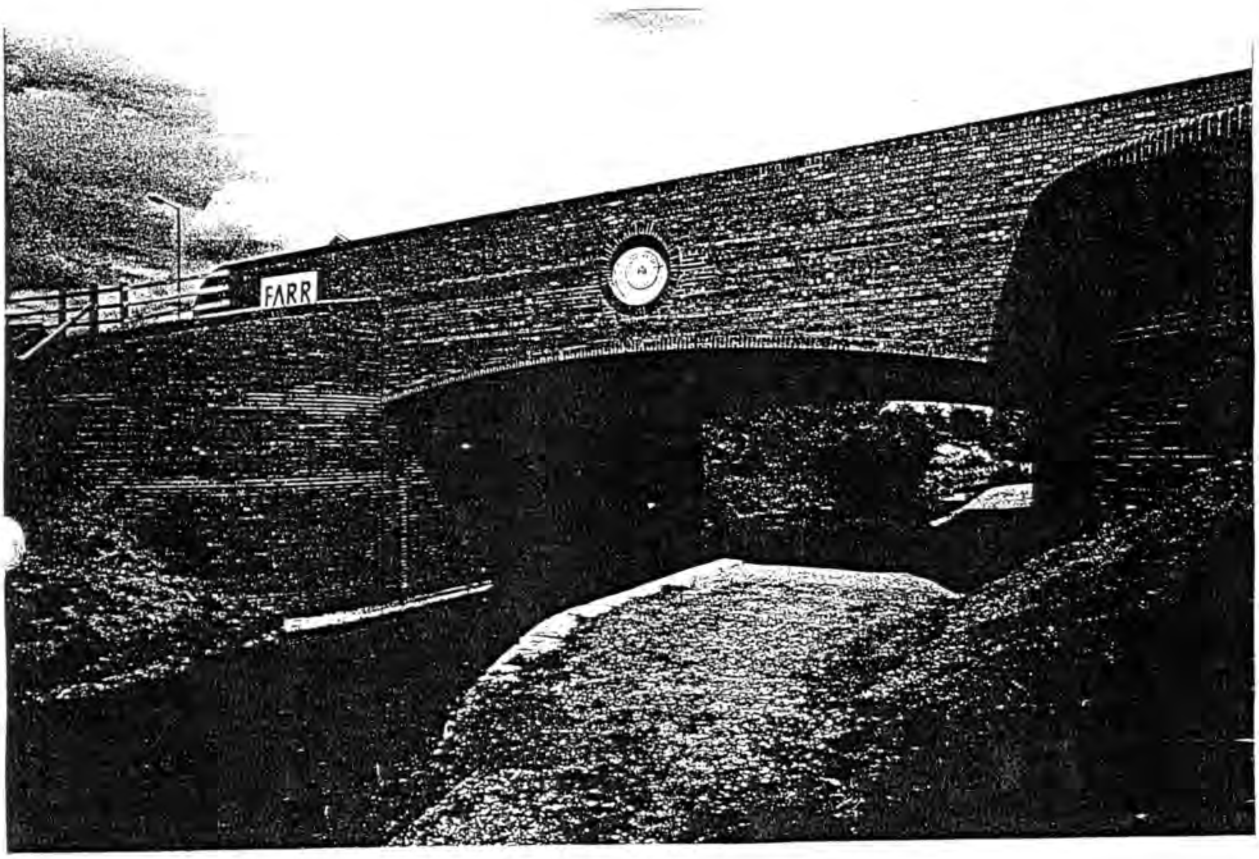
Sidney Beadle had been organising the national register of brickmarks for the British Brick Society. His sudden death occurred on 17 July 1991 after he had been so active a participant in the 1991 AGM and the subsequent coach trip barely a month earlier.

The society will miss Sidney's enthusiasm, old-fashioned courtesy, and friendly attitude.

A fitting memorial would be to continue with the brickmark project and to assist in seeing into print work he had been doing for his local history society.

A full appreciation will appear in the next issue of Information.

MH, DHK



Photograph: Coate Bridge, Devizes, Wiltshire
(see page 15)

MASONRY SKEW-ARCH BRIDGES

Martin Hammond

The need to build skew bridges first arose during the canal-building era, which was at its peak in the 1790s. If a road crossed the canal at other than ninety degrees then it caused less trouble for it to continue on its original line than to be diverted. Typical canal bridges had semi-elliptical or three-centred arches which gave good headroom across the span but were structurally weaker than other arch shapes. The faces of the arch were curved in the vertical plane. If one "wallpapered" the soffit of the arch the shape of the paper would be as in figure 1, with the brick courses parallel to the abutments. The earliest skew arches were built similarly (fig. 2) but cracks tended to occur at a and a'. The remedy was to lay the brick courses at right-angles to the centre line of the road. The line of thrust of the arch should be at right-angles to the bed joints of the

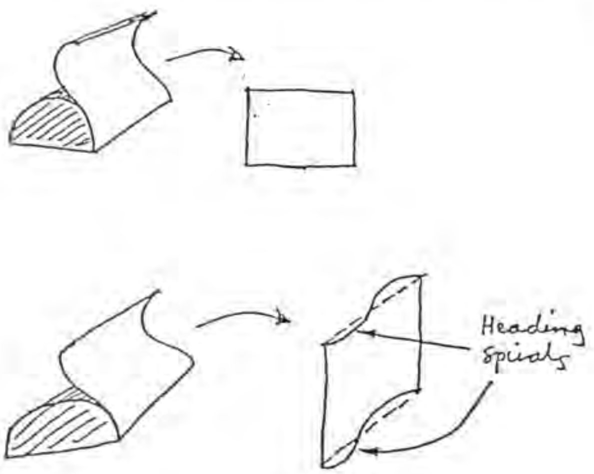
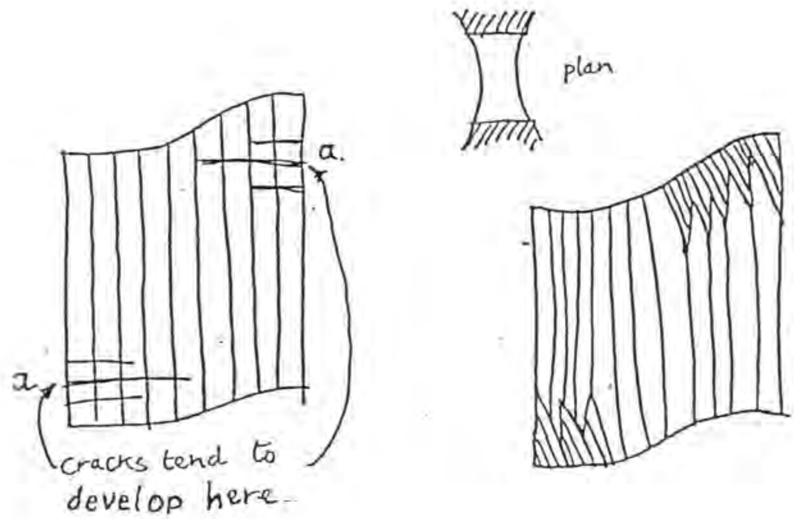


Fig.1 (left)
Heading Spirals

Fig.2 (below)
Early Forms of Skew-Arch Bridges



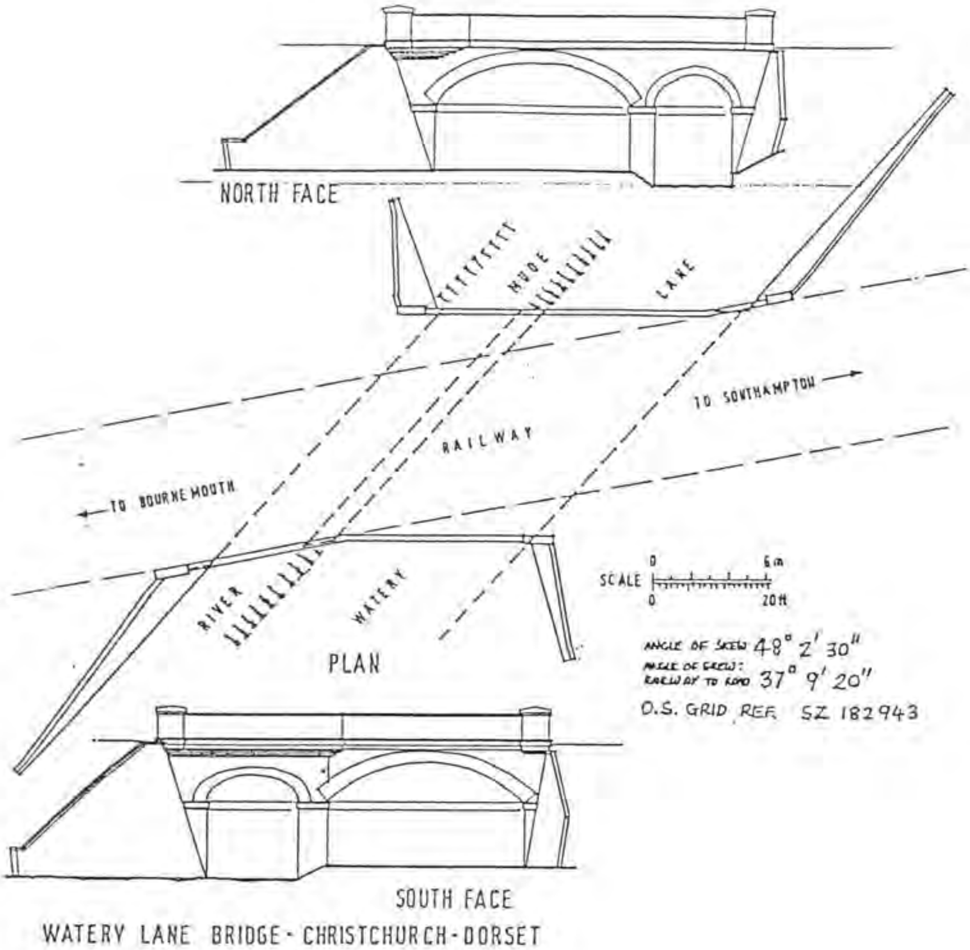
bricks or stones used, thus avoiding any tendency for the courses to slide along each other. Some prototypes were built on the Kennet and Avon Canal by John Rennie in about 1810, but Dr C.T.G. Boucher in his biography of Rennie dates them to about 1796. Others were built on the Birmingham Canal Navigations but the first mature form of spiral brick courses appeared in the Derby Road Bridge, Wollaton, on the Nottingham Canal by William Jessop in 1797. It is known that Jessop and Rennie did exchange ideas; the detailing of their locks and bridges is very similar. The faces of the arch of the Derby Road Bridge are in dressed stone. This bridge, widened twice, is still carrying heavy traffic on one of the main roads out of Nottingham.

Although many arches with spiral courses were built in the next forty years, the older form persisted, particularly in stone construction. According to the biography of George and Robert Stephenson by L.T.C. Rolt, spiral courses were unknown before the construction of the London and Birmingham Railway in 1834-1838:

> On the credit side Robert Stephenson's most original contribution to civil engineering on the London and Birmingham was his construction of skew bridges in masonry. Each stone or brick course formed, as it were, the thread of a large screw, the pitch determined by the intersection of the centre lines of road and rail and by the radius of the arch. A wooden model of each skew bridge was made and the measurements for the worked stones and courses determined from these. On the site, the centerings for the arches was covered with a sheeting on which the lines for the courses were marked out with a flexible straight-edge. 'Then', writes Conder, 'the great screws twisted themselves into place without a check and without an error'.

This could be an oblique reference to the work of George Watson Buck (1789-1854) who was resident engineer on the Camden Town to Tring section where he built the first skew arch. In 1839, he published 'A Practical and Theoretical Essay on Oblique Bridges' (second, revised edition, 1857). This and 'The Rudiments of Masonry and Stone-Cutting' by Edward Dobson appeared in the bibliography to an article by J. Matthewson in the issue of The Illustrated Carpenter and Builder of 4 May 1900. Matthewson reveals that the geometry of each individual arch stone is an extra-ordinarily complex of intersecting curved planes, and he gives his readers step-by-step instructions as to how to set them out. For practical purposes it would be far easier either to follow the method set out by Rolt or to turn the arches in brick. Bricks are so small in relation to the curves that the mortar joints take up the twist in the courses. I have noted that in stone districts, e.g. on the Settle to Carlisle railway, brick is almost always used for the arches, even if the arch faces are of stone. It is for this reason: to save on the labour of dressing stone to accurate shapes and sizes.

As the railway age progressed complicated situations sometimes arose, such as long, narrow tunnel arches where the span is considerably less than the length. Watery Lane Bridge, Christchurch, Dorset, which carries the Bournemouth Direct line over a farm track and the little River Mude, was designed by William Jacomb, a pupil of Brunel, and was completed in about 1886 (fig. 3). The farm track is a conventional segmental skew arch of 7.62 m span on the square and 10.25 m on the skew. The



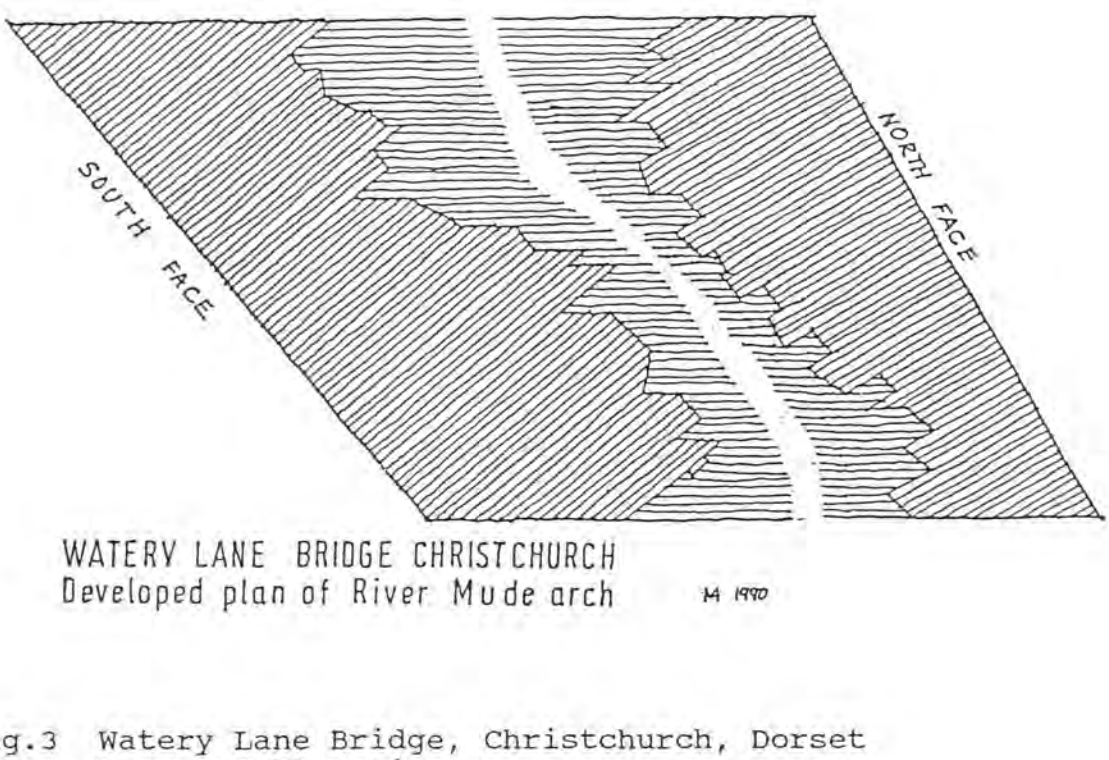
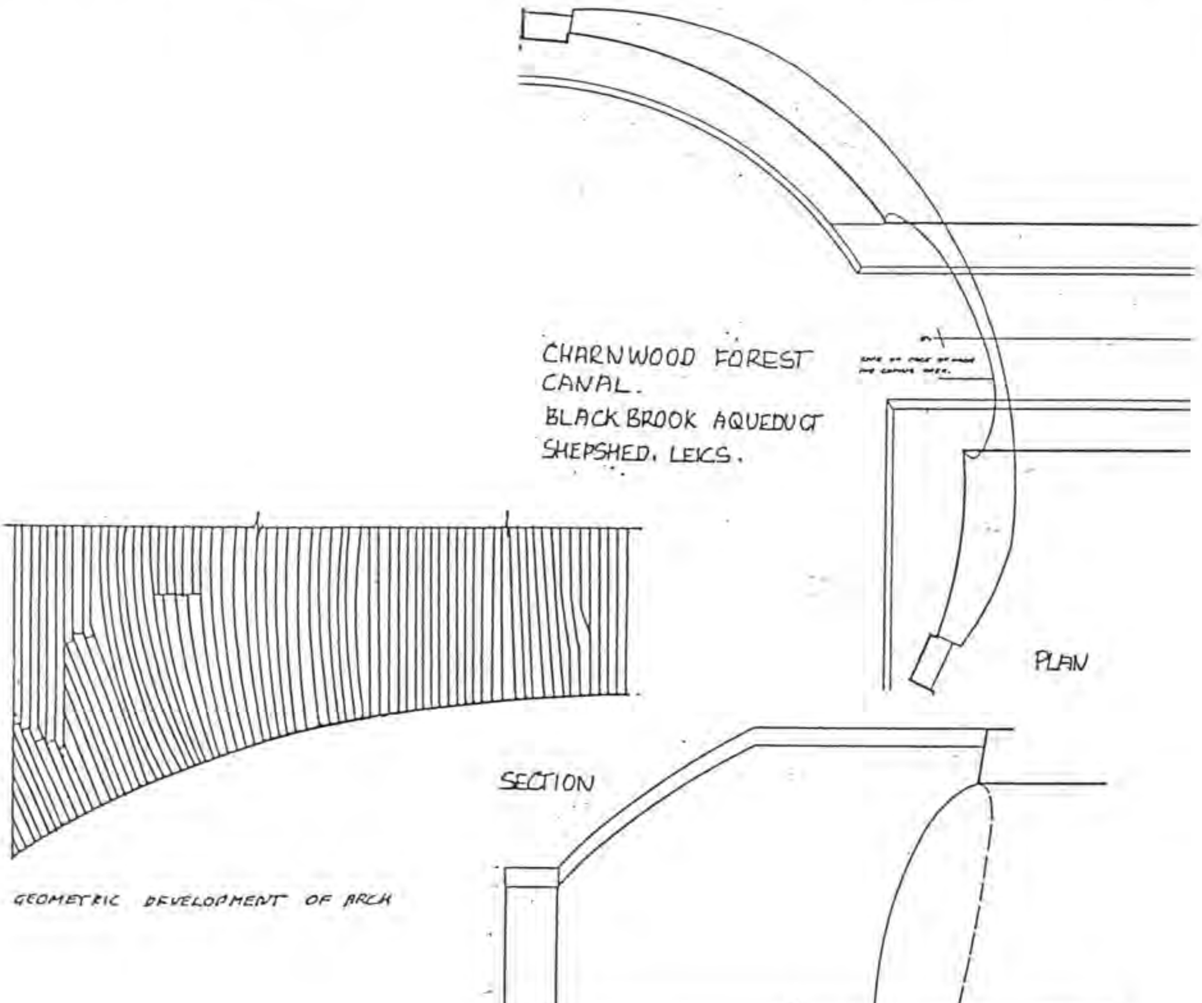


Fig.3 Watery Lane Bridge, Christchurch, Dorset
Plan and Elevations

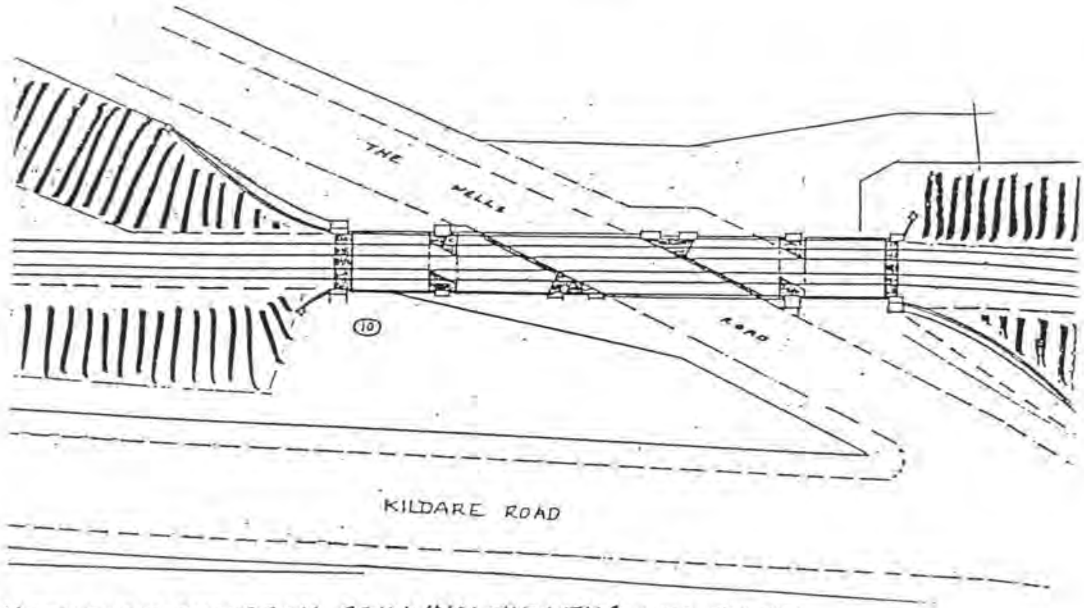
Fig.4 Watery Lane Bridge, Christchurch, Dorset
Developed Plan of River Mude Arch.

river arch is a 3.05 m span semi-circular arch. The north and south faces are not parallel, measuring 4.09 m and 5.05 m respectively on the skew. The east abutment is 16.88 m long and the west abutment 18.17 m long. As will be seen from the plan (fig. 3 centre) the railway crosses at a very acute angle, about 37 degrees, but the east-west axis of the bridge has been turned to reduce the angle of skew, which for the Watery Lane arch works out at 48 degrees 2 minutes 30 seconds from the dimensions measured on site. For the greater part of the length of the river arch the brick courses are parallel to the abutments but towards the ends they are at right-angles to the faces and are tumbled in to the main body of the arch (fig. 4). Though the junction between the two sections of brickwork is showing no sign of separation, it is a point of weakness. This method shows virtually no progress since 1801 when James Barnes reconstructed the Blackbrook Aqueduct on the Charnwood Forest Canal, near Loughborough, Leics., after the nearby reservoir burst. The construction of the north face of the arch is shown in figure 5. As late as 1900, William Galbraith used this method in the tunnel bridge which carried the former Meon Valley Railway on a high embankment over the A272, Winchester to Petersfield road, near Privett, Hants. That arch has a 50 ft (15.25 m) span and is 167 ft (50.935 m) long.



ig.5 Charnwood Forest Canal, Black Brook Aqueduct at Shepshed, Leicestershire
Plan, Section and Geometric Development of the Brick.

It is far better, and neater-looking, for the course in the face and the body of the arch to meet in a curve, forming a series of concentric circles of about 3 m (10 ft) minimum radius at the acute abutment. Edward Parry (1844-1920), who was resident engineer on the Nottingham to Melton Mowbray Railway, designed a bridge over the Grantham Canal at West Bridgford, Notts., with a central steel truss span supported by abutments which were triangular in plan. These were pierced by segmental arches with both square and skew faces; the courses were laid in a curve between the two (fig. 8). Later, Parry designed a similar bridge carrying the Nottingham Suburban Railway over The Wells Road, Nottingham (fig 6, and fig. 7). The road span was 27 ft 10 in



NOTTINGHAM SUBURBAN RAILWAY: THE WELLS ROAD BRIDGE

Fig.6 Nottingham Suburban Railway: The Wells Road Bridge Plan.

on the square and 68 ft 7 in on the skew (8.484 m on the square, 20.984 m on the skew); it was 37 ft (11.278 m) from road to rail level. The pavements pass through the abutment arches and the piers are pierced by a small skew arch of 8 ft (2.44 m) span. A real tour-de-force, it was completely demolished in June 1959. Only two bridges remained in August 1984, carrying Sherwood Vale over the main line and a single-track rope-worked incline to the former Nottingham Patent Brick Company's Mapperley works. The former is on about 7 degrees to the skew and 40 ft 4 in (12.302 m) span on the square, as it spanned the platforms of Sherwood station as well as the double track. At such a slight angle, the courses were parallel to the abutments. The latter is about 19 degrees skew and is a long narrow arch 11 ft span and 32 ft 4.5 in long (3.353 m span, 9.868 m long), (fig. 9). It has curved courses at the ends, as does Day Brook culvert further north under the junction with the Great Northern Railway's Derbyshire and Staffordshire line at Daybrook (fig. 10). The culvert and the

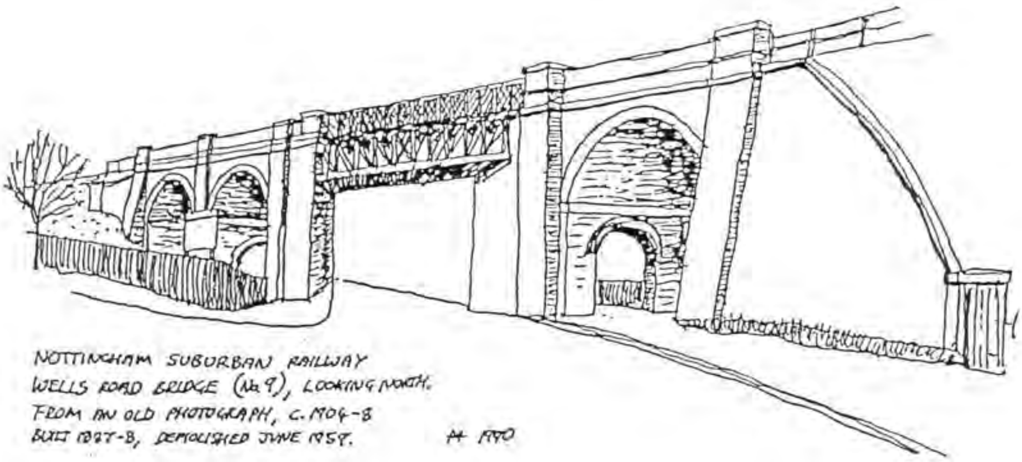


Fig.7 Nottingham Suburban Railway: The Wells Road Bridge Elevation
(redrawn from photograph of c.1904)

incline bridge are the earliest examples known to the author of this form of construction. They are faced with red brindle engineering bricks supplied by the Hathern Brick Company's works at Cliff, Tamworth, Staffs. (worked 1882 to 1961). The author has always assumed these two structures were the first to be completed on the line, in the late summer of 1887, using the first delivery of bricks from Cliff. The colour of the bricks appears to have been unacceptable to the engineer, for the rest of the structures are faced with blue brindle wire-cut bricks in a black mortar, of which Parry observed:

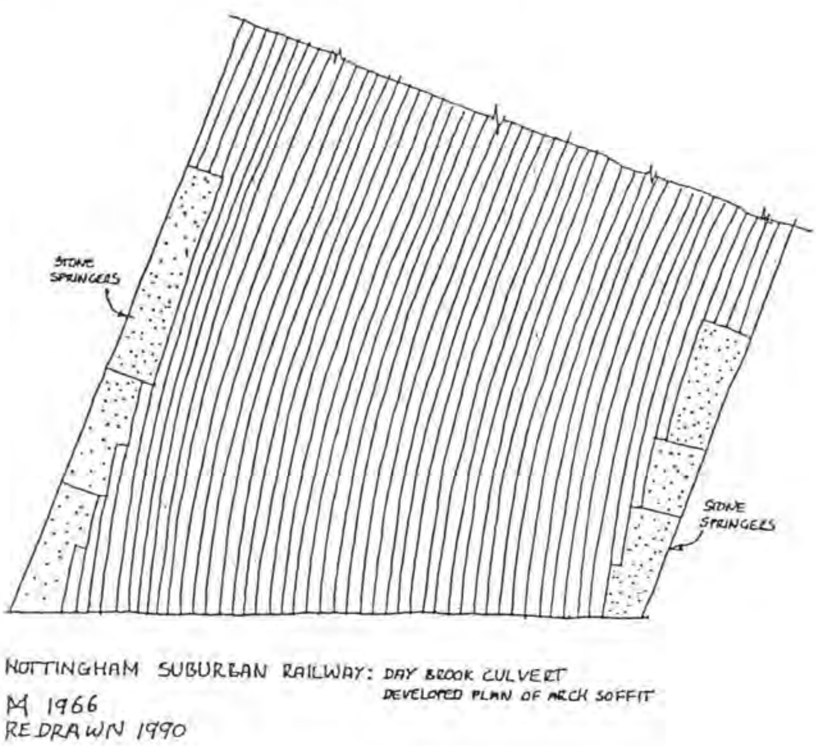
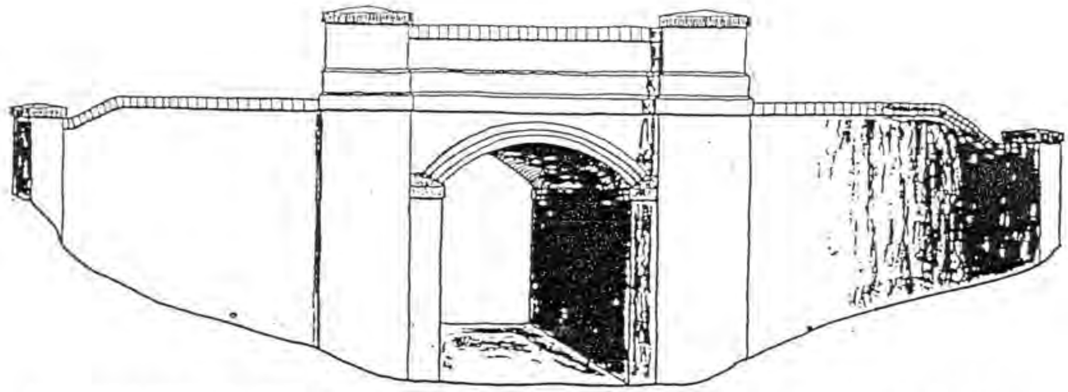


Fig.8 Nottingham Suburban Railway: Daybrook Culvert
Developed Plan of Arch Soffit



NOTTINGHAM SUBURBAN RAILWAY : MAPPERLEY BRICKWORKS INCLINE BRIDGE

Fig.9 Nottingham Suburban Railway: Mapperley Brickworks Incline Bridge
Elevation

> [it] makes an excellent finish and imparts a less sombre colour to the structure than the more expensive Staffordshire blue pressed bricks. Being of rougher grain, the brindle bricks bond better than the highly finished and smoother blue bricks, and are more easily handled.

The Mapperley incline must have been laid early during the construction to allow red bricks for the backing work to be delivered. It is interesting to note that both suppliers of bricks for the railway are still trading, as Hathenware Ceramics and Marley Brick.

One further bridge by Parry should be mentioned: that carrying the London extension of the Great Central Railway over Thurcaston Lane, on the northern outskirts of Leicester. It was another tunnel bridge through a high embankment, with a span of 26 ft on the square and 27 ft 8 in on the skew (7.925m on the square and 8.433 m on the skew); the angle between road and railway is 70 degrees and the radius of the arch is 13 ft 5.5 in (4.105 m). It is the largest known arch to be built with curved courses and is described in detail in part 3 of the issue of Proceedings of the Institution of Civil Engineers for 1898-1899. The paper includes the complex geometrical manoeuvres needed to determine the dimensions of the stone springer blocks.

Perhaps the last brick skew arches to be built in the traditional way are those in the approaches to the new Iford Bridge, carrying the A35 over the River Stour between Christchurch and Bournemouth. It was designed by the County Surveyor of Hampshire, W.J. Taylor O.B.E., M.I.C.E., and was built in 1931-32 by A. Jackman and Son Ltd., of Slough. It is entirely of brick, comprising five arches over the river and four 'causeway arches' and the six 'flood arches' on the eastern approach over the flood plain. It replaced a late- eighteenth-century bridge which still survives a few yards downstream as a footbridge. The narrowness of the old bridge had made it totally inadequate. The design of the new bridge was intended to reflect that of the earlier one in the number, shape and size of the arches. Local red multi stock facing bricks were used for all facing work except the soffit of the approach spans, which are of hard red common bricks, probably from Upton Brickworks near Poole. The flood arches (fig. 11) are 5.08 m on the square 5.45 m on the skew; the angle of the skew is 21 degrees 12 minutes.

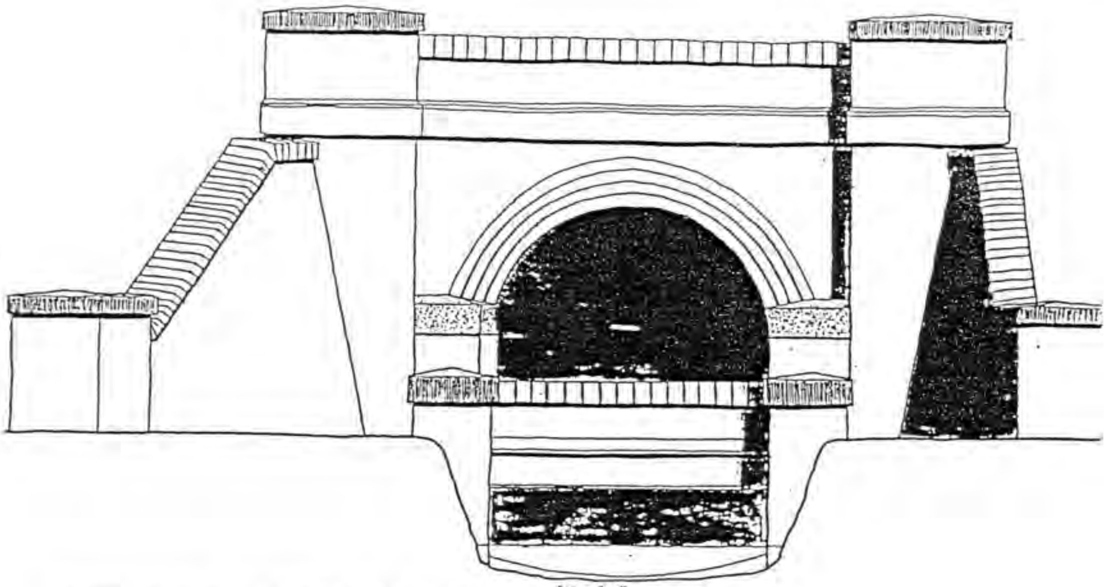


Fig.10 Nottingham Suburban Railway: Daybrook Culvert Elevation

The abutments are 15.48 m long, giving by calculation an overall road width of 14.43 m. The old bridge was only 4.47 m overall width. The arches are segmental rising 1.65 m and sprung from concrete plinths 0.8 wide by 0.15 m high, built up from a continuous concrete slab which extends under the whole plan area of the arches. The brickwork of the arches is three rings, or 0.34 m thick. The road rises about 0.15 m from east to west, and this difference is taken up by spandrel walls: the crowns of the arches being at a constant level. The spandrels have a brick-on-edge coping just above the pavement level, and the parapets consist of three horizontal steel tubes supported by cast iron standards at 2.5m centres. The causeway arches are similar in construction and span a side channel of the river. They are semi-circular, 4.35m on the square and 4.72 m on the skew; the angle of skew is 25 degrees 48 minutes. The crown of the arches is 2.71 m above the base slab.

Iford Bridge river arches (fig. 12) comprise a central three-centred arch of 10.5 m span, flanked by semi-circular arches of 7.6 m and 3.97 m span. The brickwork in the smallest arches is 340 mm or three rings thick while the larger arches all have brickwork 460 mm or four rings thick. It is apparently all-brick construction on concrete foundations, with parapets with a bird's beak moulding at the base and a coping, both in Portland stone. The same stock bricks as are used in the approach spans are used throughout for facing, including the soffit of the arches. The roadway rises westwards by about 0.45 m in the total length of the bridge, and this is taken up by cut courses just below the beak mould. The courses in the parapet are therefore not horizontal. The cut courses are interrupted at the octagonal turrets, where there is no beak mould.

The only place where I have seen spiral courses used outside Britain is in the bridge which carries the Peloponese Railway over Odos Thessaloniki (Salonica Road) in Athens, Greece. This rather narrow segmental arch is built of dressed blocks of grey marble finished with whitewash. The more usual method, seen on

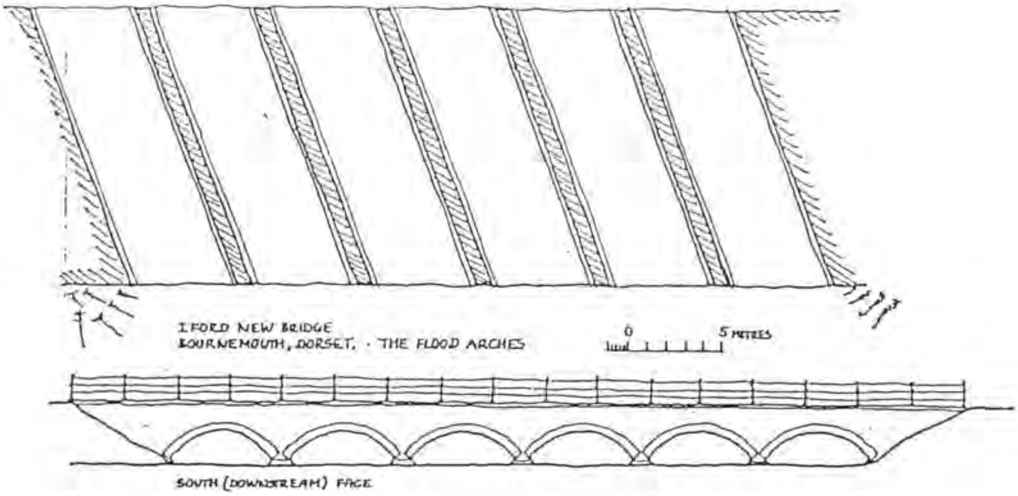


Fig.11 Iford New Bridge, Bournemouth, Dorset
The Flood Arches: South Face

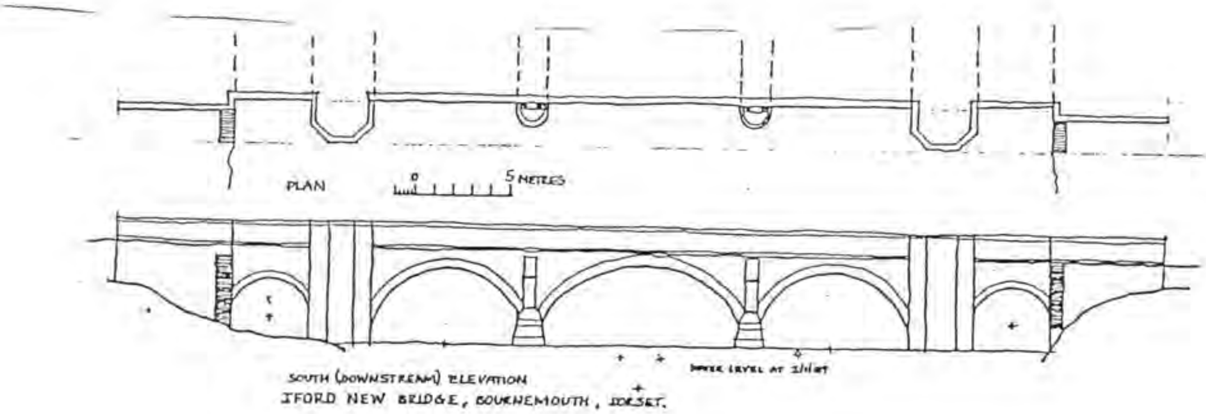


Fig.12 Iford New Bridge, Bournemouth, Dorset
Plan and South Elevation

the Ferrocarril de Soller, Mallorca (fig. 13), and elsewhere, is to build the arch is six or so narrow slices, each off-set according to the angle of the skew. There is an example of this where the Great Western Railway's High Wycombe to Princes Risborough line crosses the A4010 near Bradenham at a very acute angle. It was built in 1900.

Setting-out on site for building a skew arch needed to be done carefully. The design was dimensioned around the intersection between the centre-lines of the road (or whatever) and the railway. These lines were pegged out on site and the plan of the bridge was set out by off-set dimensions and angles from these. Dimensions and angles were calculated very accurately by the engineer, using trigonometry. An error of one degree in setting-out can produce a misalignment of 175mm (7 in) over a span of 10 metres (32 ft 10 in). The minimum size of the arches over the railway was determined by the loading-gauge. Arches over roads were built to suit the traffic of the district at the time, but nowadays minimum dimensions are laid down by the Department of Transport. Semi-circular arches, or segmental arches with a

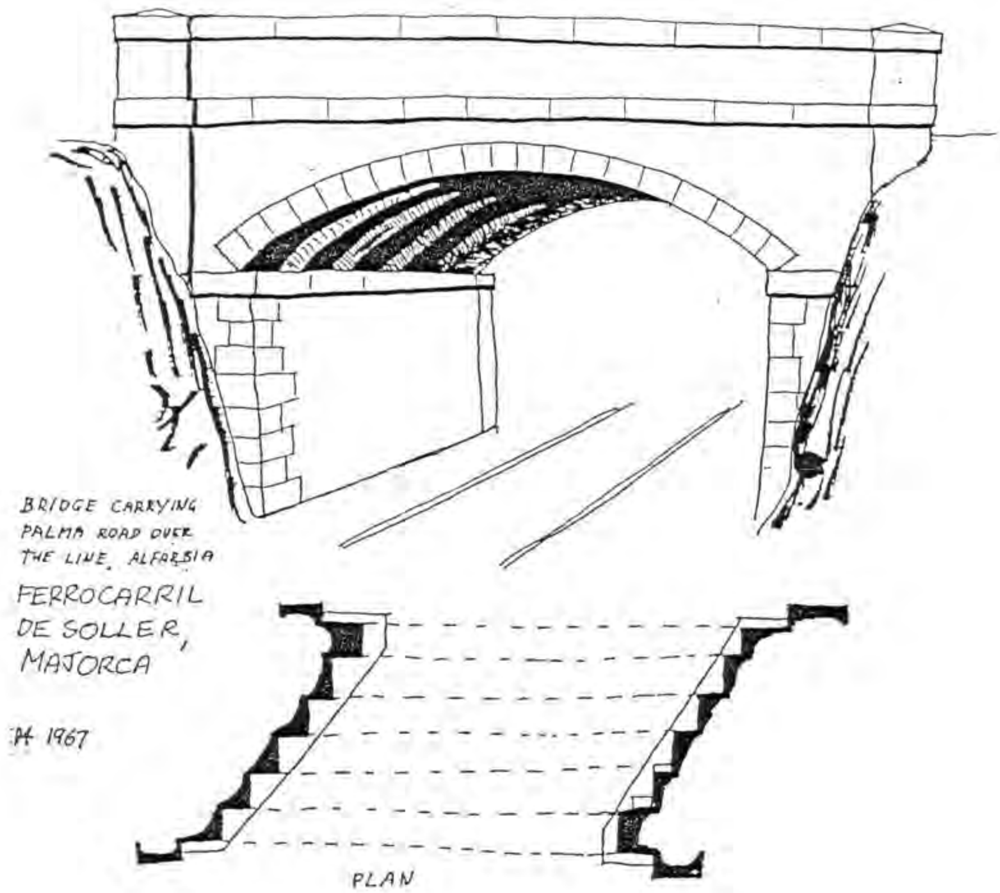


Fig.13 Ferrocarril de Soller, Mallorca, Spain
Segmental Arch Bridge
Elevation and Plan

rise equal to a quarter of the span, requiring skewbacks at the spingings of 45 degrees, were preferred. However, Isambard Kingdom Brunel, and certain other engineers, preferred semi-elliptical arches. Usually the brickwork was 460 mm (18 in) thick, although there were rules of thumb such as increasing the thickness by half a brick for every 5 ft (1.5 m) increase in span. The brickwork of Maidenhead Bridge carrying the Great Western Railway over the River Thames is ten rings, or 1.35 m (4 ft 6 in) thick on the face.

When the centring had been set up, the lines of the faces of the arch were marked on it by dropping a plumb line at intervals along a line stretched over it. The lines of ever fourth course of brickwork were then marked between them, using a flexible square and straight-edge which could bend to the curve of the arch. Brickwork then started, carried up evenly from each springing course by course and ring by ring so as not to distort by uneven loading. Where courses in consecutive rings coincided, they might be bonded together by a lacing course of headers. When the arch was complete it remained to build up the spandrels, parapets, and piers. In the late nineteenth century mass concrete was often placed between the arches in a multi-span bridge and finished with asphalt to strengthen and waterproof the structure. Bridges and viaducts were built ahead of any tipping for adjacent embankments (fig. 14).

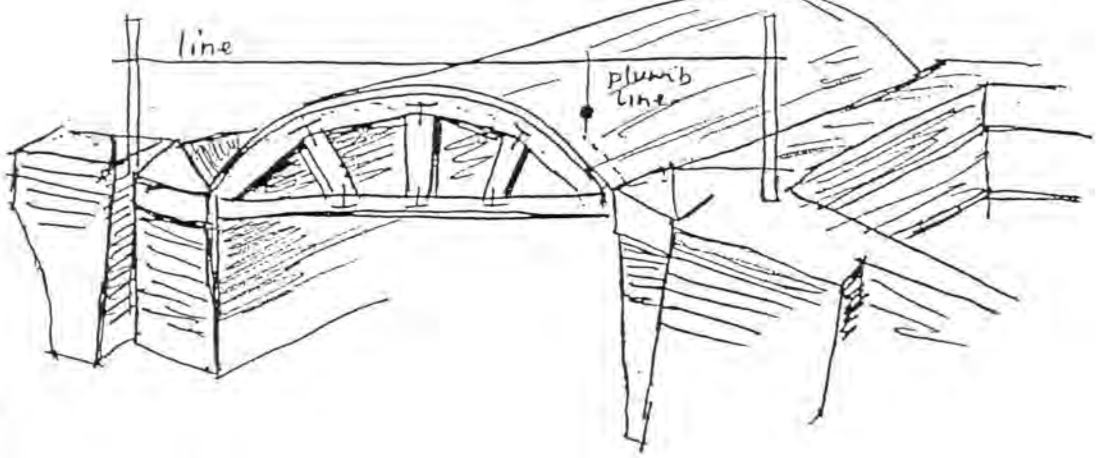


Fig.14 Building a skew-arch masonry bridge.

No engineer, to whom I have spoken, seems to know how to calculate a masonry arch. Local authority building inspectors fight shy of them, requiring that calculations be submitted for each design or the bulk of the load be carried in a beam built in above the arch. The methods described herein, which must have been in use in Roman times and earlier, in the last seventy years have become a lost art with the cessation of railway construction.

APPENDIX
EDWARD PARRY: RAILWAY BRIDGE BUILDER

Edward Parry, born at Hendy Mold, Clwyd, on 8 November 1844, began his civil engineering career with the Midland Railway in 1869, the year in which design work started on the Settle to Carlisle line. Much of Parry's later work shows a strong influence from this. He appears as resident engineer on the Nottingham to Melton Mowbray line in 1875-1879. He was County Surveyor for Nottinghamshire between 1879 and 1889, during which time he designed the Nottingham Suburban Railway (1886-1889) and the Castle Gate United Reformed Church (1884). The idea of a joint central station in Nottingham was his initially, and this materialised as Nottingham Victoria Station. The tall red-brick clock tower survives from this incorporated into the Victoria shopping centre, where it looks rather out of place. Parry went back to the Midland Railway to design their Dore and Chinley line, part of the route from Sheffield to Manchester (1888-1893). This included Britain's second longest railway tunnel, Totley, and its deepest, Cowburn.

The London Extension of the Great Central Railway from Annesley, north of Nottingham, to London Marylebone, was designed and built between 1893 and 1899. Parry became resident engineer for the northern section, Annesley to Rugby, including Nottingham Victoria, which opened on 24 May 1900. In 1905 to 1909, he was engineer to the South Yorkshire Joint Railway, a subsidiary of the Great Central. He died in Leamington Spa on 11 August 1920, aged 75.

Besides his railway interests he was also a director of the Nottingham Patent Brick Company (now Marley Brick) and of Digby

Collieries near Eastwood, who also manufactured bricks. He may have had family connections with the firebrick manufacturers Edward Parry & Co. Until recently, Butterley Building Materials marketed 'Parry Blue' firebacks made at their Catheralls works.

Most of his engineering structures were faced with blue brindle bricks, and it is unfortunate that railway politics have resulted in the abandonment of many of the lines he built. His lines were noted for their elegant, well-proportioned simplicity and for their fine durable construction which made their dismantling the more difficult. The London Extension was built to the continental loading-gauge and for high-speed running, for it was intended as a link with a proposed Channel Tunnel to form a route from Manchester to Paris. With all the current argument about high-speed Channel Tunnel links, I think it is shameful that a finely engineered line was thrown away. Parts of it are still in use for industrial and suburban traffic, and as a preserved railway near Loughborough, but the London extension of the Great Central Railway is a faint shaddow of what its promoters and builders intended.

BRIDGING THE CENTURIES: COATE BRIDGE, DEVIZES, WILTSHIRE

The re-opening in the summer of 1990 of the restored Kennet and Avon Canal added one of the longest single stretches of inland waterway to British Waterway's national network.

Running in an east to west line from Reading to Bristol, via Newbury, Devizes, and Bath, the Kennet and Avon Canal is 87 miles. It was originally developed in 1810 by a coal, iron, and stone haulage company. However, its success and prosperity were short-lived: by 1841 the company's fortunes were already failing.

A national campaign to restore the canals, bridges, and waterside structures of the canal was first mounted in the 1950s and, with the encouragement and backing of British Waterways, the Kennet and Avon Canal Trust was formed in 1963. This now has its headquarters in a restored granary on the canalside at Devizes.

Nearby the famous Coate Bridge, designed in the year of the canal's inauguration by the Victorian engineer, John Rennie, has recently been reconstructed by A.E. Farr, linked to a new Lovell housing development. The Bristol consulting engineers Parkman were responsible for the new Coate bridge's design, which features Ibstock's keyed-brick pre-assembly technique, used in conjunction with a reinforced concrete frame.

The main facings on the bridge are Ibstock's Chester Red Roughdales, with parapets, string courses, and the main central 12 metre span expressed in Ibstock's traditional Telford Blue engineering bricks.

The areas increased traffic, generated by new housing developments, demanded the dual carriageway which the new bridge provides. The actual brick arches were pre-cast in situ, with the special triple-slotted facings being used to clad the concrete sections, then hoisted into position. The remainder of the brickwork, including the polychromatic decorations and the edge finishings which echo Rennie's original design, was carried out on the site by Farr's team of bricklayers.

Andrew McEwan

BRIDGES: THE MATERIAL CONSIDERATION

David H. Kennett

BRICK AND ITS COMPETITORS

Brick is only one of the possible materials for the engineer to use for the construction of a bridge: several of these materials can be combined in the same structure. Zetland Arches is a multi-arched structure taking the Bristol to Avonmouth and Severn Beach railway over Gloucester Road in north Bristol. The piers are of masonry, being faced with the local stone. Most of the arches are brick, but the wide arch which takes the railway over the road is made up of five ribs of galvanised steel. These ribs have on a northern rib a plate stating 'Smedley Bros, Derby, 1873'. The bridge deck is wooden planks with a gravel bed for the railway track laid on top.

The appeal in October 1990 to raise £50,000 to restore the reinforced concrete bridge at Homersfield, Suffolk, prompted an enquiry into the span of time which each of the major building materials has been used to span rivers and, in some cases, seas.

TIMBER

The earliest bridges constructed would have been a simple log or plank across a stream. The principle survives today in the planks and adjacent handrails placed across the stream which runs through the Norfolk village of Sporle. The River Box in the Suffolk villages of Brent Eleigh, Chelsworth and Monks Eleigh is bridged in like manner. More elaborate is the canal bridge over the Shropshire Union Canal at Tilstock. This is a white-painted wooden basacule bridge in a red brick village. The largest house in Tilstock is Allington Hall, a brick manor house of 1592, and the brick church was built in 1835. A notable feature of this church is the retention of the original cast iron glazing bars.

MASONRY

Stone bridges in have been built in Britain since at least the period of the Roman occupation. None as early as this survive in use.

Probably the earliest bridge in Britain in use today is the fortified bridge over the River Monnow at Monmouth, which was built in 1272. Fifteenth-century bridges with the bridge chapel remaining on them are to be found in the West Riding towns of Rotherham and Wakefield. Contemporary are the bridges over the River Great Ouse in Bedfordshire at Bromham and at Great Barford. Other medieval stone bridges in Bedfordshire include those at Harrold and, spanning the county boundary with Buckinghamshire, at Turvey. In Buckinghamshire Olney Bridge was largely rebuilt in the nineteenth century.

In Bedfordshire, the only completely new stone bridge is John Wing's bridge at Bedford, which in 1800 replaced the medieval fortified stone bridge.

Crossing the River Thames between Buckinghamshire and Berkshire are several stone bridges. A notable one is the seven-arched bridge at Maidenhead, designed by Sir Robert Taylor in 1772, taking seven years to construct. It appears to the onlooker's left in J.M.W. Turner's celebrated painting Rain, Steam and Speed, north of the railway bridge.

In Cheshire, Holt Ancient Bridge at Farndon, reported as dating to either 1345 or 1545, is 520 ft (156.8 m) long and has eight arches over the marshy ground on the border between England and Wales. A strengthened arch, number three reading from the Welsh bank, may have held a tower. Contemporary with the earlier date ascribed to Holt Ancient Bridge is the Old Dee Bridge at Chester. Built of red sandstone, this bridge has seven arches. The builder was Henry de Snelleson, mason and surveyor to the Black Prince. Until 1832, the Old Dee Bridge was the only river crossing in Chester. In that year, Princess Victoria of Kent, as she then was, opened Thomas Harrison's Grosvenor Bridge, which had been designed thirty years earlier. When built and until late in the twentieth century, it was the longest stone span in the world at 200 ft (61 m). The arch was designed by George Rennie and the whole bridge was built by James Trubshaw and Jesse Hartley.

No account of stone bridges ought to omit William Edwards' bridge across the River Taff at Pontypridd, Glamorgan, completed in 1755. A single masonry span of 140 ft (42.7m) crosses the river with a rise of 35 ft (10.675 m) in a arc of a circle 89 ft (27.15 m) in diameter. The arch was relieved from the pressure of its haunches by three cylindrical holes graduated in size, the largest 9 ft (2.75 m) in diameter.

CAST IRON

All members of the British Brick Society have doubtless heard of Ironbridge, the eponymous place with the first cast iron bridge in the world. Indeed, the society held its A.G.M. in the district in 1987. But the famous bridge, built between 1779 and 1781, has no successor until Thomas Telford, as County Surveyor for Shropshire built Buildwas Bridge, in 1796. Indeed, in the ninety years after the opening of the bridge at Ironbridge only twenty-nine more arch bridges of cast iron were constructed in an area comprising Wales and the western counties of England between the Bristol Avon and the Mersey. In eastern England another twelve cast iron arched bridges are known. The maximum in any five-year period appears to have been seven bridges built in the early 1820s.

WROUGHT IRON

Wrought iron is less frequently used for bridges. Two structures, however, stand out. Of similar design, the tubular bridge across the Afon Conwy is twin track and 400 ft (122 m) long, shorter than the Britannia Bridge, across the Menai Strait, some 13 miles west. The main span of the Britannia Bridge is 460 ft (140.3 m) in length, and there are two side spans each 230 ft (70.15 m) long. Both bridges were designed by Robert Stephenson.

STEEL

Pride of place in any account of steel as a bridge-building material must go to the Forth Bridge, built in 1888, using the cantilever principle.

Equally exciting in engineering terms is the Runcorn-Widnes road bridge in Cheshire, built in 1928, of a two-pinned bowspring design, which is 1082 ft (330 m) long. It replaced one of the five transporter bridges built in England. Two of the surviving ones are at Newport, built in 1905, and at Middlesborough.

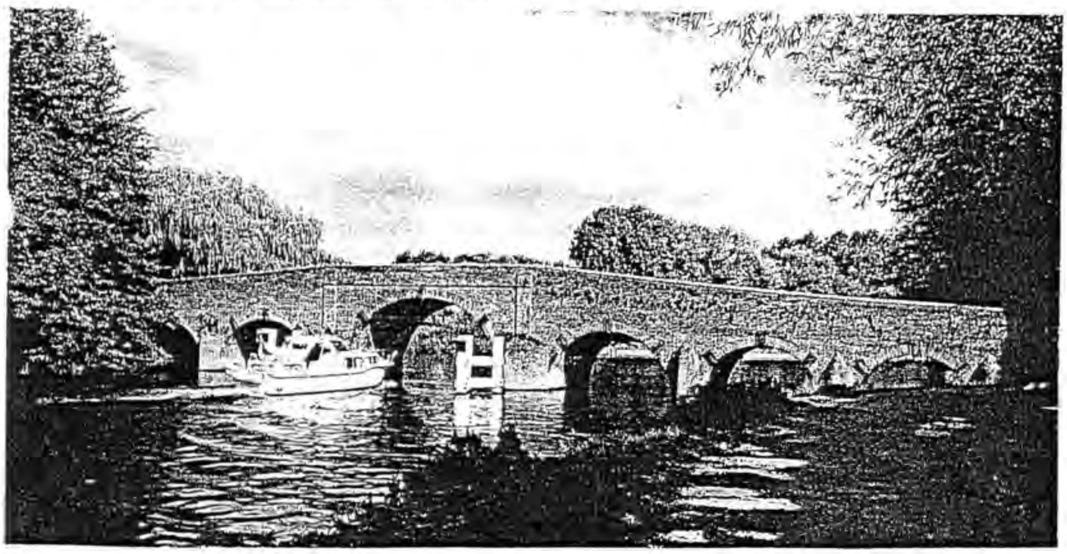
A modern steel bridge is the Conwy Arch, completed in 1958 on the seaward side of Telford's supsension bridge of 1826. The Conwy Arch has a span of 310 ft (94.55 m).

REINFORCED CONCRETE

Reinforced concrete is often regarded as a twentieth-century material. But the earliest reinforced concrete bridge in England dates to 1869. As mentioned in the opening section of this paper, an appeal is being made to raise £50,000 to restore the bridge at Homersfield, Suffolk, which spans the River Waveney on the county boundary with Norfolk.

The next oldest reinforced concrete bridge known to the author is the Glenfinnan viaduct. Built in 1897, it predates the Berw Road Bridge at Pontypridd, Glamorgan, by a decade. The latter, built in 1907 to releive the stress on William Edwards' masonry bridge. The Berw Road Bridge was designed by L.G. Mouchel and partners, who also designed the Free Bridge, Jackfield, Shropshire, which was built in 1909 across the River Severn, half a mile downstream from Ironbridge. In due time it has meant that the famous bridge can be closed to vehicles. The Free Bridge is 80 ft (24.4 m) in its centre span and has two side spans, each 56 ft (16.8 m) wide.

Rather later is date is the Royal Tweed Bridge, at Berwick-on-Tweed, Northumberland, where the Great North Road crosses from England into Scotland.



Pl. 1 Sonning Bridge, near Reading, Berkshire.

BRICK

An early road bridges built of brick is the Thames Bridge at Sonning, Berks., which has eleven arches increasing in size, both height and span, from the bank to the centre.

Contemporary with this is the Bredwardine Bridge, Herefs., whose six brick piers carry four arches in the water and two for flood relief. The bridge, built in 1769, has triangular cutwaters both upstream and downstream and two sets of these are carried into the parapet to form pedestrian refuges on the narrow roadway.

By means of the Great Haywood Canal Bridge, Staffs., the towpath crosses the Trent and Mersey Canal. The bridge is a segmental arch in a flat span, noteworthy for the ring arch of two courses of brickwork capped by a course of sandstone blocks. It was designed by James Brindley, probably in 1772.

The Kennet and Avon Canal was built between 1794 and 1816, with John Rennie as engineer. He probably designed an early skew-arch bridge, that at Great Bedwyn, Wilts., which has irregularities in the coursing possibly due to a greater width at the springing than at the crown.

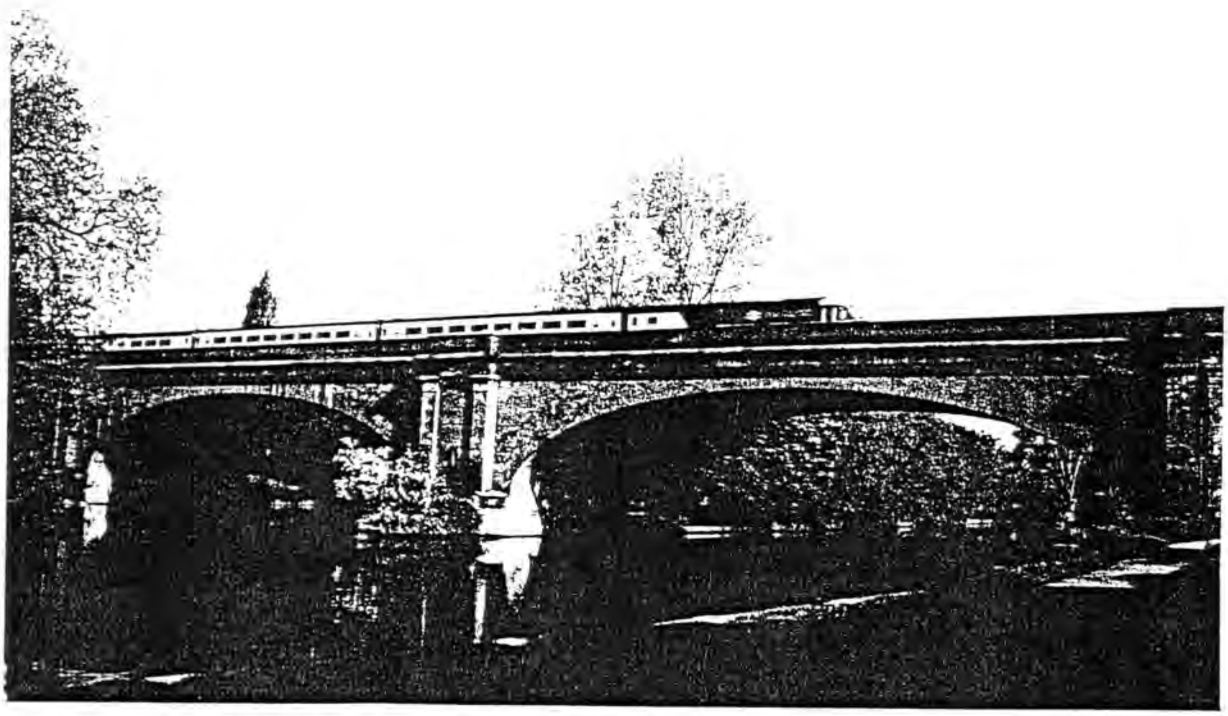
At the end of the eighteenth century bridges were rebuilt in many towns. The earliest brick bridge built in Luton was that of 1779 which crossed the River Lea almost on the site of the Domesday Church Mill on Church Street. Parts survived despite the later rebuildings until the most recent refurbishment in the 1960s. Elsewhere in the town, both the bridge on Bridge Street and that taking both Kimpton Road and Crawley Green Road over the river were timber until the flood of 1795. A double-arched brick bridge was built on Bridge Street in 1797: parts could be seen of the south face until the complete reduction of the river to a tunnel in 1959. The bridge at the western end of Crawley Green Road remained until a similar date but is now buried beneath later works. When the three bridges were built most of the town's houses still did not have brick fronts. On the whole these date to the late 1820s, mainly after a flash flood of 1828.

By then the railways had begun to be built. The railways increased the number of bridges in Britain by seven-fold. Not only did the railway cross rivers, it crossed roads and was crossed by roads. Many bridges are not just single arches or even five-arched affairs. Railway bridges develop into railway viaducts which cross the land with majestic ease.

The longest brick bridge in the world was built as early as 1836; it is the railway viaduct of the London and Greenwich Railway (now part of Network South-East) from London Bridge to Deptford Creek, which has 878 arches and is 3.75 miles (6 km) long. The world's longest brick structure still takes heavy use today. Members of the British Brick Society who came on the outing following the 1991 A.G.M. saw part of it.

Many of the better-known railway viaducts were built early in the history of the steam train. Between 1833 and 1837 on the Grand Junction Railway (later the London and North Western Railway), the first work of Thomas Brassey was the construction of the Penkridge viaduct of seven arches, each with a 30 ft (9.15 m) span. Each pier is brick below a stone cornice and the whole has a brick parapet. The Balcombe viaduct in Sussex was built in 1841. This is 1475 ft (449.58m) in length and has arches within each of the piers.

A later example is the Hownes Gill Viaduct, near Consett, Co. Durham, built in 1858 to span a precipitous dry gorge where previously the Stanhope and Tyne Railway had used first cradles and then a funicular railway. The Hownes Gill Viaduct is 150 ft (45.72m) high and in its construction used two and a half million bricks. The designer was Thomas Bouch who later designed the first Tay Bridge.



Pl.2 Maidenhead Bridge, Berkshire
(photo: M.Hammett)

When Isambard Kingdom Brunel, engineer to the Great Western Railway, had to build a bridge across the River Thames between Taplow, Bucks., and Maidenhead, Berks., in 1835, there were a number of problems confronting even his considerable ingenuity. The Thames Commissioners insisted that only one supporting pier in an overall length of 300 ft (91.5 m) could be used. The river had to remain open for traffic and as unobstructed as possible. The railway approaches the river at a level which means that only a rise of 24 ft 3 in (7.4 m) is possible. The solution was two semi-eliptical arches, each 128 ft (39 m) long. In Murray's Handbook to Buckinghamshire of 1902, John Meade Falkner described the arches as 'perhaps the largest brickwork span in the world': no claim has ever been made to the contrary. This is the bridge on which a broad guage steam locomotive with a driving wheel perhaps as much as 8 ft (2.44 m) high appears in the celebrated painting by J.M.W. Turner, whose full title is Rain, Steam and Speed - The Great Western Railway. The brick bridge appears on the viewer's right: the train is going from Paddinton to Bristol. In the course of construction in May 1838, Maidenhead Bridge was described by John Fowler as 'in a dangerous situation'. The contractor did ease the centering before the cement had set and three courses of bricks near the crown of the eastern arch separated. But after this was repaired no other engineering problems were experienced. In a gale in December 1839 the centerings blew down; they had been free of the structure for over twelve months.

Of Maidenhead Bridge (als o known as Taplow Bridge), the Buckinghamshire historian, Sheahan, wrote (1):

> To the eye familiar with geometrical beauty, the perfect execution of an elliptical arch, on so large a scale, and so high a degree of eccentricity, is an uncommon gratification; but when the practical mechanician considers the difficulties and risks which must have

> attended its construction ..., then indeed, and only then will he sufficiently appreciate the courage and capacity which have approached so near the verge of possibility without transgressing its bounds.

Sheahan, of course, wrote in the era of comparatively slow trains of limited weight.

Brunel built his bridge for a maximum speed of under 50 miles per hour: in trials in 1838 the North Star locomotive attained 40 mph with a load of 40 tons and the first train from Exeter to London in 1844 did the journey in 4 hr 40 min. The time for the journey was cut to 4 hr 30 min in May 1845 giving an average speed including stops for the 194 mile journey of 43.9 mph. These were the world's first express trains. The 'Firefly' class engines, of 2-2-2 wheel arrangement, with 7 ft driving wheels, pulled seven or eight 10 ton carriages: the total weight of the train was under 100 tons. A decade later the Iron Duke locomotive and others of its class, weighing 35 tons and pulled a train load weighing 150 tons, which became the regular pay-load when new carriages were introduced in 1874. Then, the time allowed for Paddington to Swindon was 87 minutes for 77.25 miles, but few locomotives managed even 60 mph at the end of the broad guage era.

Today's trains both weigh rather more and go very much faster. An eight-coach 125 unit with two locomotives has a tractive weight of 419 tonnes. It also goes rather faster. As the name suggests the top speed is 125 mph. They certainly attain this. There is a train, the 18.00 from Paddington to Swansea, which covers the 111.5 miles to Bristol Parkway in 67 minutes, an average speed of 100 mph. Even the slowest of the trains to south Wales does this journey in 87 minutes, an average speed including three stops of 76.9 mph. The average time, 77 minutes, means an average speed of 86.9 mph, not quite double that of Brunel's trains. There is also the thrust of over double the weight for each train.

Brunel's bridge was built for far fewer trains than it takes today. When built, the good burghers of Bristol envisaged perhaps three or four trains each day from Temple Meads to Paddington and a similar number on the return journey. Today there are many periods when within a single hour no fewer than six expresses and ten local trains leave Paddington for the west. Also there are a very much larger number of much longer and far heavier freight trains: a forty waggon roadstone train weighs 892 tons without its load.

The brick bridge over the Thames at Maidenhead has done it its job exceptionally well. The strength is tribute not merely to the engineer but also to his choice of material: brick. Equally the much greater demands, of the number, weight, and speed of the trains are no mean testimony to the inherent strength of the material chosen.

It is no exaggeration to suggest that the railways made brick the popular material it is today. The railway builders had a need for a strong material capable of withstanding the thrust of great loads moving at high speeds. Looking round for marketing outlets for their material they sold bricks to builders at much cheaper prices than hitherto. Railway use of bricks in vast quatities probably also helped to hasten the end of the brick tax: it was abolished in 1850.

MATERIALS CHOICE: DESIGN CHOICE

Elegance is very much an aesthetic judgement. As indicated all the major materials can be visually satisfying. But it is possible to rank the materials choice for a number of characteristics: length of span required, strength, durability, the need for maintenance, height of the bridge deck.

With length of span possible and known to be successful the suspension bridge design using box-girder frame exceeds all other known design forms. Ten of the world's suspension bridges are longer than a kilometre (3279 ft). The central cantilever of the Forth Bridge is 1710 ft (521m) long in contrast to the span of the Forth Road Bridge, at 3300 ft (1006.5m) the eighth longest suspension bridge in the world. Reinforced concrete reaches only half this distance and steel has been used across almost the same distance. Wrought iron can be taken over a longer span than cast iron or brick. Both of these have the advantage over masonry and timber will bridge the smallest distance of all.

However, the strength of brick is greater than that of cast iron. Brunel's bridge at Maidenhead is still in use by the vehicles for which it was designed; Abraham Darby's famous iron bridge did not survive into the era of the motor car, being closed in 1931. Good quality ancient masonry, however, will withstand the weight of modern traffic and modern materials are designed with the 42-tonne axle in mind.

Judging between materials for durability would place brick at the top of any list of choices. Like masonry, the material is strong. Discussing railway bridges D.K. Horne recently wrote (2):

> It is as well to appreciate the advantage of an arch when durability is the prime concern. There are no inherent cracks! When a straight beam is bent, the bottom surface extends--the top contracts. But if the beam is given sufficient vertical curve and the ends are restrained, this 'tension' along the bottom can be eliminated and the carrying capacity will depend solely on the compressive strength of the material. Cast iron and concrete are relatively weak; timber, wrought iron and steel are relatively strong but these latter are much more perishable. On the other hand South Staffordshire blue bricks which were virtually standard on the LMS had a compressive strength about 5 tons per sq in and were almost indestructable -- all for the price of burnt muck.

It was this quality of near indestructability which made the Great Western Railway chose brick for the bridges over the south Wales direct line opened on 1 May 1903. The line includes three massive brick viaducts at Winterbourne, the largest of which is eleven arches and 90 ft (27.5 m) high.

The line cuts through the southern end of the Cotswolds but the native limestone was not chosen (3).

NOTES

1. Quoted N. Pevsner, The Buildings of England: Buckinghamshire, (Harmondsworth, 1962).
2. D.K. Horne, 'Railway Bridges versus Railway Engines', Backtrack, 5, no.2 (March 1991), 59-64; quote from 59-60.
3. Paper completed June 1991.

BRITISH BRICK SOCIETY NEWS

Arising from the A.G.M. a number of items may be relevant to individual members of the society.

BRICKMARKS AND REGISTERED NAMES OF BRICKMAKERS

Sidney Beadle had been co-ordinating the collection of data on behalf of the society about brickmarks and brickmaker's registered names. Entries will be published under four headings initially:

a: Mark
b: Name and Address of Brickmaker
c: Description of the Brick: dimensions, texture, colour
d: Date of Production

Other material, if available about individual finds, should be included. Material by 1 December 1991 to

Michael Hammett,
9 Bailey Close, High Wycombe, Buckinghamshire HP13 6QA
telephone 0494-520299.

BRICK COLLECTIONS

Alan Hulme would like to hear from all members with a brick collection. Replies to

Alan Hulme,
20 Swan Close, Poynton, Stickport, Cheshire SK12 1HX

QUERY

Helen Pegden is researching the brick and tile works and their products at Ramsdell, Hampshire. Any information beyond the notice in Information 22 (November 1980) would be welcome. Replies to

Helen Pegden,
'Rosemeade', Ramsdell, Charter Alley, Basingstoke, Hempshire
RG26 5PS