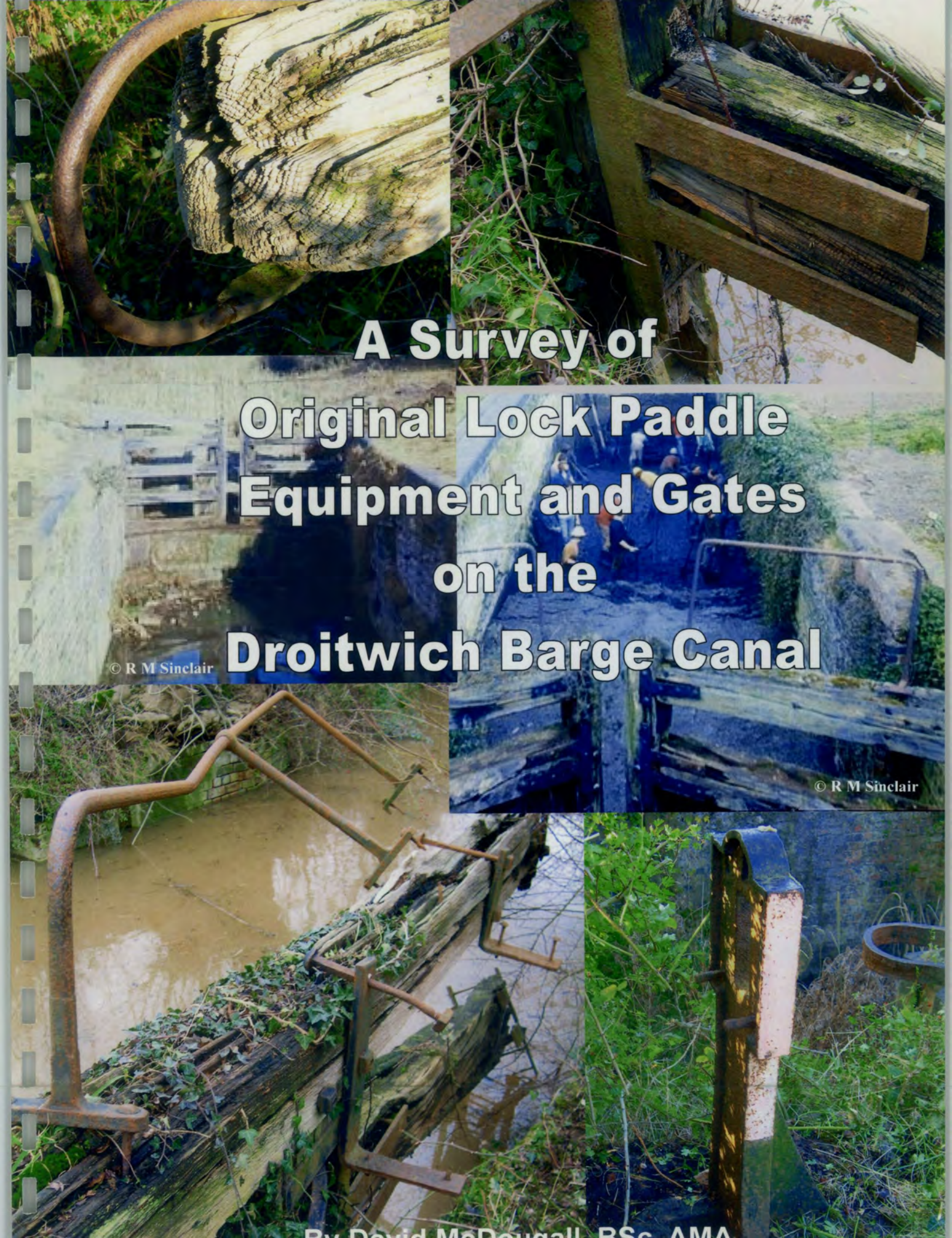


A Survey of Original Lock Paddle Equipment and Gates on the Droitwich Barge Canal

By David McDougall, BSc, AMA

Contents

Introduction

Aims and scope of survey

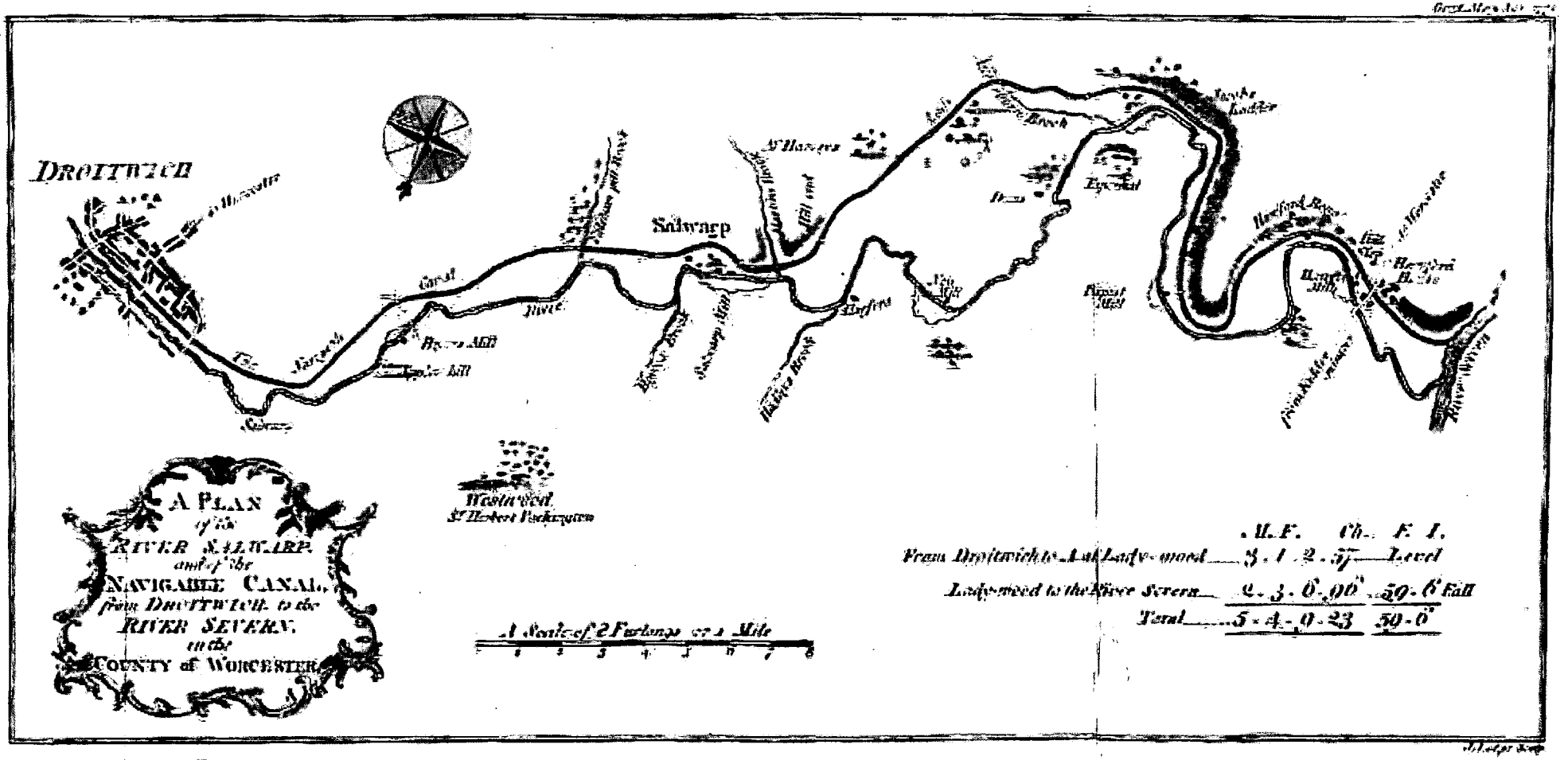
This Industrial Archaeological survey aims to record surviving typical detail of the lock gate structures and ground and gate paddle mechanisms on the Droitwich Barge Canal to inform the restoration process. The survey includes the unique broad lock of the Droitwich Junction Canal at Vines Park, Droitwich, which forms the connection to the navigable section of the River Salwarpe.

The connection to the Droitwich Junction Canal led to early reconstruction of the original 'Brindley' locks of the Barge Canal and changes to their lock equipment in the middle of the 19th century. These changes are highlighted in this survey along with further changes made to the Salwarpe lock at Vines Park due to frequent reconstructions necessitated by subsidence from brine pumping in the town.

Restoration work on the Ladywood flight of locks in the 1970's and 1980's has removed much of the original lock detailing of gates and paddle gear and replaced these with 'foreign' material. This substitution is highlighted as appropriate. Detail recording is concentrated on the surviving original material and features to be found on the unrestored locks Nos 8,7,6 and 5 (the modern numbering system)[1]. Additional material to complete the missing detail has been carefully selected for inclusion from the Worcester & Birmingham Canal locks, gates and paddle mechanisms as these were developed jointly with the Droitwich Canal in later periods of its operation.

Very few really old historic photographs are available. Those that could be located have been used to research further missing details.

[1] See 1.11 Historical Development on lock numbering systems

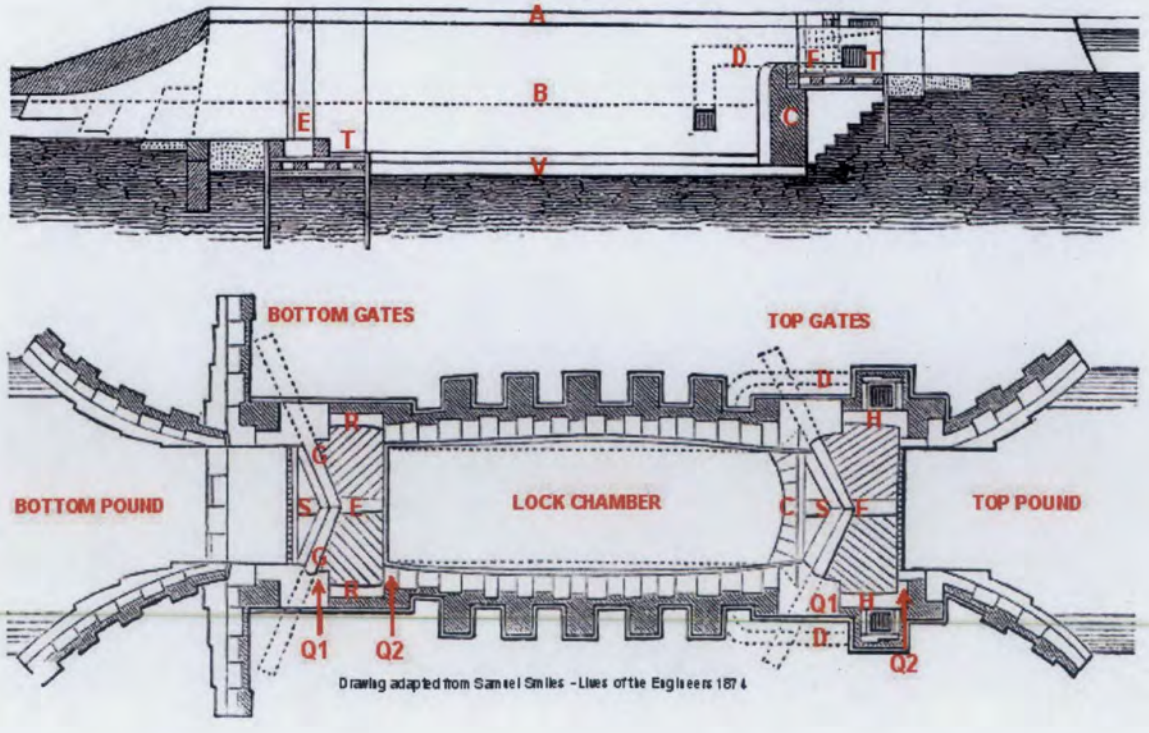


Published plan of the intended Droitwich Canal from The Gentleman's Magazine of 1774. the map indicates 59 feet 6 inches of lockage to meet the unimproved River Severn. Later maps show the lesser total fall to the weir controlled river after the construction of Diglis Locks and Weir.

Lock Nomenclature - Droitwich Barge Canal

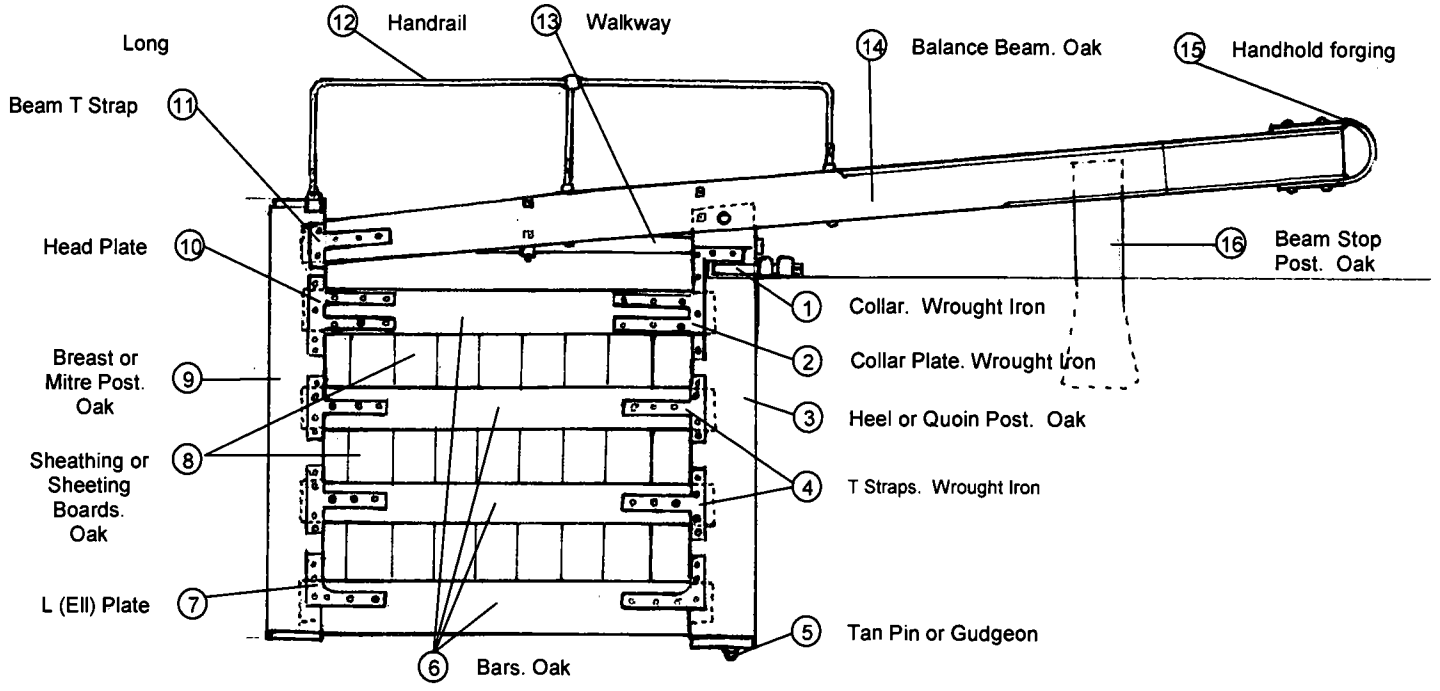
A	COPING	- the capping of the lock and approach walls in large stone blocks
B	CHAMBER WALL	- buttressed and tied back thick brick or stone retaining walls
C	COUNTER ARCH	- the head of the lock supporting the top gate sills
DD	TOP PADDLE CULVERTS	- water passages (trunks) from the top paddle shutters
E	BOTTOM MITRE	- the angled meeting of the bottom pair of gates
F	TOP MITRE	- the angled meeting of the top pair of gates
GG	GATE PADDLES	- lower gate mounted water-control shutters (cloughs)
H	GROUND PADDLES	- upper (top) water control shutters (cloughs)
Q1	HOLLOW QUOINS (4)	- shaped stonework forming semi-circular upright groove in which gate swivels
Q2	SQUARE QUOINS (4)	- end of gate recess and meeting of chamber walls
R	GATE RECESS (4)	- step inwards of chamber walls to allow gate to open fully
S	GATE SILLS (2)	- timber beams set at meeting angle of gates to form seal (cills)
T	GATE BAY FLOOR	- timber or stone structure over which gates swing
V	INVERT ARCH	- stone or brick chamber bottom and foundation of chamber walls. Some early locks have a complete timber floor structure.

Fig 1 Section & Plan of typical river navigation or early canal lock

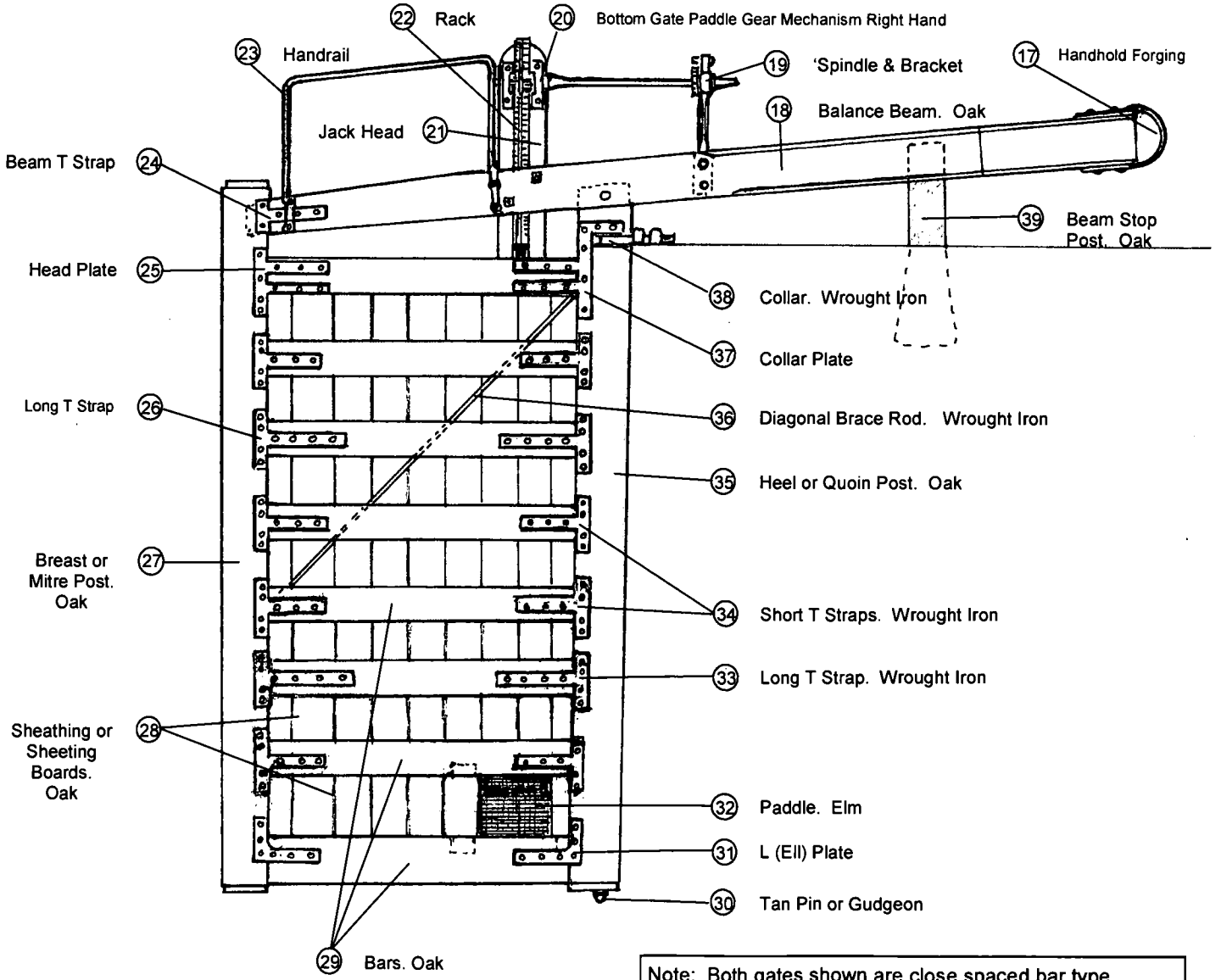


Drawing adapted from Samuel Smiles - Lives of the Engineers 1874

DROITWICH - WEIRED TOP GATE RIGHT HAND



DROITWICH - WEIRED BOTTOM GATE RIGHT HAND



Note: Both gates shown are close spaced bar type.

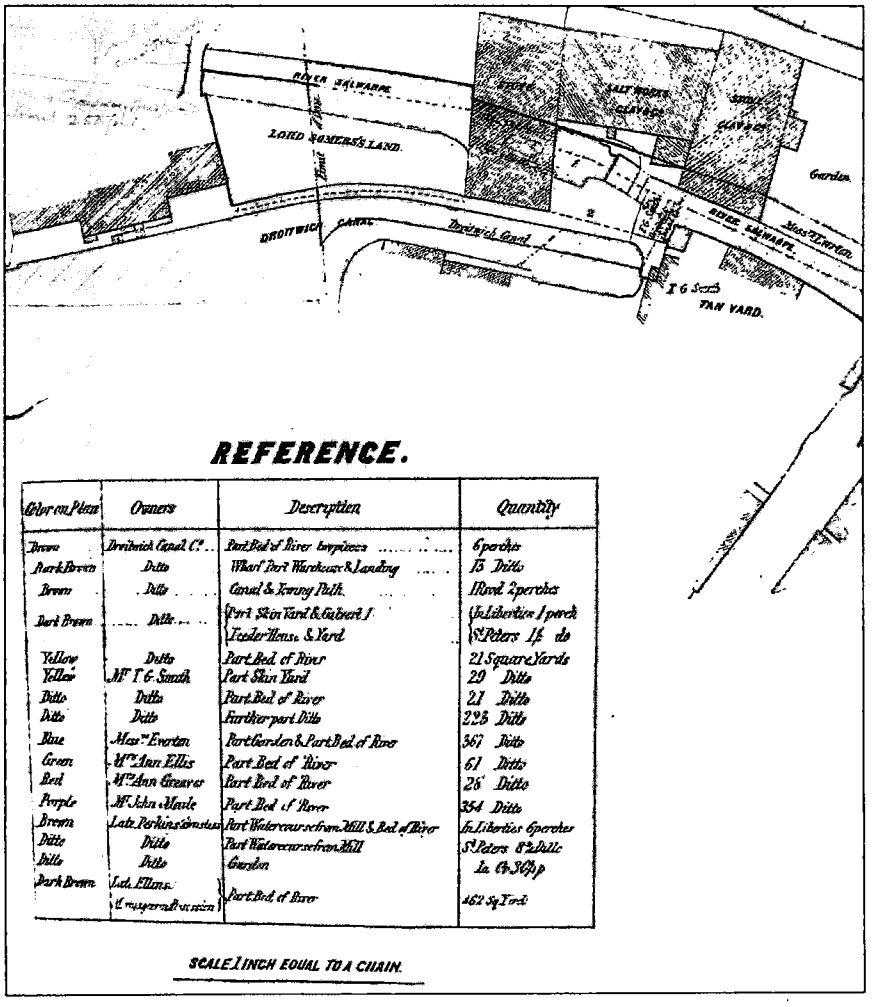
List of Figures in text

List of Drawings

1.1 Droitwich Canal Navigation

1.11 Historical Development of the Barge Canal's lock equipment

The original Canal Navigation from the Severn at Hawford to the salt works at Droitwich was planned by James Brindley to have eight locks of 61/2 feet [1.98 metres] nominal rise, each lifting the canal to the summit level at Ladywood 56 feet 6 ins [17.22 metres] above the Severn. This original scheme had a basin at its terminus alongside the River Salwarpe in Droitwich but no connecting lock. Water supplies were taken from the Salwarpe on Sundays only via a sluice in a valve house at the basin end. (shown on map)



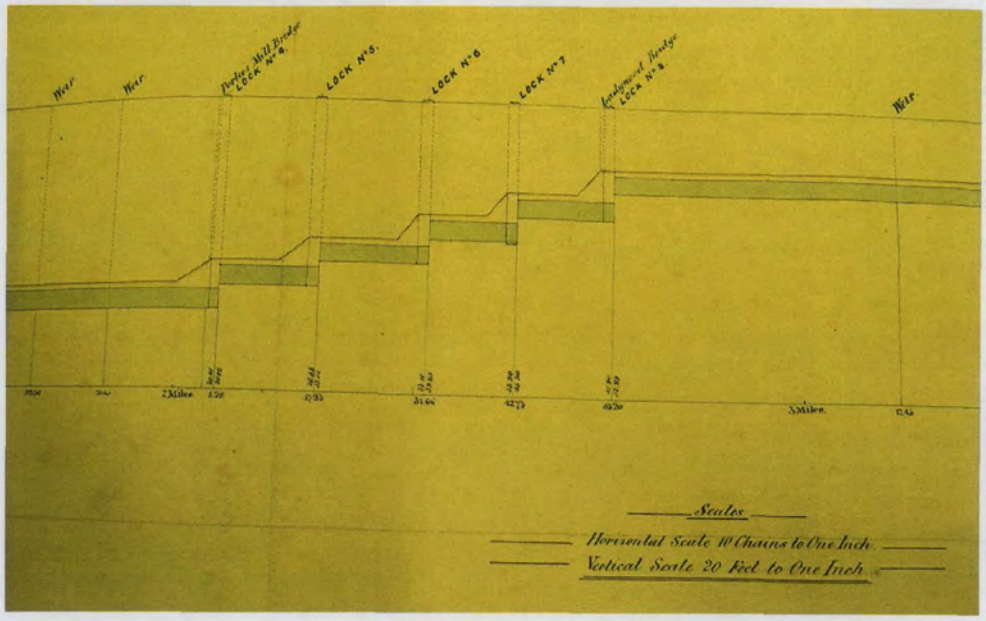
Map of the original terminus of the Droitwich Barge Canal by the River Salwarpe made in 1854 © GCRO

Additional water supplies were obtained from brine pumping in later years. The canal water was always salted to such an extent that common freshwater fish were unable to live in it.[2]

[2] Priestley's Navigable Rivers & Canals 1831

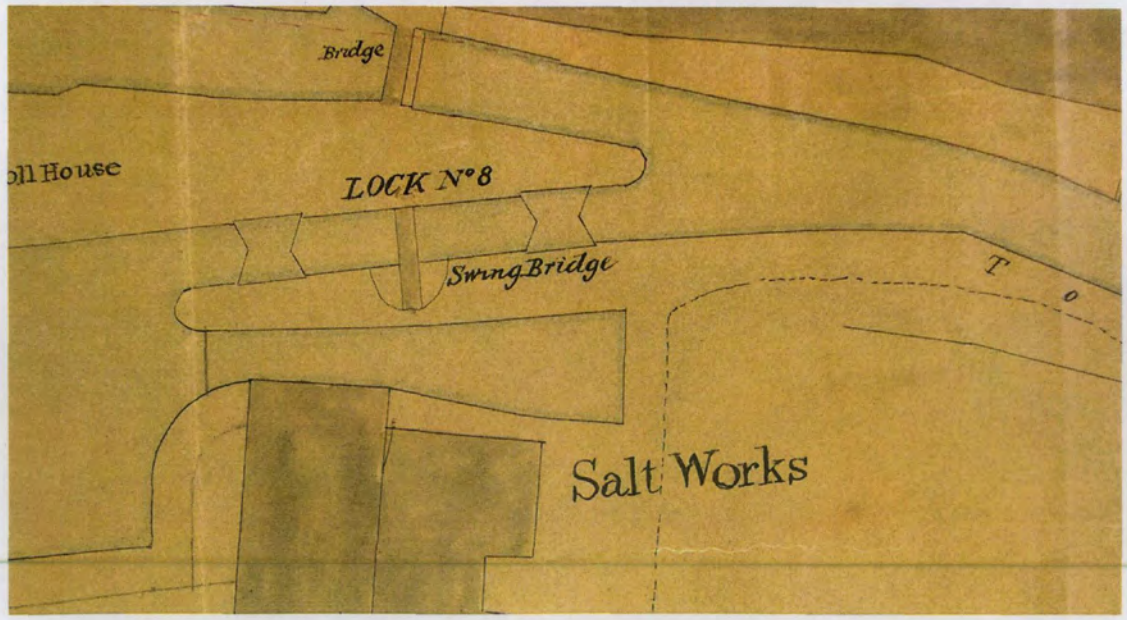
Lock numbering

Brindley's first lock at the Severn (Hawford) was originally numbered 1 (carved in a sandstone block still in situ). This upward numbering system to Droitwich was clearly still in use in 1882 as the chart produced that year of the rises and measurements over the sills taken by W Francis Hobrough, the Worcester & Birmingham Canal Company's engineer, shows.



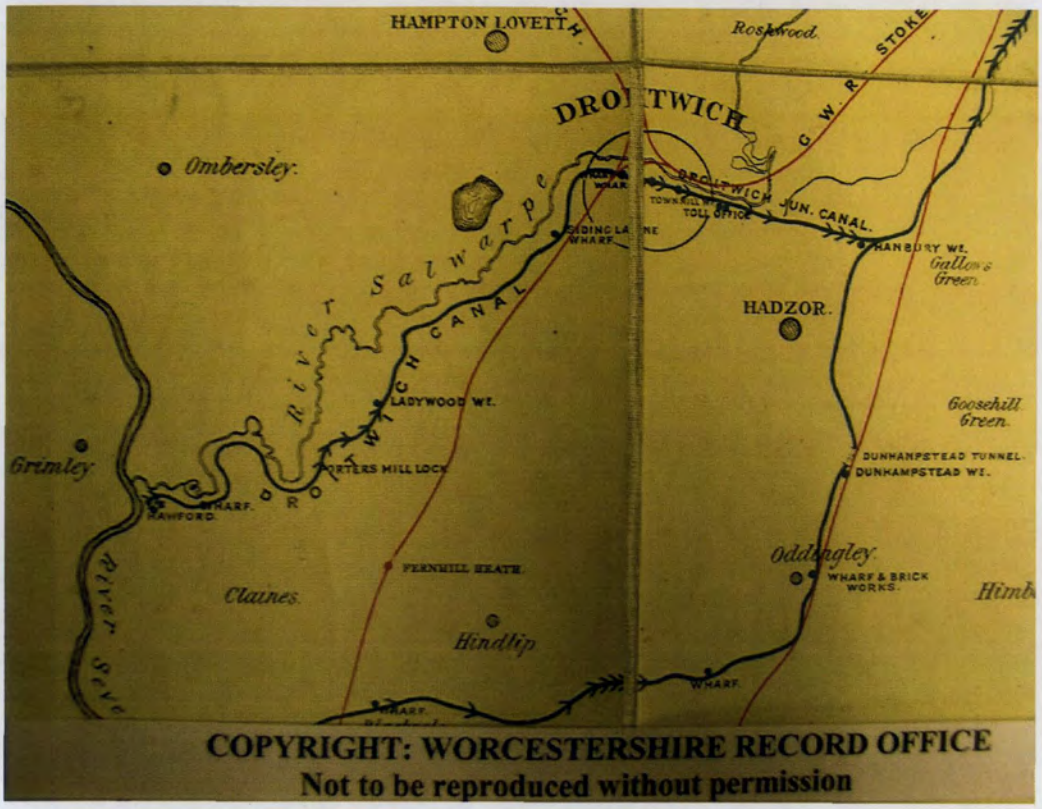
Lock numbers and sill heights above the datum of the bottom sill of Hawford Lock 1 from a survey made in 1882 by Francis Hobrough © GRO

Confusingly, the map of Droitwich basins of 1887 clearly marks the Salwarpe Junction river lock as Lock 8. This was also drawn up by W Francis Hobrough.



Part of map of Droitwich Canal and Salt Works showing the River Lock in 1887 © GRO

HR De Salis publishes a downwards numbering system for the Barge Canal starting at Ladywood as No1 in his Bradshaw's Guide of 1904. The broad river lock at Droitwich is given here as No 7 in the numbering sequence of the narrow Junction Canal working down from Hanbury Wharf Top Lock.



Published plan of the Worcester & Birmingham Canal of 1893
and connection to the Droitwich Canal and River Severn BA 1624/7iv

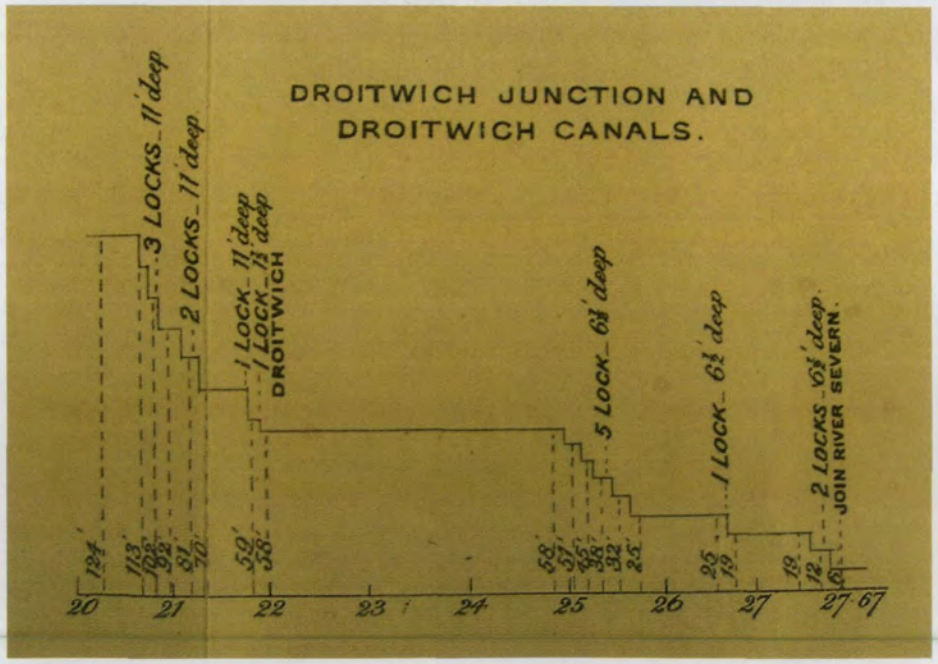


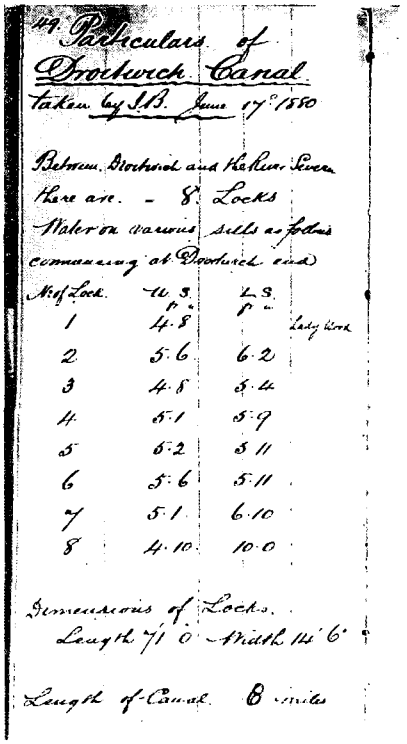
Table of falls for the Droitwich and the Droitwich Junction Canals 1909
© Worcestershire Record Office

Original Barge lock dimensions were quoted by Brindley as 'about 70 feet long by 14 feet wide in the bottom and 15 feet on the surface', giving the chamber walls an outward batter of ½ inch in 1 foot.

There was clear difficulty passing narrow boats through the locks often quoted as only 64 feet long (this probably being the maximum length of a full beam trow able to pass them). The lease agreement of 16th August 1853[3] with the Worcester & Birmingham Canal Company gave consent 'to lengthen and enlarge the existing locks in order to render the said canal more navigable by canal boats of the ordinary class' (narrow boats).

The lock lengthening was carried out in conjunction with the construction work on the new narrow Droitwich Junction Canal and the provision of 'a towing path for use of horses and other animals' and an 'additional supply of water for working the said canal'.

The 1853 lock reconstruction was carried out at the head of each lock by rebuilding the head wall, top stone sill and wooden clap sill for the gates, along with hollow and square quoins, gate recesses and paddle culverts for the top gates. At this date new features introduced were cast iron hollow quoins, stop plank grooves, cast iron paddle stands (Worcester & Birmingham pattern) in place of the original wooden stands and top paddle arches in brickwork. The new paddles were sited below the arches facing uphill rather than in line in the lock approach walls as found on most early canals. Here the paddle mechanisms were far less exposed to risk of damage from boats as well as being safer to operate as they were away from the canal edge.



Particulars of
Droitwich Canal
Taken by J.B. June 17th 1880

Between Droitwich and the River Severn
There are - 8 Locks
Water on various sills as follows
commencing at Droitwich end

No of Lock	W. S. ft. in.	E. S. ft. in.	
1	4.8		Lady Wood
2	5.6	6.2	
3	4.8	5.4	
4	5.1	5.9	
5	6.2	5.11	
6	5.6	5.11	
7	5.1	6.10	
8	4.10	10.0	

Dimensions of Locks.
Length 71 0 Width 14' 6"

Length of Canal 8 miles

The rebuilt locks were capable of taking boats 77 feet [23.45 metres] long by 14 feet 6 inches [4.420 metres] wide. Vessel draft was restricted by the uneven depth of the top sills of the locks. Locks 1 & 3 (Ladywood) had only 4 feet 8 inches [1.422 metres] depth over the top sills at this time.

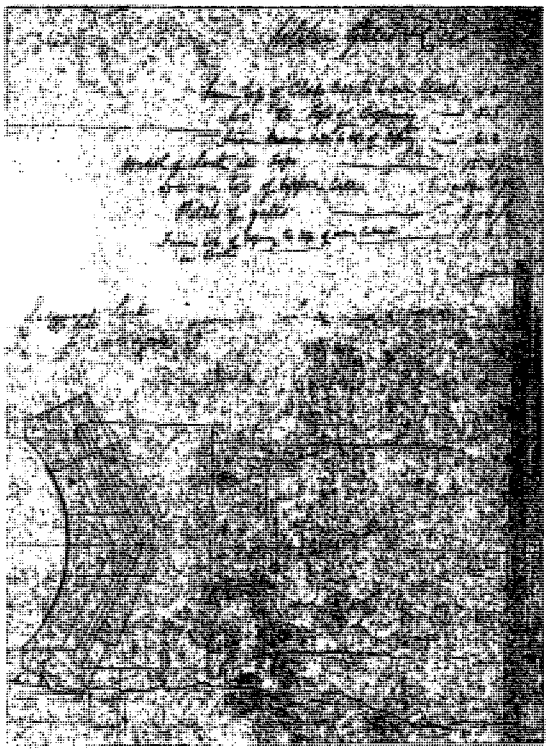
1880 sill measurements numbered from Droitwich
The Severn at Worcester was raised when Diglis Weir was built. This would give extra draught over the bottom sill of Lock 8 which is indicated at 10 feet.
Via RM Sinclair. Original source GRO document not located.

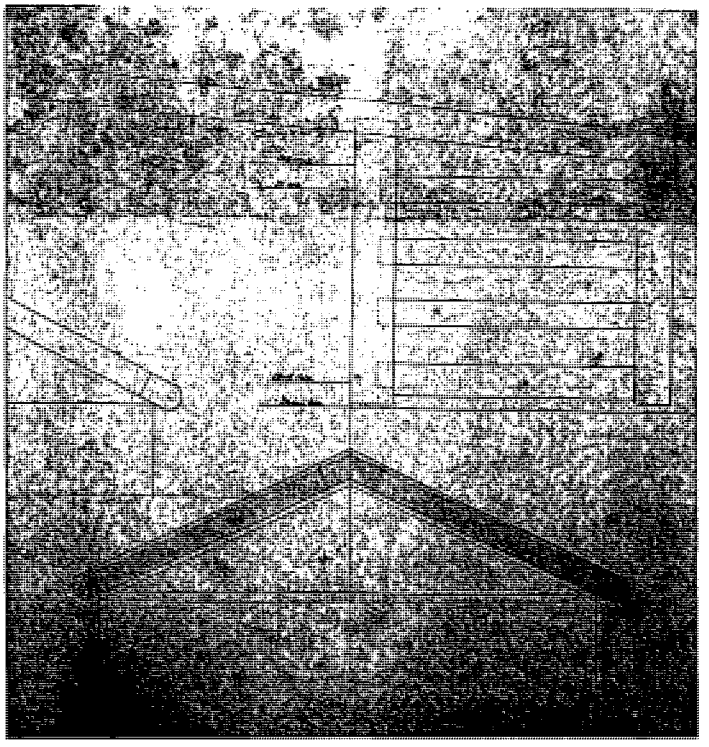
[3] Consent agreement Worcestershire Record Office Acc No 1006 doc 26

After a thorough dredging programme in 1881 under the recently formed ownership of the Sharpness New Docks and Worcester & Birmingham Canal Company, plans were made to lower the sills of the upper gates of all of the Barge Canal locks. This alteration was to provide an even 6 feet [1.83 metres] over sill depth to increase the capacity of the canal to take vessels of 115 tons loading. This improvement was undertaken in 1888-9. Navigable depth was given as 5 feet 9 inches [1.75 metres] elsewhere. Archaeological investigation may show that some of this improvement was carried out by raising the weir levels on some of the Ladywood flight pounds as the lock head sills do not all match in construction detail.

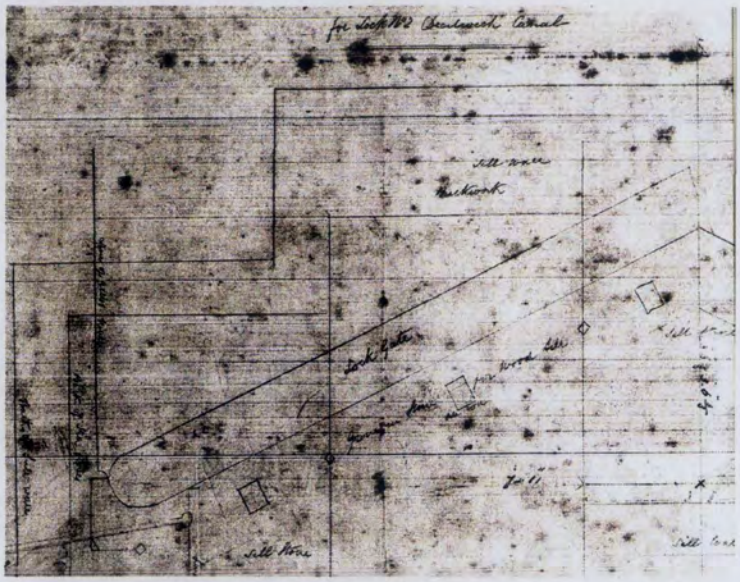
Recent check measurements of sill depths below nominal water level suggest that the supposed 6 feet (1.83 metres) draught was not evenly obtained. Top sills on Mildenham Mill Lock particularly suggest only 4 feet 10 inches (1.475 metres) was available here. (Given as 5 ft 6 ins (1.675 metres) in 1880.)

Drawings survive for this period showing stone sills and gate clap sills for locks No 2 and Ladywood. (Lock 2 here is assumed to be the second up from the Severn at Hawford and not in the Ladywood flight).





The Ladywood lock drawing shows the right hand top gate and both top and bottom sills, the original is at the Staffordshire County Record Office, Stafford Accn No TP 598. (Photocopy only held at the Worcestershire Record Office Accn No 6507/6)



Part of Lock 2 original drawing showing only the bottom sill arrangement. Also on the drawing is a section of the wooden Clap Sill.
© The Waterways Trust Archive, Gloucester
Accn No BW 585/81 (undated).

The Barge canal locks fell into disuse after 1916 and little maintenance was carried out after this. By the time the canal was abandoned some of the paddle gearing seems to have been either salvaged for re-use elsewhere or vandalised and sold off as scrap. The photographs recording the canal in 1939 show little remaining in the way of bottom gate gear and incomplete top paddle mechanisms.

Images from photographic survey of the canal by Worcestershire Highways Engineer 1939. ©Worcester Record Office

1.2 Droitwich Barge Canal Gate Features

Gates still surviving on the canal as remnants, and those shown in photographs still in situ at Ladywood flight until their replacement in the 1980s, exhibit classic early features going back to the construction of the canal, particularly in their original ironwork provision. This matches that originally found on the Staffordshire & Worcestershire and Worcester & Birmingham canal lock gates.

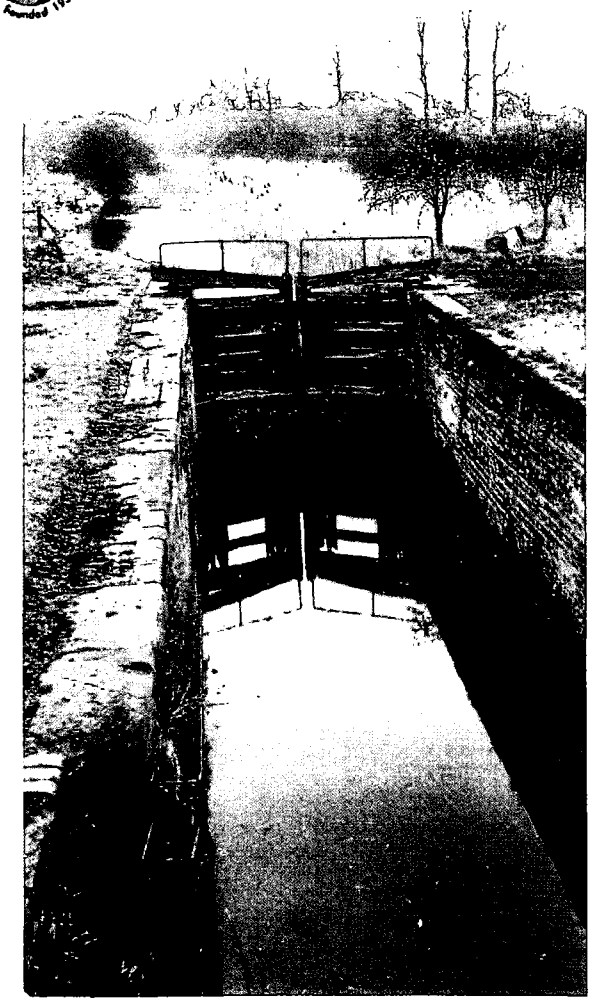
Lock 4 of Ladywood flight in 1912 - the only known photograph of the locks in use. Note particularly there is no reduction gearing on the bottom gate paddles. Photo courtesy of RM Sinclair.

A painting of 1897 showing Lock 2 of the Droitwich Canal by David Bates is one of the few illustrations showing the top gates. Courtesy of RM Sinclair

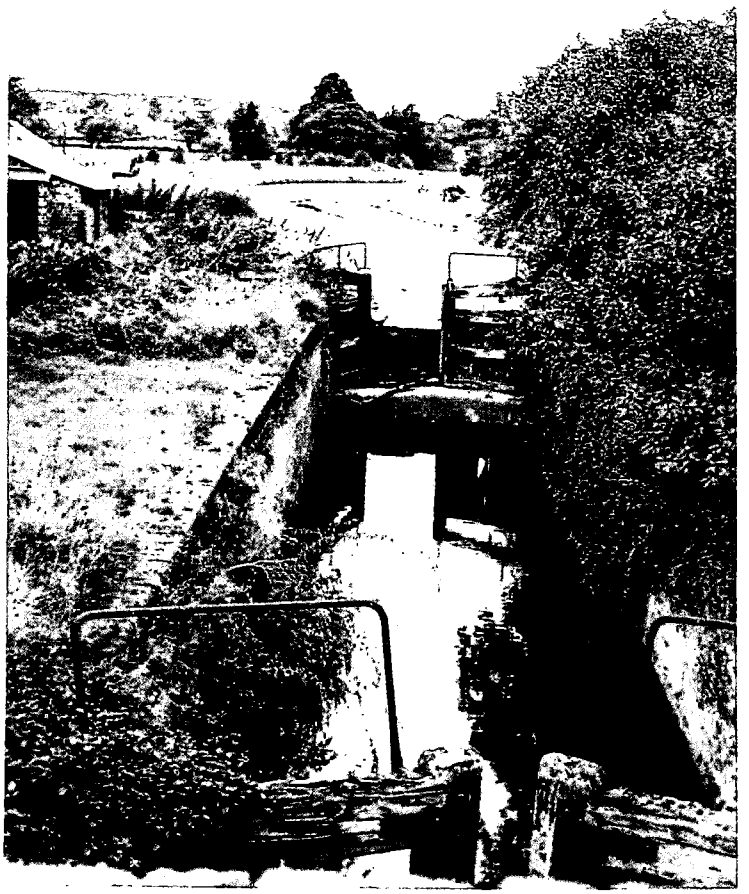
The relatively low rise of each of the locks meant that the bottom gates were not particularly deep or massively heavy. Lower and upper mechanisms were fitted without reduction gearing and paddles themselves were small compared with locks of greater rise.

The lightness of traffic on this relatively little used canal meant that protective diagonal or upright fendering was not considered necessary on the upper gates to protect them from damage so does not appear as a feature.

The upper gates of Ladywood Top Lock, however, clearly differed from the other top gates in the number, spacing and size of its bars. There were clearly 4 bars to these particular gates rather than only 3 fitted on others on the Barge Locks. This may be connected with the lowering of the sills undertaken in the late 1880s.



Ladywood Top Lock No 1 1947
Four bar top gates

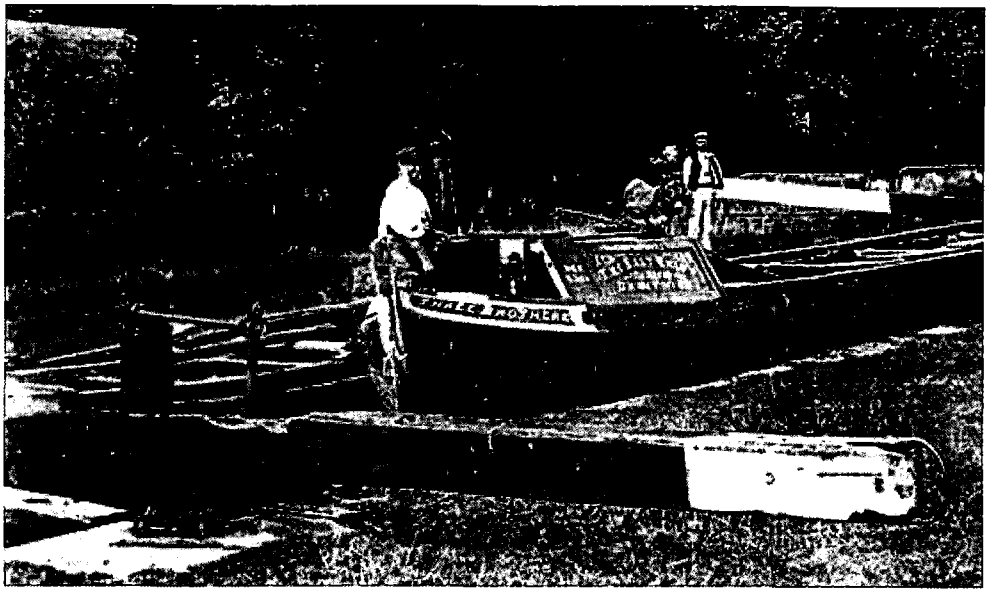


Porter's Mill Lock No 5 1956
Three bar top gates

Both photos courtesy of Railway & Canal Historical Society

1.21 Walkways

Plank walkways were provided on forged wrought iron brackets bolted through the balance beams on upper gates above the gate bay. This seems to have been common to every lock (not Lock 2?) except the Junction Lock at Vines Park. Provision of a walkway for the lower gates seems less widespread. Locks with overbridges at the tail, (Ladywood, Porters Mill and Mildenham Mill) may not have had them. High lower gate handrails were offset on the bottom gate beams suggesting that the beams themselves were used to cross the gates. The one surviving old photograph of Lock 4 clearly shows no lower gate handrails in place, though a walkway is fitted below the gates.



Lock 4 showing lower gate walkway and no handrails 1912

Lock chamber bridges now in situ on Locks 2, 3 and 4 at Ladywood are modern fitments across the lock walls. They have no historical precedent in these locations. This design is not of local or appropriate features.
The Lock 7 bridge in the middle of the chamber is likewise a recent addition.

The Severn lock at Hawford probably had no lower walkway. Paddle gear may have been operated originally from platforms above each lower gate as was common to locks forming the junction with a river. Barge locks at Stourport, Worcester, Framilode and others were so arranged for safety purposes.

1.22 Gate Ironwork

Gates on Brindley engineered canals were exceptionally well fastened at the mortice joints between the heel post, quoin post and the gate bars.

An early Staffordshire & Worcestershire drawing survives at Staffordshire Record Office (No TP598). This identifies and illustrates all the iron strapwork components (plates) for replacement gates in 1830.

Top gate lifted out for replacement showing iron plates (straps) and walkway brackets fixed to the beam with low handrail above.

The forged wrought iron components used on the Droitwich lock gates are probably all replacements fitted on re-gating by the Worcestershire-Birmingham Company or later by the Sharpness New Docks concern. It is likely that the iron forgings and fire-welded straps were made up in the company workshops at Diglis Yard or in Gloucester Workshops, both of which had large blacksmithing facilities. Gate repairs are known to have been carried out at Stoke Prior Workshops. Gate replacements at 35 year intervals make it very unlikely that any Brindley ironwork could survive in situ. No steel components have been spotted on the gates. This is as expected due to their age and that no repairs were undertaken after the canal went out of use.

The salt water nature of the canal due to brine pumping would give steel a short life in service even if it were thickly galvanised, as salt would seek out any bare metal such as on screw threads. Most iron strapping or plates are hot riveted through the oak gate structure. This gives tight fixings at the same time as slightly charring the oak which slows down tannic acid corrosion of the iron in contact with the wood.

Collar straps (plates) See Drawing No 11a (and balance beam Drawing 6)

These distinctive double strap 'F' shaped fittings give a very stiff fixing through the top bar of the gate and fit over the collar hole cut in the heel or 'quoin' post. The riveted over pins fixing the two plates together (5/16" (16mm) diameter) are formed into slight countersinks to give sound nearly flush heads.

Wrought iron stock size is 3 inches wide by ½ inch (75mm x 12.5mm) thickness. Joins are made by fire-welding at the right angles.

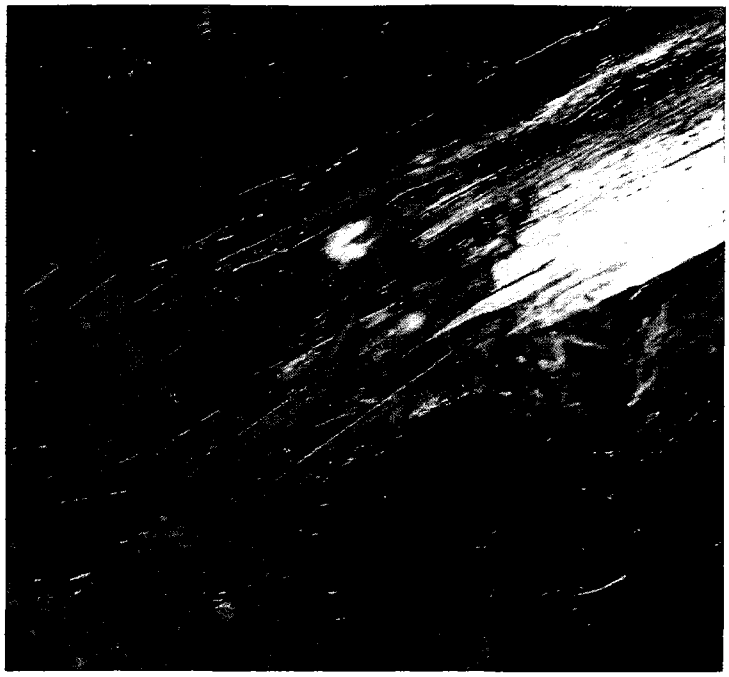
The collar strap is a distinctive and functional feature of these large gates. In addition to the extra bracing obtained by this double strap, the 'L' feature holds together the quoin post over the collar hole and helps to prevent splitting and shrinkage cracking of the tenon joint above. These plates are recessed into the bars, planking and quoin post each side to lie flush with the timber surface.

Collar plates still in situ on Lock 7 top gate

Head straps (plates) See Drawing No 11b (+ balance beam Drawing 6)

The matching fitting for the mitre post to top bar joint is an 'F' shaped pair of wrought iron straps having no 'L' extension. This double strap gives the same advantage in stiffness as the collar plates above. Iron stock size is again 3 inches wide by ½ inch (75mm x 12.5mm) thickness. The upright component on the inside of the mitre is reduced to 2½ inch (62.5mm) width to reduce

weight and fit the mitre better. Wrought iron pins are hot-riveted through to provide tight fixings as above.



Head straps or plates in situ on upper gate of Lock 7. This is sitting on the tie rod below.
© David McDougall

'T' straps (Tee plates) See Drawing No 11b

Three different sizes of 'T' plate or strap are fitted on the original gates of the Droitwich Canal Barge Locks.

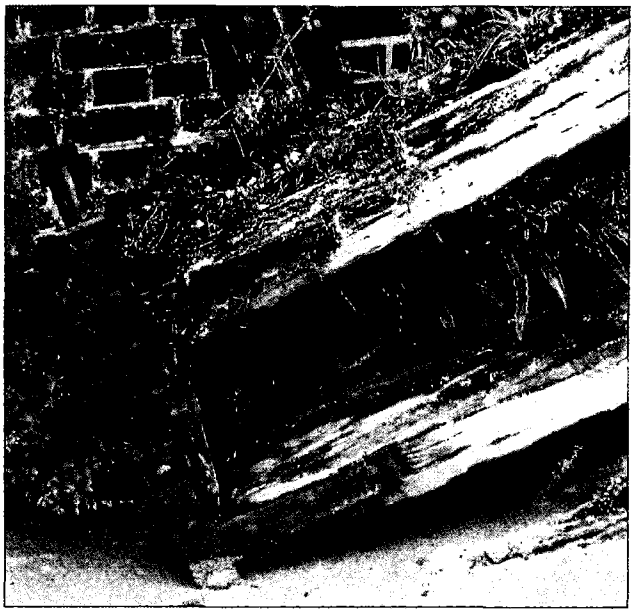
Angled 'T's provide the beam fix to the mitre post mortice and tenon joint. These are cut and fire-welded at the angle the balance beam makes with the mitre post to stay on the centre line of the beam end. Iron stock size is 3 inches width by ½ inch (75mm x 12.5mm) thickness. These 'T's are through bolted on the uphill side to allow damaged beams to be replaced. The 'T's appear to be recessed into the balance beam as with other plates.

Angled 'T' plates fixing the balance beam to the mitre post top gate Lock 7

© David McDougall

Long and short 'T' plates are used for the gate bar to 'quoin' and mitre post mortice and tenon joints. Long 'T's have a 4 pin fixing through the bars, short 'T's having only 3 pins on this arm. Iron stock size is 3 inches wide by ½ inch (75mm x 12.5mm) thickness. The right angle arm joint is fire-welded in the wrought iron. Pins are countersunk and hot riveted through. These 'T' plates are recessed into the planking, quoin post and mitre post to lie flush with the woodwork. The upright part of the 'T' is set further towards the hollow quoin and mitre than is the case with the collar and head plates as they are shorter.

Long 'T's are used in pairs each end of the bars on the lower gates giving extra stiffness.



A pair of short 'T' strap assemblies on collapsed gate at Mildenham Mill Lock 6
January 2007
© David McDougall

'L' straps (Ell plates)

Drawings indicate that the bottom sill bar fix is with a pair of wrought iron right angle plates with hot riveted wrought iron pins as other construction strapping. No example has been located for measurement. Any saved by the Droitwich restorers would have been weighed in for scrap along with all other salvaged ironwork at the DCT depot.

Samples will be found on the remnants of gates in locks 5, 6, 7 and 8 as the chambers are cleared. Some should be retained for measurement and recording.

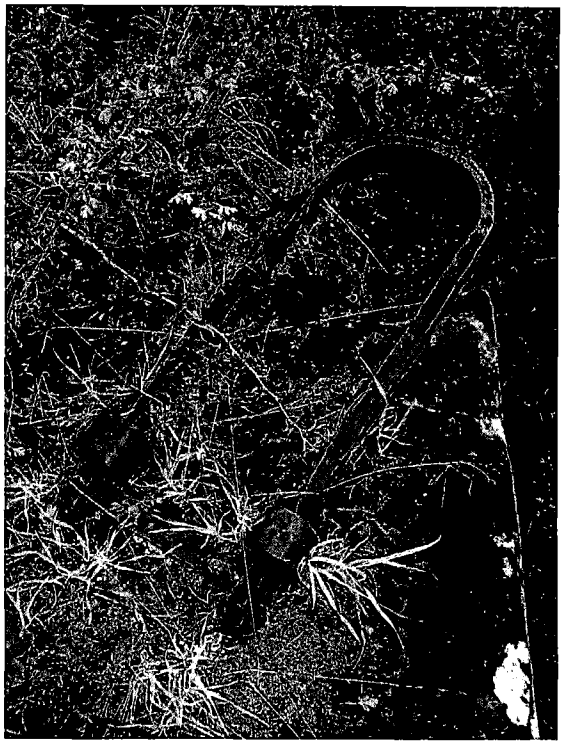
Derelict gate Lock 1 at Ladywood showing iron straps and 'L' plates in lower corners
© RM Sinclair

Collars

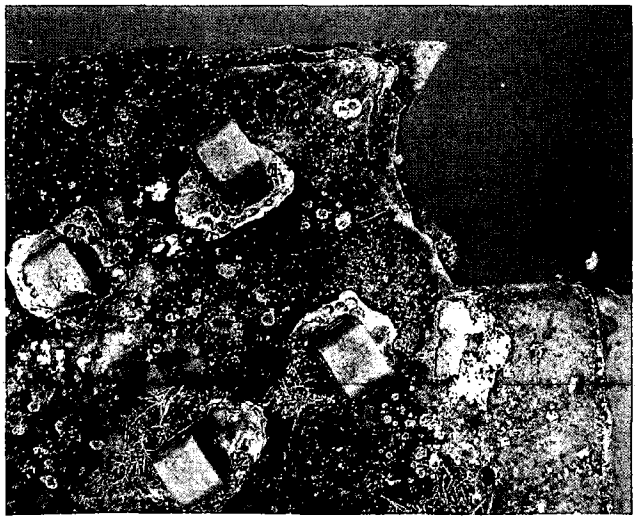
Wrought iron collars are still in situ on many of the derelict locks. Measurements show that they are bent to take a 10 inch (250mm) full thickness gate measured on the quoin post rounding.

Collar forgings are from 3 inches (75mm) width by 1¼ (32mm) thick wrought iron, flat stock, square-edged with no change of section. The extra long horns are slot punched near the end to take a tapered cotter or wedge plate. Slots are 2¼ inches (57mm) long x ¾ inch (20 mm) wide, 1 inch (25mm) from the ends of the horns.

Collar forging at Mildenham Mill Lock 6 retaining replacement top gate.
Note cast iron quoin.



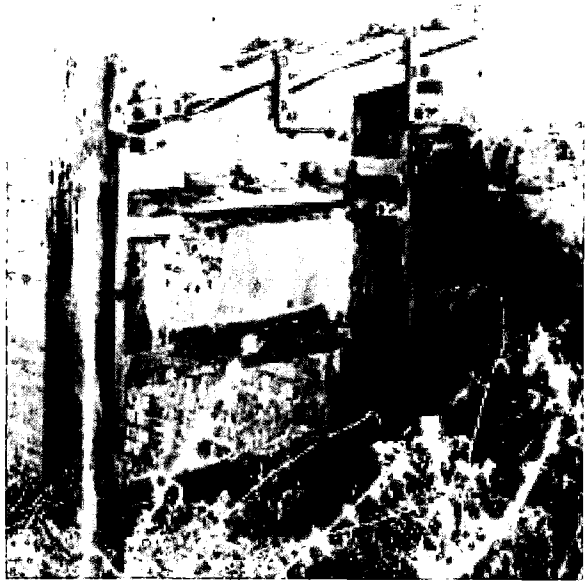
Collar forging in situ at Hawford Lock 7.
Two of the staples have sheared off.



Staples for the collar forging are double each side. Many of these have broken away. Molten lead holds the iron staples into the stonework of the quoin coping.

Tie rods (tie bars)

The gate bar mortice and tenon joints are pulled hard together by horizontal wrought iron square section tie rods or bars threaded each end with large hand wrought square nuts let into recesses cut in the quoin and mitre posts so that they do not protrude. The upper tie bar is let into a square groove cut for it on the underside of the top gate bar making it largely invisible in most photographs. The wrought iron bar section is 5/8 inch (16mm) square forged into a coarse hand made thread for the nutted end at the mitre post. Examination of the quoin post rod end was not possible on the only original gate still intact (top gate lock 7).



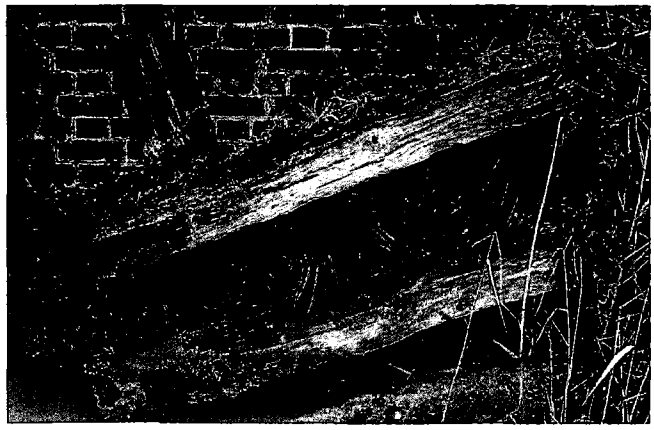
Top gate Lock 4 in 1965. Tie rod below top bar comes through the mitre post into a square hole for the nut. Tie rod is hidden in a groove in the bottom of the top bar.

Further tie rods are set just above the bottom gate bars (sill bars) on top gates, and top, middle and bottom bars on lower lock gates.

Correspondence of the nut recesses in a pair of gates is likely to provide a leakage point under water pressure. Wooden plugs were probably fitted to reduce this when the gates were new.

Diagonal braces

Lower gates only were fitted with a single wrought iron diagonal bar threaded through the aligned holes bored on the centre line of the top four bars of the gate. These help to prevent sagging of the gate structure when hung in the lock. The bars run downwards from the quoin post to the mitre post, this being the most effective position. See Drawing No 5.



Collapsed lower gate at Mildenham Mill Lock 6 showing diagonal brace through bars.

Historic drawings of the Diglis Basin barge locks indicate that this was a common feature of wide gates engineered by the Worcester & Birmingham Canal Company and its successors. Diglis Basin locks still have these.

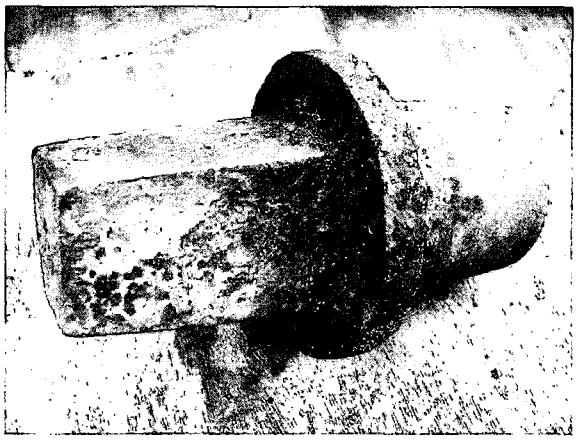
The aligned bored holes are difficult to produce. The usual modern technique is to fit a flat strap in more easily cut recesses behind the gate planking.

Tan pin (or gudgeon)

A salvaged pin was available for measurement of this vital component forming the pivot at the bottom of the gate quoin post.

This old casting at Droitwich DCT Depot was measured and is shown in Drawing No 13.

This is a spare casting left over from re-gating of the locks on the Ladywood flight in the 1980s (Nos 1, 2, 3, etc) and is the common form of large gate pin.



Tan pin at Droitwich Canal Trust Depot 2007

No pivot or tan pin cup has been measured owing to flood water in Lock 7 at the time of survey for this report. Measurement would be advisable as a check for the fit of this old pin before others are ordered for new gates.

1.23 Balance Beams (See Drawing No 6)

Balance beams on the lock gates of Brindley's canals were originally termed 'sway poles' suggesting they were rough hewn from large section trees using the extra balance available from a tree's natural growth (larger at the base of the trunk). They may have been fixed to the gate structure rather than integral with it (See 2.23 Balance beams).

Top gate beams particularly needed a slight curve away from the chamber so that full width boats did not foul when entering or leaving a full lock. This could be obtained by picking a curved tree or by manually sawing a curve at the sawpit used to cut the beam to size.

Machine sawing, except on a bandsaw, produces straight cuts so replacement and modern beams tend not to have graceful curved shapes as did original old beams.

Oak beams seem to have been favoured on the Droitwich Canal for their weight and durability. A single example has survived practically intact for measurement on the top offside (right hand) gate of Lock 7 at Hawford. This matches well the beam shown in the only photograph of the canal at work (Lock 4) which suggests that similar beam sections were in use for top and bottom gates.

Beams were mounted conventionally on the quoin post with a mortice and tenon joint secured with bolts – one fixing being that of the deepest walkway angle bracket. Beams are mortice and tenon jointed into the head of the mitre post with a pair of angled T straps (plates) bolted through either side. (See Drawing No 11b).

The Lock 7 beam is considerably decayed but measured up at 11 x 12 inches (280 x 305mm) on the outer end shaped half round under the handhold forging. The beam tapers in thickness to the mitre post after the curve of the offset (crank) running at 11 inches (280mm) wide over the quoin post down to 10¼ inches (260mm) under the bolted T straps.

Beam depth also reduces to save weight at the mitre post.

Precise measurement of height of the joint could not be recorded due to decay – 9 to 10 inches (228-254mm) seems likely.

Top gate balance beam at Lock 7 has a curve offsetting the beam by 12 inches (300mm) at the end. The handhold is forged from D section wrought iron and riveted through the beam depth.

1.24 Beam stop posts

Beams stops set in the ground on the lockside appear to have been an early feature of the canal. Evidence for this appears in the oil painting of Lock 2 by David Bates dating from 1897. Oak posts seem to be set by the top gates as position stops. This feature was found on the Stroudwater and Thames & Severn Canals (both similar wide waterways). It is suggested that these had a function to prevent gate distortion and failure if they were misaligned on closure. The beam stops would make sure the gates met correctly when shut. No photographs are available showing this feature: some archaeological evidence may be found on careful cleaning up of the lock sides in the form of rotted posts and post holes. Careful consideration of the function and safety of these features is required before they are omitted on restoration.

David Bates' oil painting 1897

1.25 Handrails

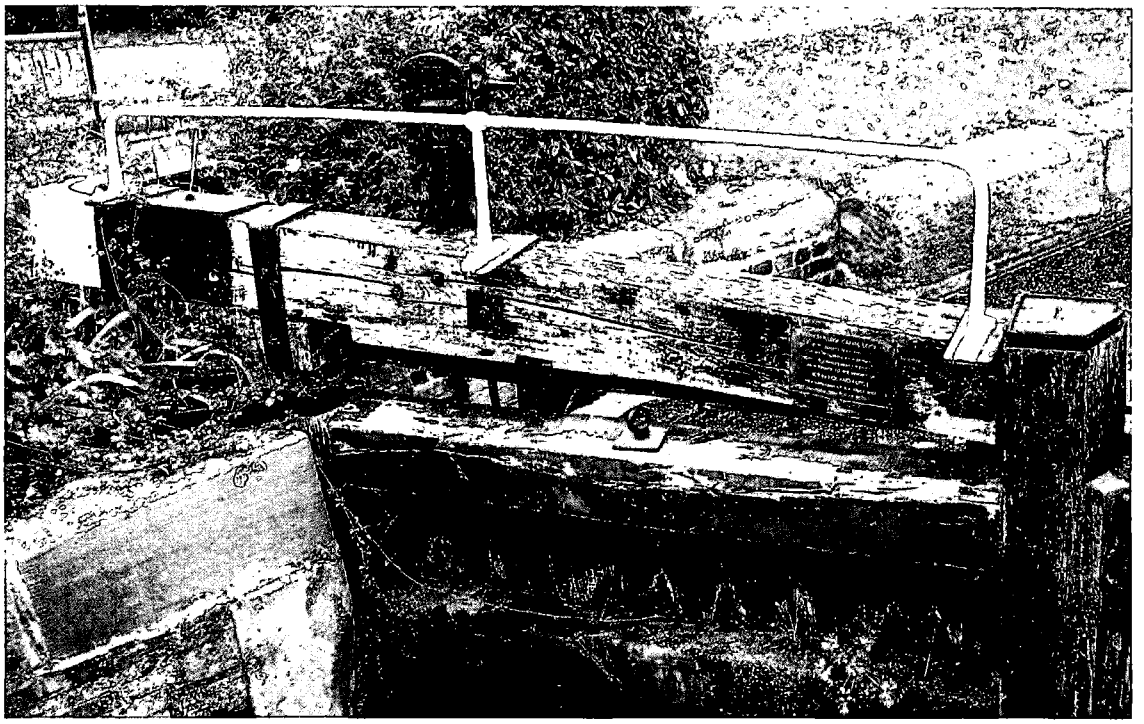
Original Brindley fitment handrails were probably timber; no evidence of them has been found.

Three basic iron handrail designs have been identified on the locks. Each has the appearance of Worcester & Birmingham manufacture as design features match those on locks at Worcester Diglis Basin.

Diglis Locks, Worcester. Worcester & Birmingham made handrail in wrought iron

All handrails are of forged wrought iron having interesting detailing imparted due to their fire-welded construction. The section change from square via octagonal to round is well-formed on each stanchion.

The simplest handrail design (Drawing No 6a) is a low top gate rail with 3 2 bolt through fixing stanchion feet to fix on top of the balance beams. Stock size is 1¼ inch (32mm) diameter, overall length 10 feet (3.05 metres). These handrails are designed for use with a low set walkway. The only examples on the canal are recycled and fitted on the cranked beams of Lock 1 Ladywood. Here they are fitted on angle brackets to position them for use with the walkway fitted on the uphill side of the bottom gates. Similar handrails are to be found in situ at Diglis Basin Locks.

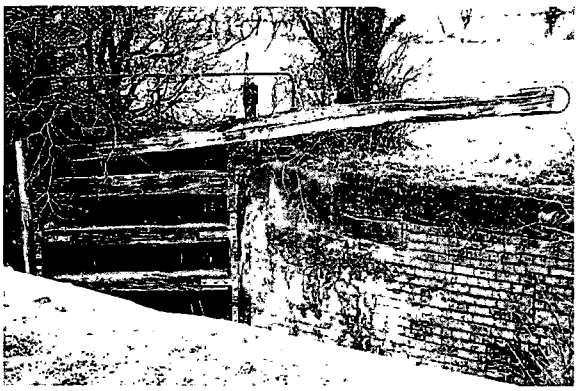


Lock 1 at Ladywood has recycled handrails from upper gates fitted on the cranked bottom gate beams.

The more usual top gate handrail (Drawing No 6) is considerably higher and sits on top of the mitre post to which it is coach screwed through the saddle forging integral with the end stanchion. The centre and other end stanchions terminate with similar blacksmith forged fire-welded feet for 2 bolt through fixings as on the low handrail above.

Certain photographs show additional strapping used to secure this handrail at the mitre post suggesting the coach screw fixing was subject to failure due to wood rot weakening of the screws. This may be the major reason for the surviving handrail being severely bent in situ.

Ladywood Lock top gates with high iron handrails 1965



Lock 7 1965 top gate right hand

Photos © RM Sinclair

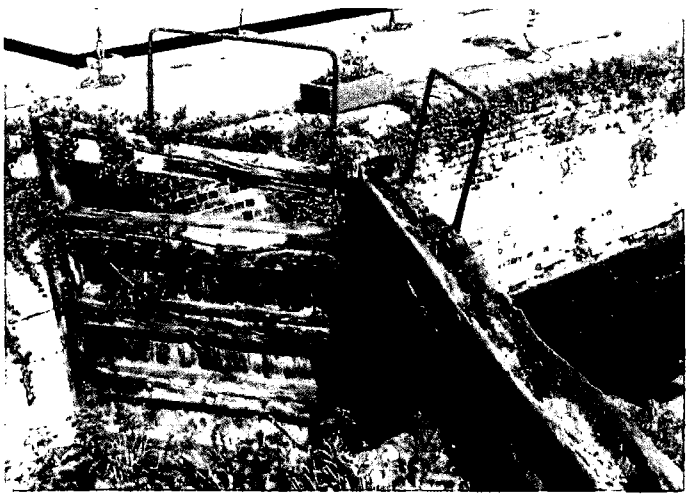
Lock 7 surveyed handrail on top gate

© David McDougall

Stock size is again 1¼ inch (32mm) diameter wrought iron bar, handrail length 10 feet (3.050 metres). Bolts securing the handrail through the depth of the balance beam are 5/8 inch diameter.

Bottom gate ½ length rail (Drawing No 7 and 7a)

These 5 foot (1.525 metres) rails are offset on the beam and recessed into the top surface to allow the beam to be crossed to access either side of the lock in safety where walkways are not fitted. The paddle gear extension spindle of the bottom gate gear acts as a further handhold for the other half of each gate. Photographs show these rails fitted either on uphill and downhill sides of the beam.



Bottom gate handrails at Porter's Mill Lock 1971
Arthur Watts' photo
© Waterways Archive Gloucester

The Lock 7 rail measured is from a downhill fit. As these handrails are handed they are capable of being used either way as desired. Their height suggests they are only designed to be fitted on gates where 'walking' the beam was required.

1.3 Paddle Gear Mechanisms

1.31 Ground paddle mechanisms

Brindley's original wooden mounted ground paddle stands and mechanisms were replaced after modification work on the locks to lengthen them and alter the sill depths. A standardised version of the Worcester & Birmingham Canal cast iron replacement paddle stands was substituted as a modernisation and to provide easy ongoing maintenance through part interchangeability.

1.32 Original form

There is no photographic or drawing evidence of the original wooden jackhead design or rack configuration. It is considered likely that a design similar to those simple mechanisms fitted on other Brindley canals constructed in his lifetime such as the nearby Staffordshire & Worcestershire Canal or the remote Chesterfield Canal would have been utilised.

Wooden ground paddle jackhead on Wolverhampton Locks BCN 1981
© David McDougall

Top: Staffs & Worcs Canal wooden ground paddle jackheads 1977 Swindon Lock
© David McDougall
Bottom: Whitsunday Pye Lock 1970
Arthur Watts Collection
© Waterways Archive Gloucester

Drawing No 2 shows a typical arrangement with no reduction gearing. This layout is nearly identical to the wooden jackheads known to have been on the lower gates of the Droitwich as it went into disuse.

The oak posts continue through the stone or brickwork over the paddle arches and form part of the wooden paddle frame below. Tapered spindles on the rack pinion would be to fit a large throw windlass (probably cranked). Original racks were probably fitted with offset teeth but may have been of larger tooth pitch than the 1 inch (25mm) standard fitting now widely used.

The 5 or 6 tooth spindle runs in two forged wrought iron or cast frames bolted through the wooden jackhead post. Racks would either bear against a slipper block or small roller set into the woodwork behind the rack ensuring that the teeth remain in correct mesh. Lower gate gear contains a small roller.

Staffordshire & Worcestershire Canal upper paddle jackheads were heavily iron bound with 2 rolled D sections to prevent damage from boat lines and splitting of the timber in service. It is not known whether this feature is the original form of strapping or a later addition or whether this was also found on the Droitwich locks.

1.33 Worcester & Birmingham Canal modification (Drawing 1)

Ground paddle gear in cast iron was developed to replace wooden paddle stands or jackheads during the 19th century. The advantage of this was its longevity as there was no timber post at water level where rot would form shortening the life of a wooden stand.

Cast iron stands were common replacements on the canals of the Shropshire Union system, the Birmingham Canal Navigations, Kennet & Avon Canal, etc. The date of introduction to the Worcester & Birmingham Canal is unknown. The design is the Worcester & Birmingham Canal's own and is unlike any other. This design has not been utilised elsewhere on the canal system unlike the Shropshire Union / BCN derived pattern which has become standardised and is now to be found throughout the West Midlands and North West narrow waterways.

It is important to retain the individuality of each waterway under restoration and utilise, if possible, original detailing.

The cast iron paddle stands original to the modified Droitwich locks 8 and 7 (Hawford River lock and above) are still in situ, though stripped of their mechanisms' components. The basic castings standing are considered capable of re-use with new gearing, racks and catch components which are standard Worcester & Birmingham Canal parts. The bearing frames, however, seem from measurement to be larger than standard; it appears that components from elsewhere are now being used as replacement parts. A double check of the compatibility of these is required. No reduction gearing was fitted to these original units.

Lock 5 (Porter's Mill) and 6 (Mildenham Mill) have lost their cast iron paddle stands and will need replacements as these are missing.

1939 record photograph shows rack stripped from this stand at Lock 4
© Worcester Record Office

Square ended alternative stand at Diglis Basin Barge Lock with original components
© David McDougall

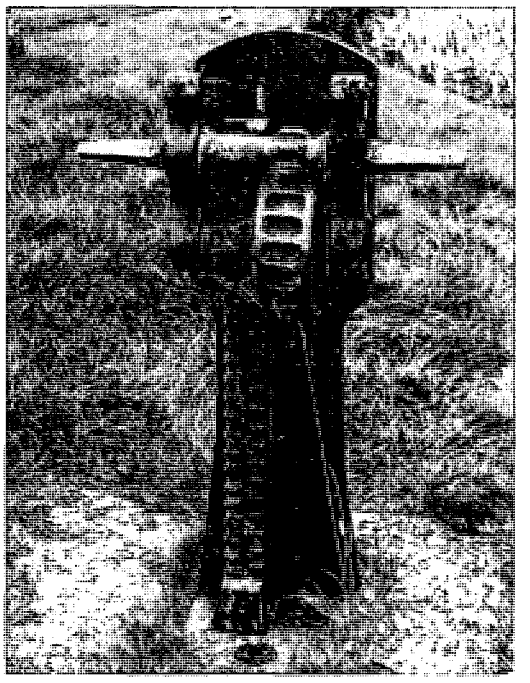
Lock 7

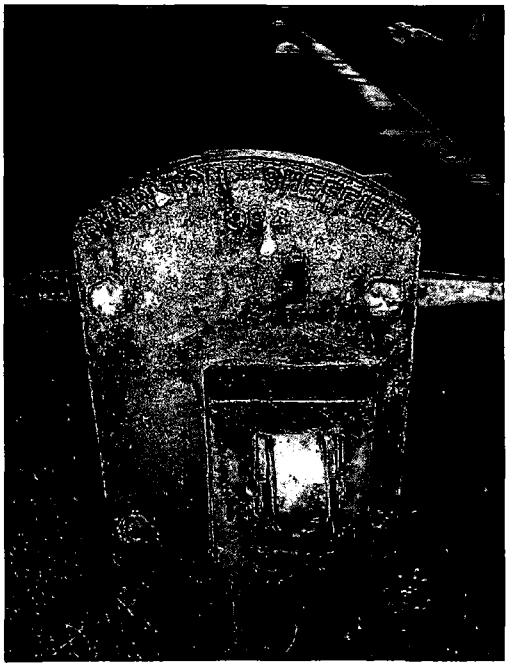
Lock 8

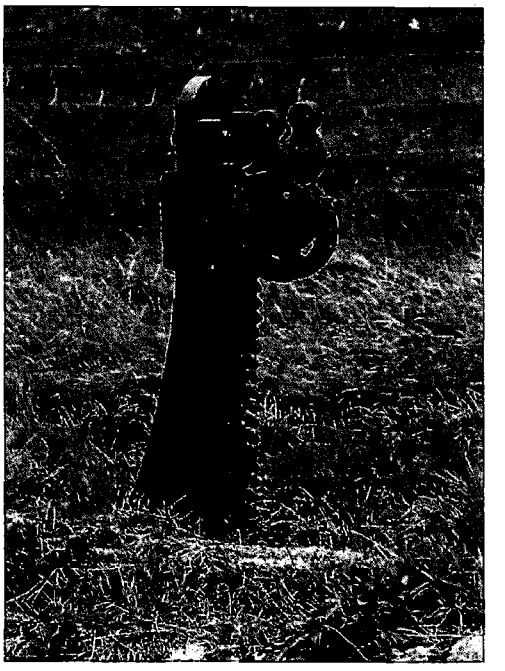
Original Worcester & Birmingham Canal type cast iron stands are in situ on Locks 7 & 8 stripped of their gearing and racks but are capable of refurbishment.
© David McDougall

1.34 Replacement Paddle Gear

Locks restored on the Droitwich have been fitted with standardised Shropshire Union / BCN castings which take a reduction set of gears usually found on bottom gates. These were cast by Charlton of Sheffield and fitted in 1984. Gearing gives a 5:18 reduction (1:3.6). Double taper spindles of 1 inch square taper with 5 teeth are fitted.

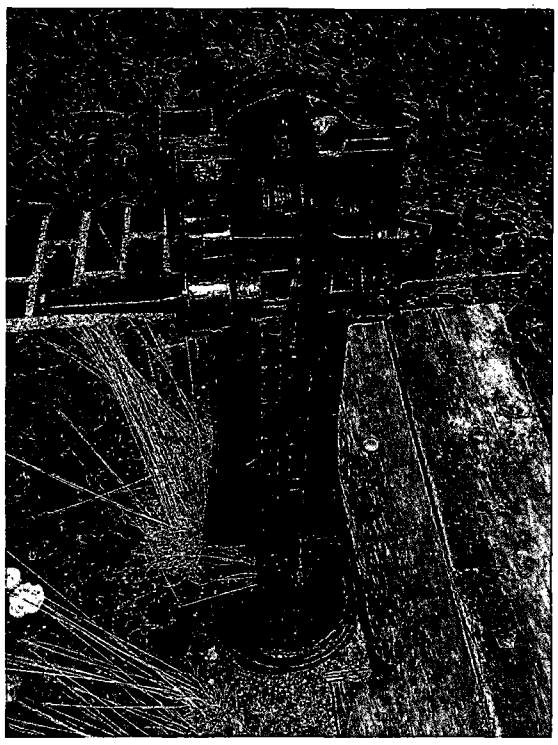


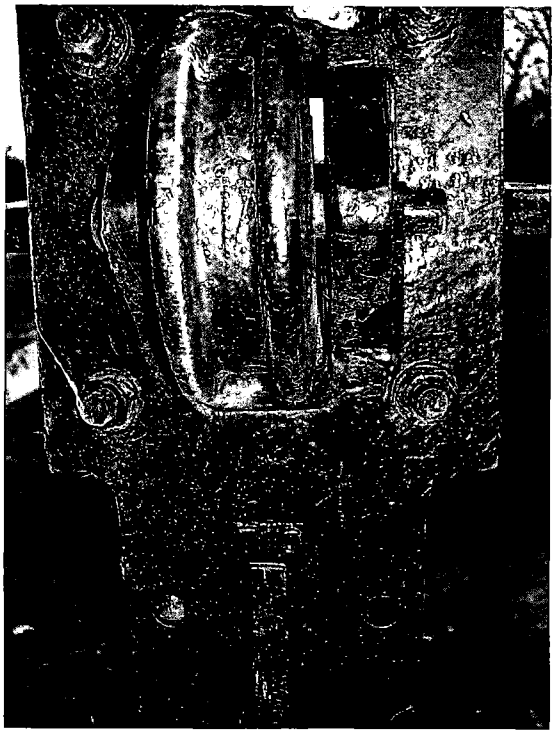


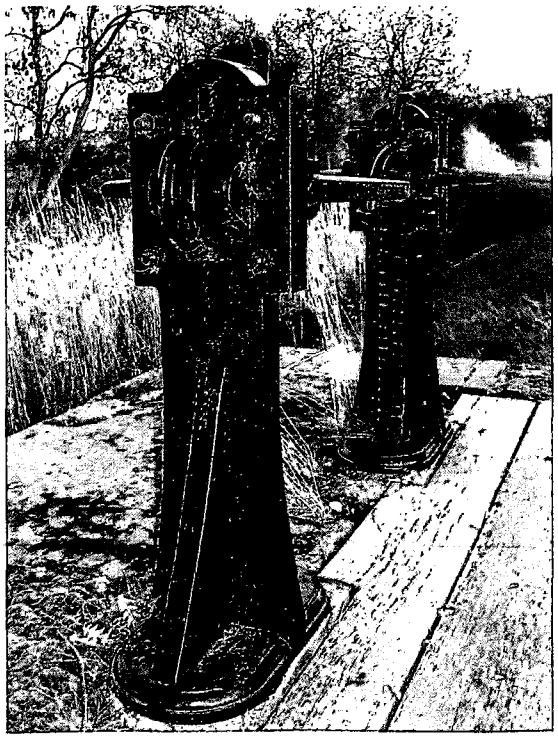


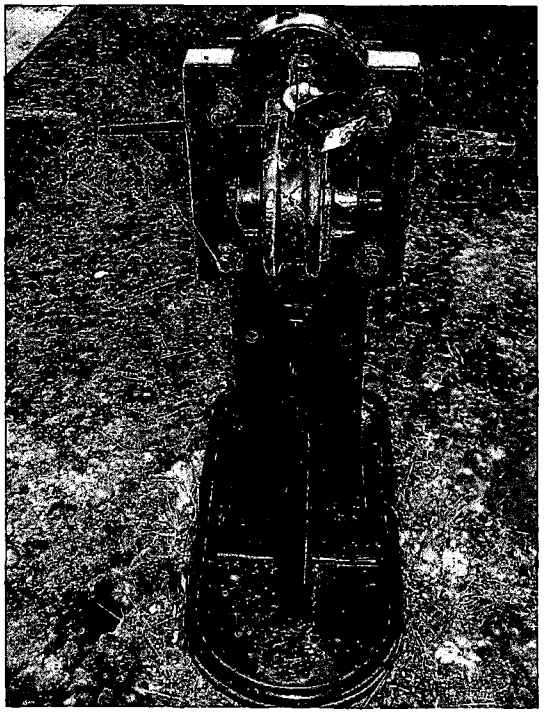
Replacement ground paddle gear on locks 1 to 4 of the Barge Canal are BCN component pattern with reduction gearing fitted with no catches. Castings from Charlton of Sheffield.

Recently restored locks on the Hanbury flight of the Droitwich Junction Canal are fitted with complete sets of new authentic Worcester & Birmingham cast iron paddle stands and components all numbered in a 700 sequence to the patterns. These have been sourced from British Waterways' stock patterns. These are non-reduction mechanisms as the paddles are small and the paddle apertures not deep set for the upper mechanisms on this narrow boat canal. Stand 711 is practically identical to the Worcester & Birmingham stands on locks 7 and 8 of the Barge Canal.



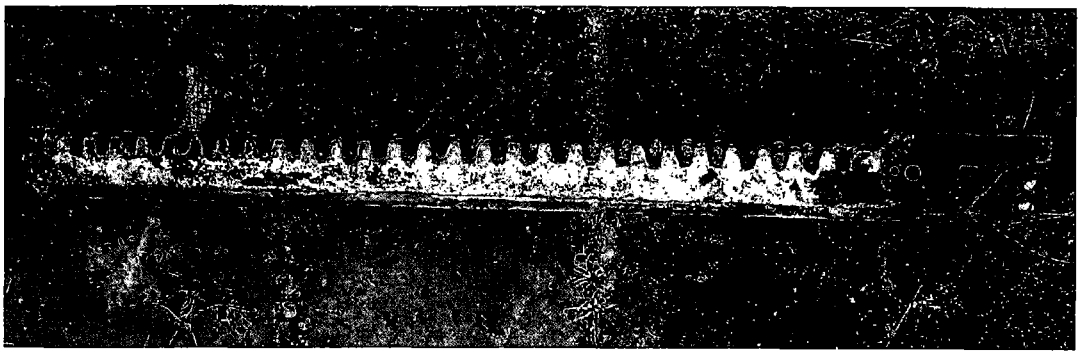






1.35 Racks

Original racks fitted on the Worcester & Birmingham Canal ground paddles had double rows of offset teeth at 1 inch (25mm) pitch. Short racks measured 2 feet 5 inches (737mm) having 25 teeth, longer versions measuring 2 feet 9 inches (837mm) having 28 teeth. Tooth profile was slightly deeper on old racks than on their more modern replacements of BCN and Shropshire Union origin.

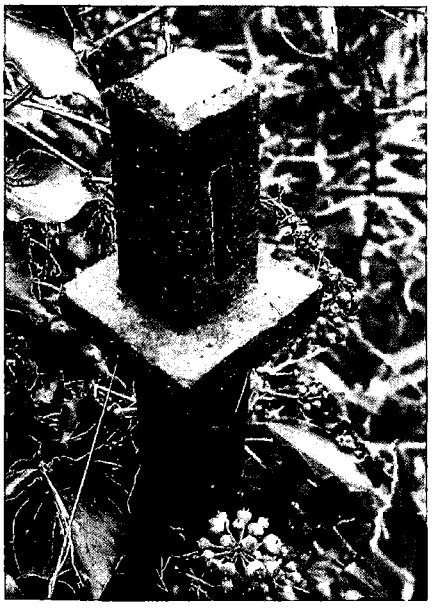


Broken rack at Droitwich Canal Trust Depot of deep tooth form with Worcester & Birmingham Canal rib on back.

The back of the rack has a central cast rib with concave profile sides which mates with the central grooved profile of the rack roller part no 715 (See Drawing 1). These rollers come in several sizes

Paddle bar or rod fit is into a cast square socket in the bottom of the rack of nominal 1¼ inch (32 mm) square having a cross slot of $1^{5}/_{8}$ inch length by $^{5}/_{8}$ inch (40 x 16mm) width for the cotter key securing the paddle bar.

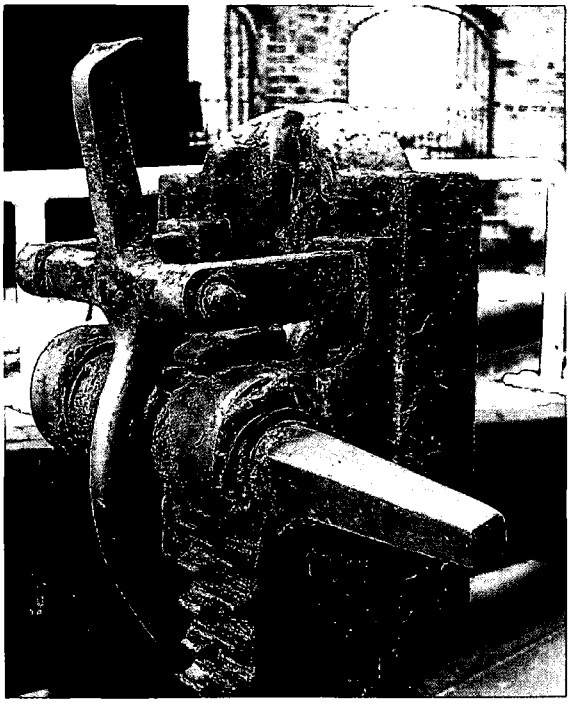
The paddle bar itself is of round wrought iron of 1 inch or 1¼ inch diameter forged to square on a taper below a square collar fire-welded into the upper parallel and slot punched terminal of the rod. The end of this rod is chamfered all round as part of the forging process.



Paddle rod termination at Mildenham Mill

1.36 Catch (Ratchet provision)

The Worcester & Birmingham Canal catch forging is a cruciform wrought iron fire-welded component which was made either left hand or right hand by forming the curved handle and tapered 'spade' end on alternate faces of the component. These parts were handed as it was important that the catch handle was nearest the side of the rack closest to the spindle on which the loose windlass handle being used was fitted.



Above: Right and Left hand forged catch fittings at Diglis Locks

Below: The modern version is a casting which appears to be made only right handed

The modern replacement parts are castings rather than forgings and have Part No 5037 cast on them. These seem only to be made as right hand components making them slightly less easy to use.

1.4 Bottom gate paddle gear

Lower gate paddle mechanisms do not seem to have been updated; wooden jackheads were retained throughout the working life of the Droitwich Barge Canal. These had no reduction gearing fitted. Their operation from the lock side may, however, have been a later improvement with extension spindles added on brackets which appear to match the Worcester & Birmingham style of forging.

1.41 Bottom gate paddle jackheads or stands

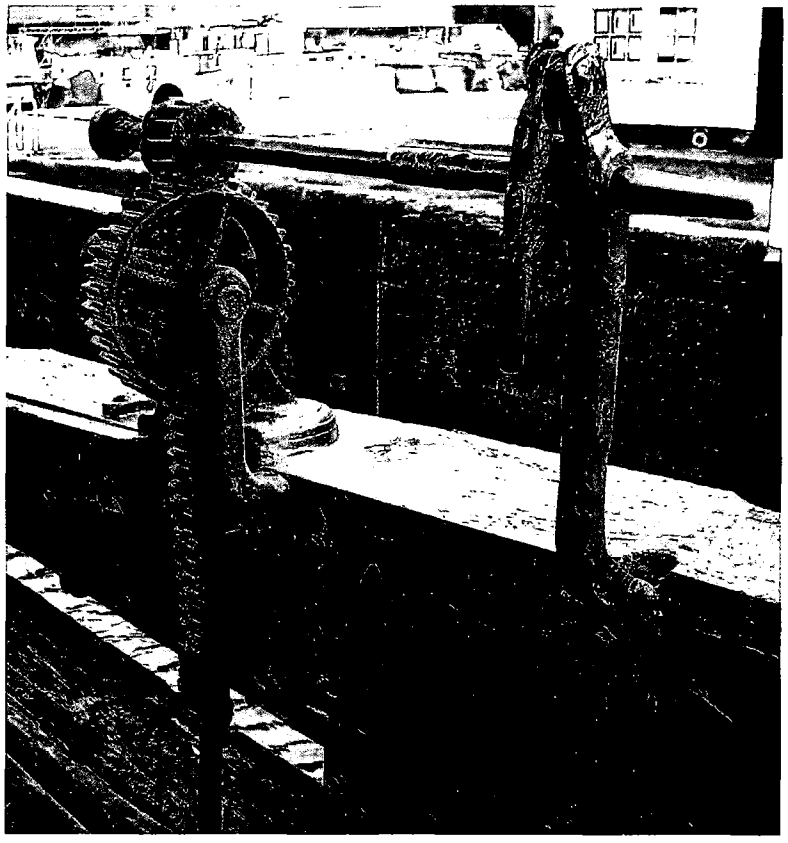
These are rounded top oak posts in the order of 9 inches (230mm) square in section. Evidence in the lock brickwork (mostly later blue brick work) suggests that these did not continue below the top bar of the gates. Early balance beams may have been bolted through 'piggy back' beams which would give a double depth 'fix' for the paddle stands. (See Drawing No 8a Junction Barge Lock)

To give the paddle bar or rod working clearance from the gate structure the rack has to run in a deep groove cut into the jackhead. The pinion spindle bearings or frames also have to be recessed into the timber to give the required gearing mesh. A rack roller is buried deep into the timber running on a through bolt to preserve this mesh. Because the locks are relatively low rise no reduction gearing was required. Large throw windlasses would be carried by the boatmen and used on all the locks encountered by the trows and salt ('wich') barges.

It is likely that the original paddle gear had no extension spindles and was wound by standing on the gate walkways or platforms provided. Spindles extending to the lock side were originally considered as an unnecessary expense.

1.42 Later design

Drawing No 3 shows the assembly of wooden jackhead with deep groove for racks and extension shaft or spindle running horizontally through a wrought iron forged upright bracket with unbushed bearing. The extension shaft incorporated a pawl wheel, usually fitted on a square forged section of the shaft. This pawl wheel is held in place against a fire-welded collar integral with the shaft.



Forged iron support bracket for extension spindle fitted on Barge Locks at Diglis Worcester

© David McDougall

The forged brackets are standard fitments on the locks of the Worcester & Birmingham Canal and are usually found in conjunction with reduction gearing as here on the Diglis Basin Barge Locks.

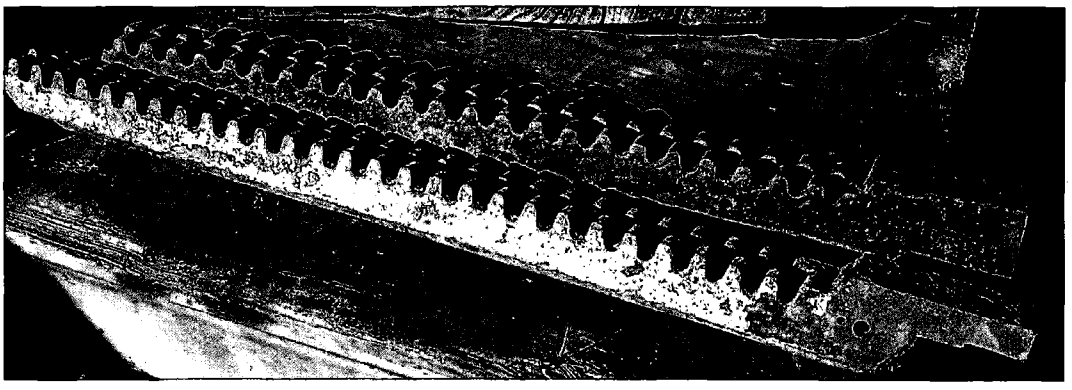
1.43 Bottom gate racks

No original Droitwich rack has so far been located for measurement, though a broken rack at Droitwich Canal Trust's Depot appears to be of the correct Worcester & Birmingham Canal type and length.

Broken rack of Worcester & Birmingham Canal origin © David McDougall

The square socket end is of the correct dimensions to fit the paddle bar or rod termination measured in situ at Mildenham Mill Lock (see Drawing No 14), where the gates have decayed leaving the paddle rod standing. Elsewhere paddle rods have snapped or bent as the gates collapsed. Racks may be found in the silt of locks 7 and 8 when they are cleared.

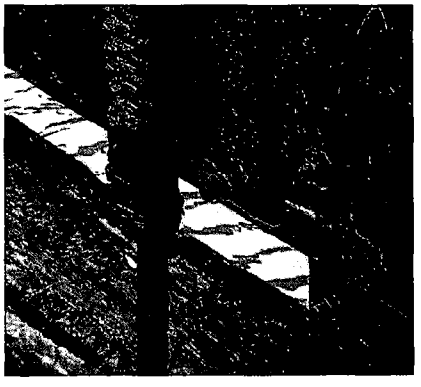
Teeth on this rack are 1 inch (25mm) pitch, double row offset of $^{7}/_{8}$ inch (22mm) width. Tooth form is deeper than standard racks of BCN and Shropshire Union Canal origin now widely fitted throughout the Midlands canal network and supplied from Northwich and Bradley BW workshops.



Broken Rack of Worcester & Birmingham Canal origin compared with a similar standard rack behind. The standard rack is a short version.
© David McDougall

The clear indication of its origin is the central cast rib on the back with concave profile sides to mate with the grooved roller embedded in the wooden jackhead. (For detail of BCN and Shropshire Union racks see Drawing BCN steel paddle gear Section 1.44.)

Paddle bar ends are secured to racks with rectangular section tapered cotters through the slots in the rack castings. These cotters are bent over either side of the rack to prevent loosening. The square collar formed on the paddle bar end gives a secure fixing to the rack to help prevent casting breakage. These collars appear to be dispensed with in some modern rack fitments.

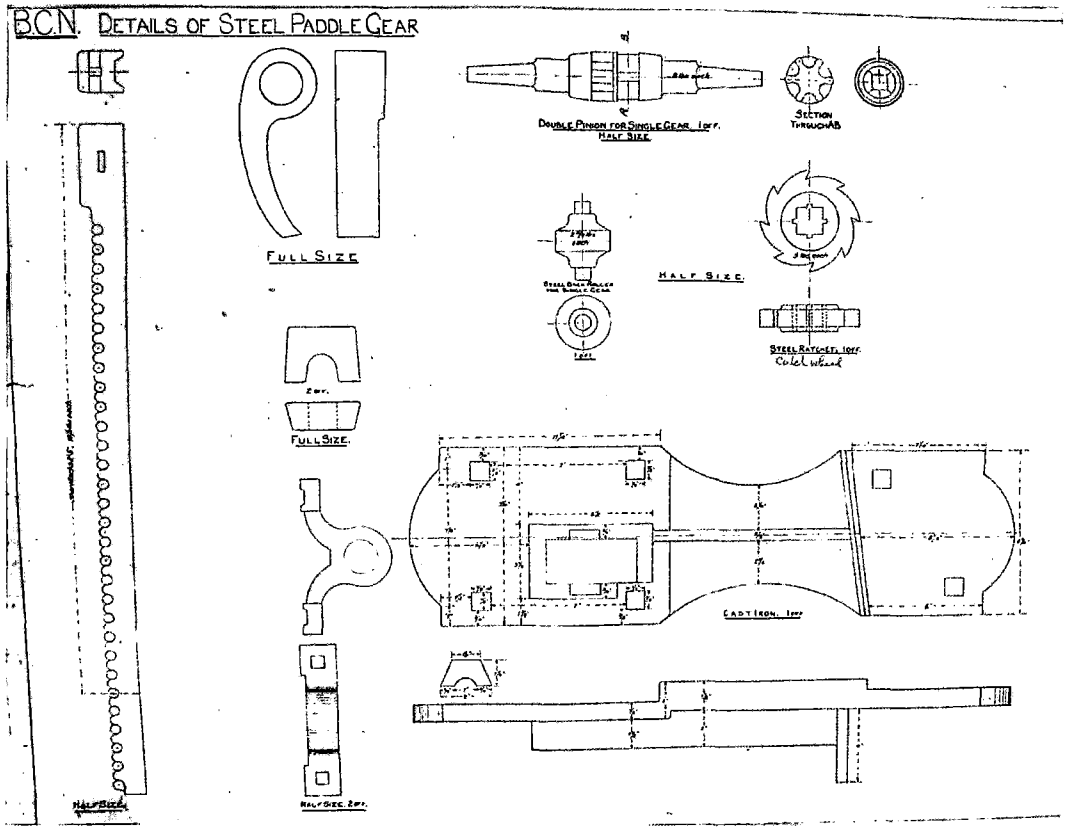


Rack fitted to end of gate paddle bar with cotters bent over to secure them.

Paddle bar rod ends have punched rectangular slots to take the cotter.

© David McDougall

Although this is described as steel paddle gear virtually all components shown are cast iron. This paddle gear utilises standard short BCN racks as shown on the drawing with grooved and chamfered backs. Tooth pitch is 1 inch (25mm), twin offset rows with 25 teeth per rack are used on the Droitwich assemblies. Gear reduction obtained is 5:18 or 1:3.6.



BCN cast iron paddle gear for gates © The Waterways Archive BW165/18/8/12

As the Droitwich locks are not in use no extension spindles have been fitted nor are support brackets available for them. Two worn out Shropshire Union / BCN assemblies are in Droitwich Depot as potential patterns. These may not give correct fit and would not be as appropriate as Worcester & Birmingham Canal brackets and spindles.

Using the paddle gear currently fitted requires operation from the gates themselves as walkways are not fitted except on the uphill side of Ladywood top lock (because of the cranked balance beams). The paddle gear makes this walkway very difficult to use.

Lock 1
© David McDougall

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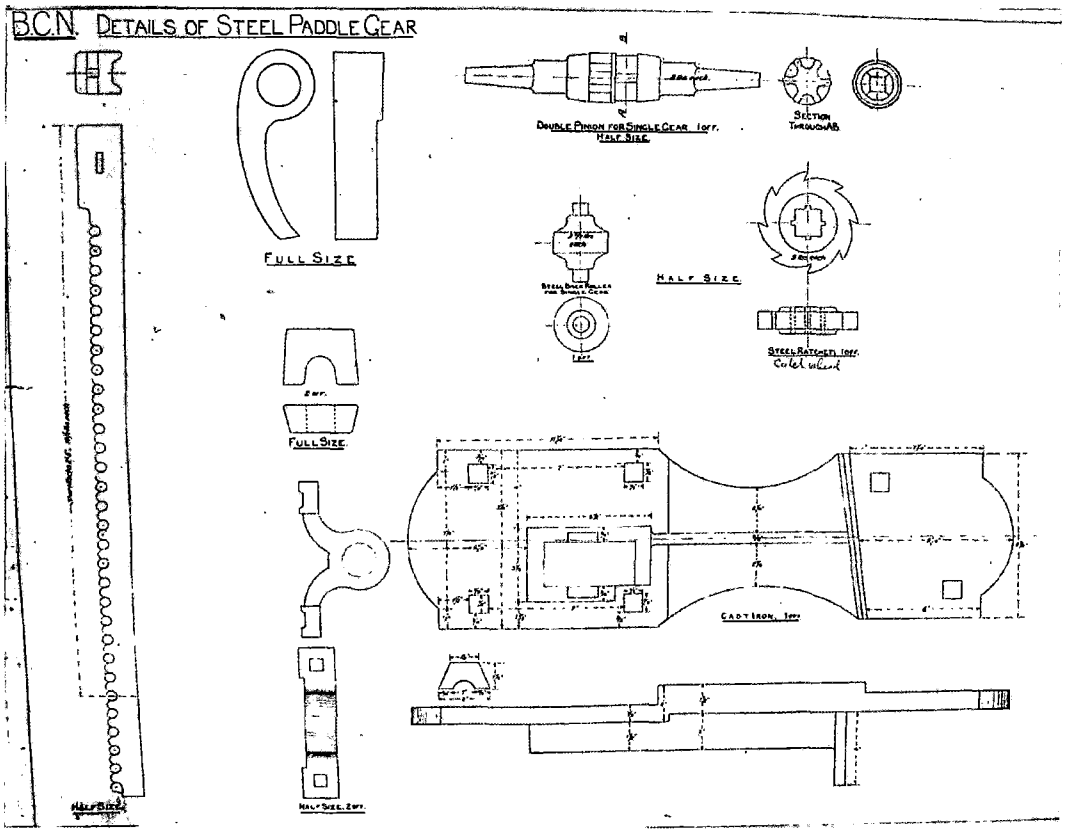

BCN cast iron paddle gear for gates © The Waterways Archive BW165/18/8/12

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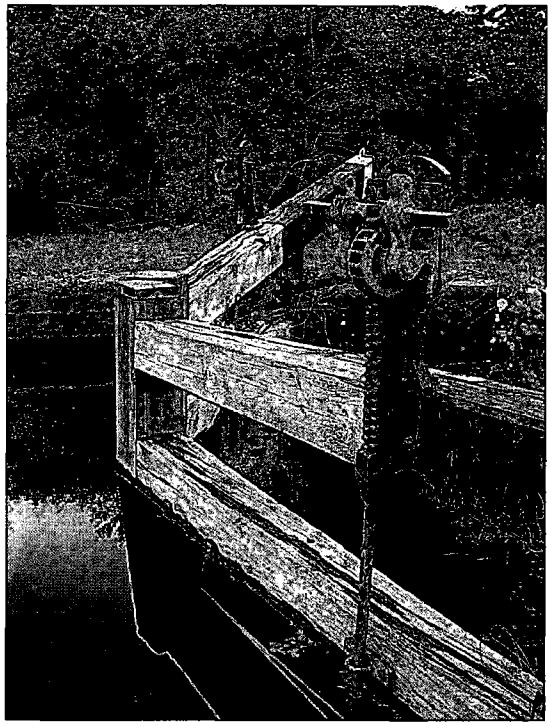
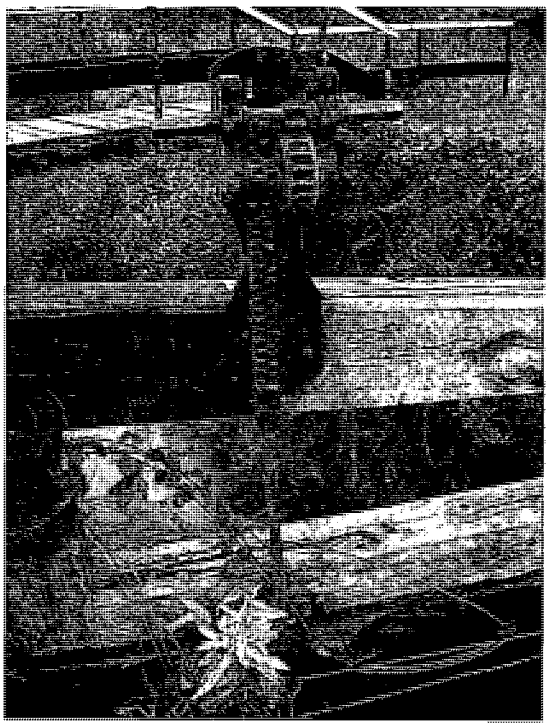
Lock 1
© David McDougall



Lock 3



Lock 3

Lock 2

Part 2

2.1 Droitwich Junction Canal

2.11 Droitwich River Lock (Barge Lock at Vines Park)

This unique lock was built in 1853 to link the new narrow boat sized Droitwich Junction Canal coming down from Hanbury Junction with the narrow Worcester & Birmingham Canal to a short section of the canalised River Salwarpe. The river or 'barge' lock was sited alongside the original terminus basin of the Barge Canal. The lock approach from the Barge Canal indicates this in the dogleg of the canal walling. This new lock was constructed large enough for 2 narrow boats abreast, approximately 15 feet 6 ins (4.73m) wide and 74 feet (22.560 metres) long in the chamber.

Map of 1858 showing double-gated junction lock with the River Salwarpe alongside the original Droitwich Basin. From survey of 1854 by Webb & Buck.

To cope with changing river levels and to be useable at all levels of flood and drought, the lock was arranged with twin sets of gates each end, both outward and inward facing pairs provided. Paddle mechanisms were fitted on one of each of the pairs of gates, no ground paddle being provided. These paddles were sited on the gates nearest the basin to the west [bottom sets of gates] and on the gates on the opposite side nearest the moveable weir on the east [top sets of gates]. Only 4 gate paddles were provided in total. To use the lock which had a nominal fall from the Salwarpe to the barge canal of 1 foot 6 ins (0.46m) the moveable weir structure, alongside on the river had to be dropped to build up the level of the Salwarpe to provide a navigable depth on the pound to the tail of Town Mill (narrow) lock.

To provide extra navigability in times of low river flow the two opposing lock sills at the river Salwarpe (eastern) end of the lock were set lower than those at the western end even though the nominal fall was the opposite way. This probably also helped with mud removal as it could be flushed back to the river.

The lock suffered from continual subsidence caused by brine pumping at the numerous saltworks and was subject to a number of rebuilds in its working life. The most major work involved complete reconstructing of the lock and the towing path walling and river pier undertaken in 1875–6. This reconstruction raised the sides, bottom and cills between 8 and 9 feet (2.44 - 2.74m). The lock sides were completely reconstructed from the foundations to allow future raising of the walls as further subsidence occurred.

Further raising work of the lock walls, cills, hollow quoins, etc was carried out in 1903, lifting the structure by another 5 feet (1.525m). At this time the towpath and river retaining walls were raised by 3 feet (0.915m). The lock gates were repaired and partly reconstructed at Stoke Prior workshops.

Another 3 feet (0.915m) of brickwork was added to the towpath walls, lock approach walls, river pier and the cill of the river sluice along with its side walls in 1905 when the Vines Bridge was also renewed. At this time the adjacent river embankments were re-laid 3 feet higher with clay puddle to assist with floodwater flow. This work is underway in the photograph below.

Barge Lock reconstruction to the lock approaches in 1905 © Worcester Record Office

By 1939 the canal basins were choked with silt, the lock was in complete disrepair and unusable with the gates decayed, paddle gear partly removed and the chamber full of silt brought in by the river floods. The moveable river weir guillotine gate seems, however, to have in usable order at this time.

The Barge Lock derelict in 1939 from the River Salwarpe © Worcester Record Office

The lock walls, sills, etc, surviving today are the result of the 1903 rebuild with 1905 rebuilt approaches.

Modification and lowering work on the adjacent weir has removed much of the rounded pier brickwork and copings back to the cast iron stop plank groove on the northern side of the lock approach.

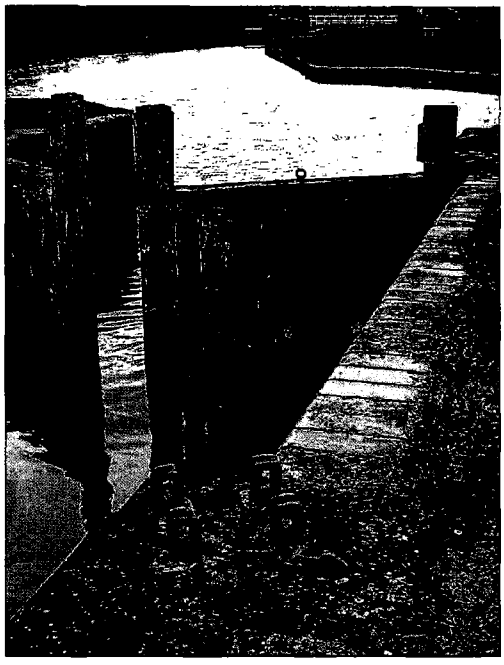
The Barge Lock
from the Salwarpe
2007
© David McDougall

2.2 River lock gate features

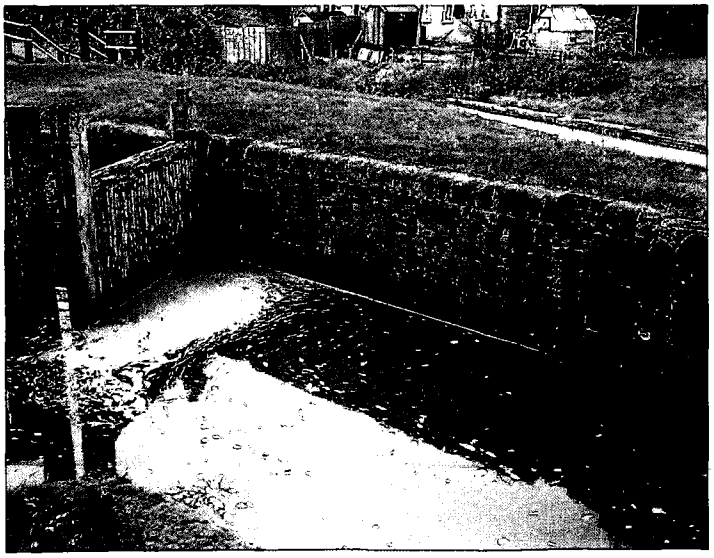
Only 3 historic photographs of this lock showing the gates are known to survive. The decayed remains of gates were replaced after the canal was re-excavated through Vines Park in the 1970s. The replacement gates are only fitted in the upward facing hollow quoins to the river and assume that there will be a fall into the canal from the Salwarpe now controlled by a low fixed weir.

New gates have no ironwork at joints, paddle gear or balance beams fitted. Round section tie rods alone hold the mortice and tenons together. The gates have sagged out of shape due to lack of bracing and balance beams. Decay at the joints is evident.

Outward facing gates to the Salwarpe at the east end of the lock 2007



Outward facing gates at the west end of the lock 2007



Paddle channels in the brickwork of the northern east end gate recesses

2.21 Original gate provision

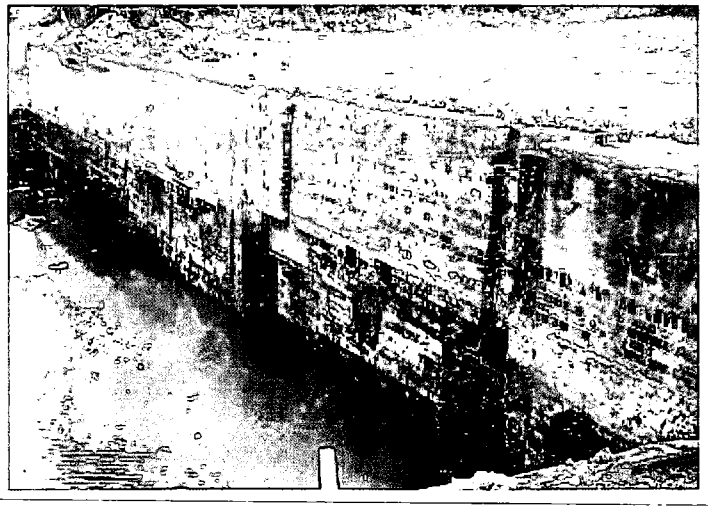
The earliest scenic view of Droitwich clearly shows the gate form and balance beam provision of the flood and river junction lock prior to the 1903 rebuilding work. Essential features deduced from this are shown in Drawing 8a. This represents only the eastern gates and quoins on the moveable weir side of the lock nearest the Salwarpe. On this side were sited the two eastern paddles. The inner gate pair is fully sheeted up to the balance beam to give flood protection up to the lock coping level. The outer gate pair is of weir type as flooding would push this open anyway. Balance beams are clearly of 'piggy back' type bolted on top of the upper gate bar. This gives a good fix for the paddle jackhead without requiring large cutaways in the lock coping. Balance beams are long but relatively lightweight. Lock gates have no walkways or handrails fitted. The central swing bridge over the lock provides the only access required for operating the gates and paddles. Paddles are arranged on this side for convenience of operation of the moveable weir structure adjacent. This was a largely timber structure as the photograph shows.

River Salwarpe and Junction Lock from Dodderhill prior to 1903
from postcard published by Valentine's from David McDougall collection

The 1903 reconstruction work to the lock approaches was arranged in conjunction with partial re-gating and repairs. New 'conventional' balance beams of larger section but shorter length were fitted with new paddle stands to the inner pair of gates now no longer fully sheeted. Flooding was now fully controlled by a new moveable weir and raised walls to the lock and clay puddle to the Salwarpe channel. Gates shown in Drawing 8b are the new arrangement which were in situ at abandonment by which time the older outer gates had disintegrated.

Post 1903 view of the lock showing new balance beams, and swing bridge to the left
© RM Sinclair

Re-gating was carried out after reconstruction of the chamber brickwork in 1980? The lock has not been used. Part of the pier brickwork to the Salwarpe was removed when the new weir was installed. This leaves the stop grooves and sill unusable at present.



Work on the lock chamber prior to re-gating showing paddle channels and cut outs in the wall
© RM Sinclair

2.22 Gate ironwork

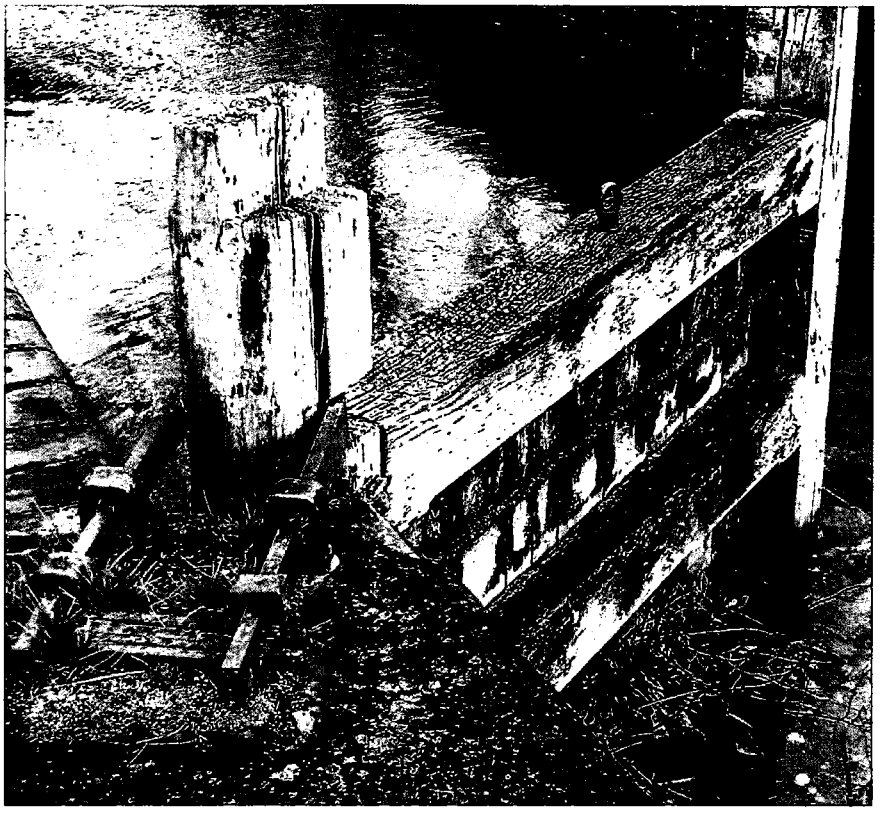
No original gate ironwork remains to be measured or recorded. Most of this was standard forged wrought iron work as samples recorded on lock 7 – see sections 1.22 and 1.23. Gates fitted here had some non-standard detailing in particular the outer gates to the east were fitted with head plates ('F' straps) on both top and second bars at quoin post and mitre post mortices. This would produce a stiffer than standard gate construction. It is possible, however, that this was part of an economy repair undertaken to extend the life of these gates when the new beams were fitted. These outer gates had virtually disintegrated by 1939, whereas the inner gates were largely intact. (See Drawing No 8b.)

Decayed gates at the Salwarpe end of the Junction Lock in 1939

Collars

The double gate recesses are fitted with 8 cast iron quoins similar to those on the top gates on the remainder of the Barge Canal. Only 4 gates in total are hung in these. The long collars slot through sets of 4 'staples' leaded into the quoin coping stone above the quoin casting. Some of these staples are missing, removed or broken.

Collars fitted to the gates in situ are forged from 3 inch x 1 inch (75mm x 25mm) square edged stock steel. Inner bend diameter round the quoin post is 10¼ inches (260mm). There is no forged or cut change of section. Horns are slotted for cotters. Punched or drilled slots are 4 inches long x 1 inch wide (102mm x 25mm) 2¼ inches (57mm) from the end of the horns.



Collars are wedged behind the four staples which secure the forging to the quoin stone

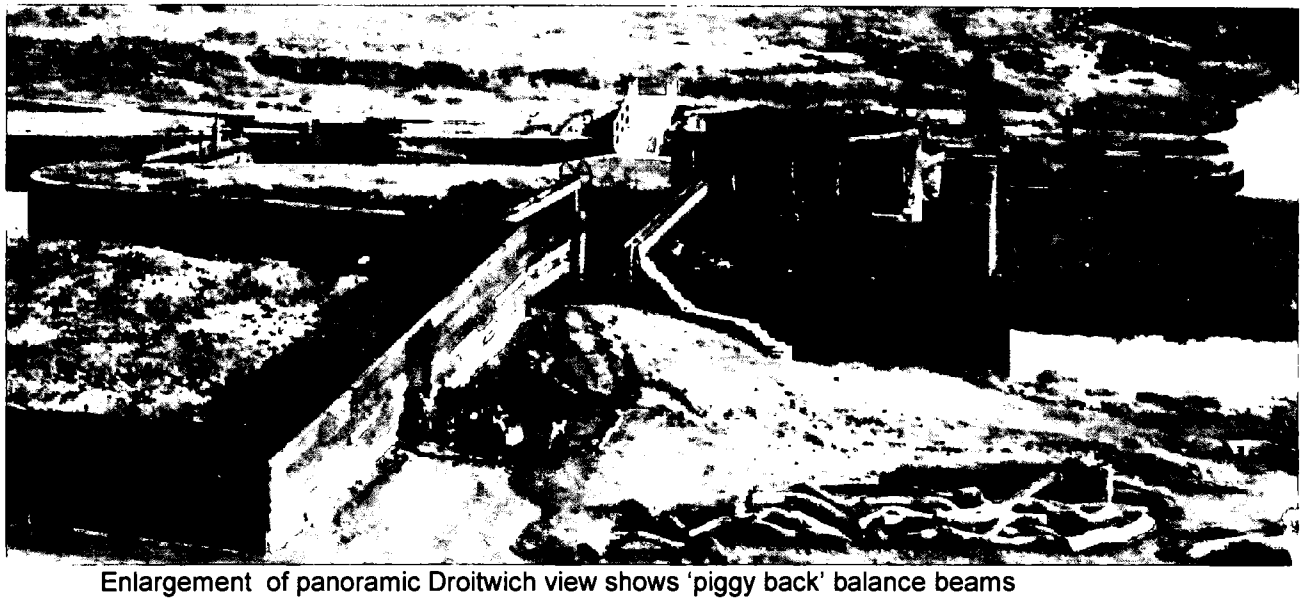
Tie rods

The replacement sets of gates rely on the tie rods to hold their joints together as no plates or straps have been fitted. Concerns regarding salt corrosion of these straps was one reason why they were omitted.

Round steel bar of 1½ inches (38mm) diameter has been used to make tie rods for ease of cutting threads and fitting. These rods are staggered on the pairs of gates to reduce the risk of leakage developing if they coincide vertically. Tie rod positions are shown on Drawing No 9. Tie rods alone have not prevented the new gates from sagging as no balance beams are fitted to counter the offset weight at the mitres. Open joints from shrinkage and displacement due to sagging have led to premature decay of the joints.

2.23 Balance beams

Balance beams prior to the 1903 rebuilding were of 'piggy back' arrangement. The top beam portion was lighter weight smaller section but longer than later provision. Probable size was 10 inches (254mm) square. This would match the narrow lock gate beam size and the handhold fitting used on these. A sample measured in the Droitwich DCT Depot had been riveted to a tapered end of a beam measuring 9½ inches (240mm) deep. 'Piggy back' beams would have been through bolted with a number of vertical bolts. The joint between may also have had joining straps linking the two timbers. (The lower timber is also the top bar of the gate. See Drawing No 8a and 8b for later design.)



Enlargement of panoramic Droitwich view shows 'piggy back' balance beams on the Junction Lock prior to rebuilding in 1903

2.23 Beam stop posts

These are not evident on the photograph above and it is unlikely they would be necessary as the nominal level change was only 1 foot 6 inches (458mm). Lockside work is unlikely to produce evidence of these particularly because of the regular reconstruction due to subsidence and the extent to which this occurred.

2.24 Handrails

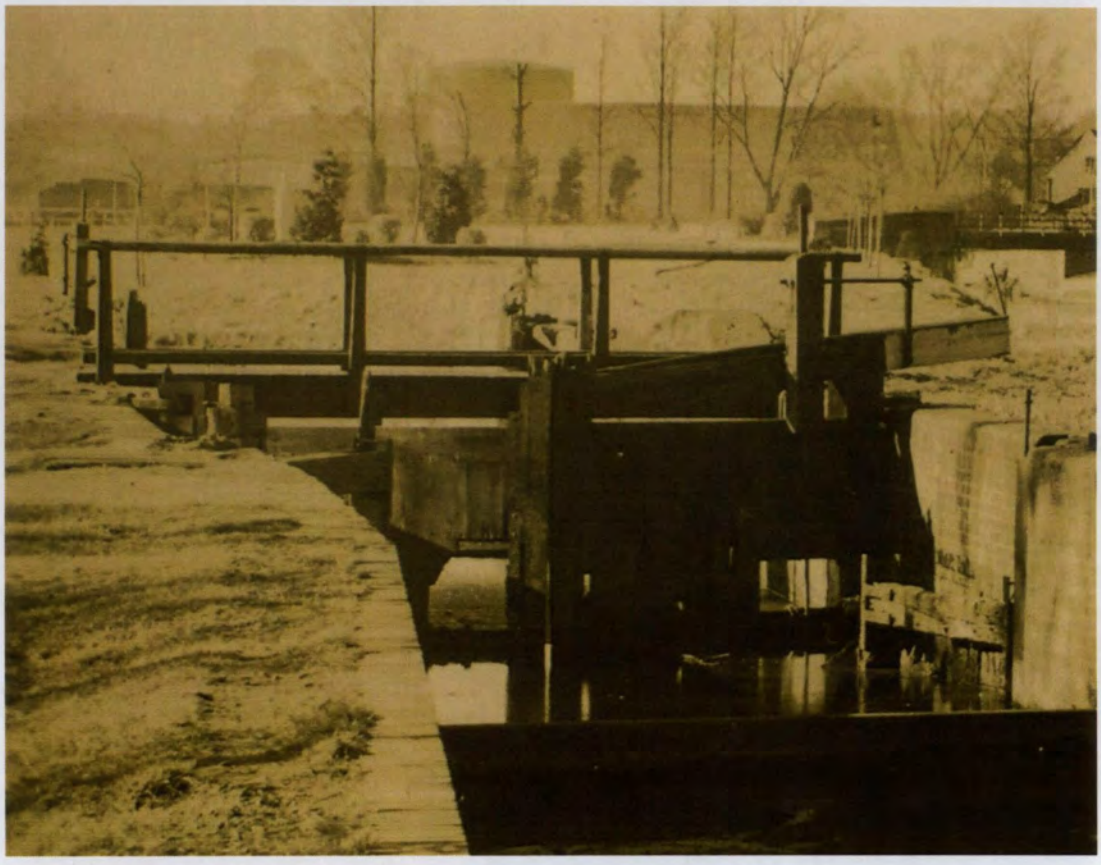
There is no evidence that handrails were fitted on any of the eight gates fitted to this lock as access to the far side was via the central swing bridge and not via walkways on the gates. If the lock provides a change in level after restoration, access across the gates may be desirable in addition to the bridge for operational purposes.

2.3 Paddle gear mechanisms

2.31 Gate paddle gear

Paddle gear fitted in the gates of the lock prior to 1903 and after 1905 appears from photographs to be the same standard equipment for the canal. Drawing Nos 3 & 4 illustrate this layout of wooden paddle stand (deeply grooved for rack clearance) with extension spindles on forged iron Worcester & Birmingham Canal brackets with catch arm riveted on.

This equipment, with no reduction gearing, was clearly in place in 1939 when the canal was infilled at this point to form Vines Park.



Enlargement of 1939 view of derelict Barge Lock to show paddle gear

2.32 Racks

Standard Worcester & Birmingham Canal paddle gear racks were fitted on the gate paddles; it is not possible to determine whether they were long or short racks. See 1.43 Bottom gate racks.

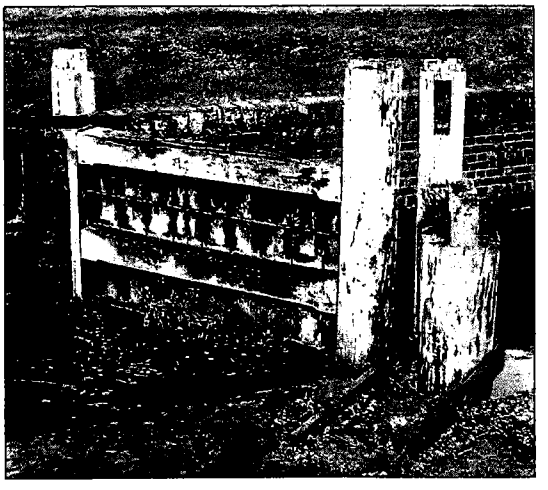
2.33 'Ratchet' provision

The standard Worcester & Birmingham catch of hanging arm and catchwheel on the extension spindle was fitted to the 4 paddle gear assemblies. See 1.44 'Ratchet' provision.

Worcester & Birmingham catch
on Diglis River Lock 1

2.4 Replacement gates

The two pairs of new gates fitted are heavily built in oak with wide bar spacing. See Drawing No 9. Planking is 9 inches x 3 inches (230mm x75mm) thick fixed with coach screws rather than nailed in place. Small stopped chamfers are run on the arises of the top bar. Paddles and paddle runners are fitted without any paddle mechanisms for their operation. Paddles are just visible below water with the river at weir level. Depth of sills has not been investigated as the chamber is laden with silt from the Salwarpe.



The gates have dried out and are decaying at the mortice and tenon joints.

Part 3 Lock furniture

3.1 Bollard Provision

Lock bollards are fitted at many of the locks restored in the 1980s. These are concrete 'bulb' shaped castings from a mould used on the Basingstoke Canal.

Concrete bollards at Mildenham Mill Lock
© David McDougall 2007

There are insufficient historic photographs to give evidence of 'original' bollard locations or provision. It is likely that wooden stumps were provided for checking trows and salt 'barges'. One is evident in the Lock 4 photograph set well back from the chamber edge above the bottom gate. Elsewhere on the Worcester & Birmingham Canal, the Sharpness New Docks Company provided cast iron bollards. There seem to be no survivors on the Droitwich. Some might be expected on Lock 8 at the River Severn Junction but are not evident. Archaeological evidence may come to light of locations on locksides of wooden stumps where at least 6 might have been located. Two check bollards at the lock head would be normal with others at the head and tail of the chamber each side.

3.2 Other lock features

No special features of the locks have been identified to assist in their use by working boats in the past. Protective iron work for boat line wear has not been provided on gates or paddle gear. Protective fendering on the gates was also omitted – an indication of the relatively light use in later years of operation.

3.3 Archaeological potential

Lost, and unrecorded and unidentified detailing of the gates and paddle gear is known to be in locks 7 and 8 at Hawford. Lower gate remains at lock 6, Mildenham Mill are also significant for ironwork detailing. It is unlikely that paddle gear will be found here or at lock 5, Porter's Mill.

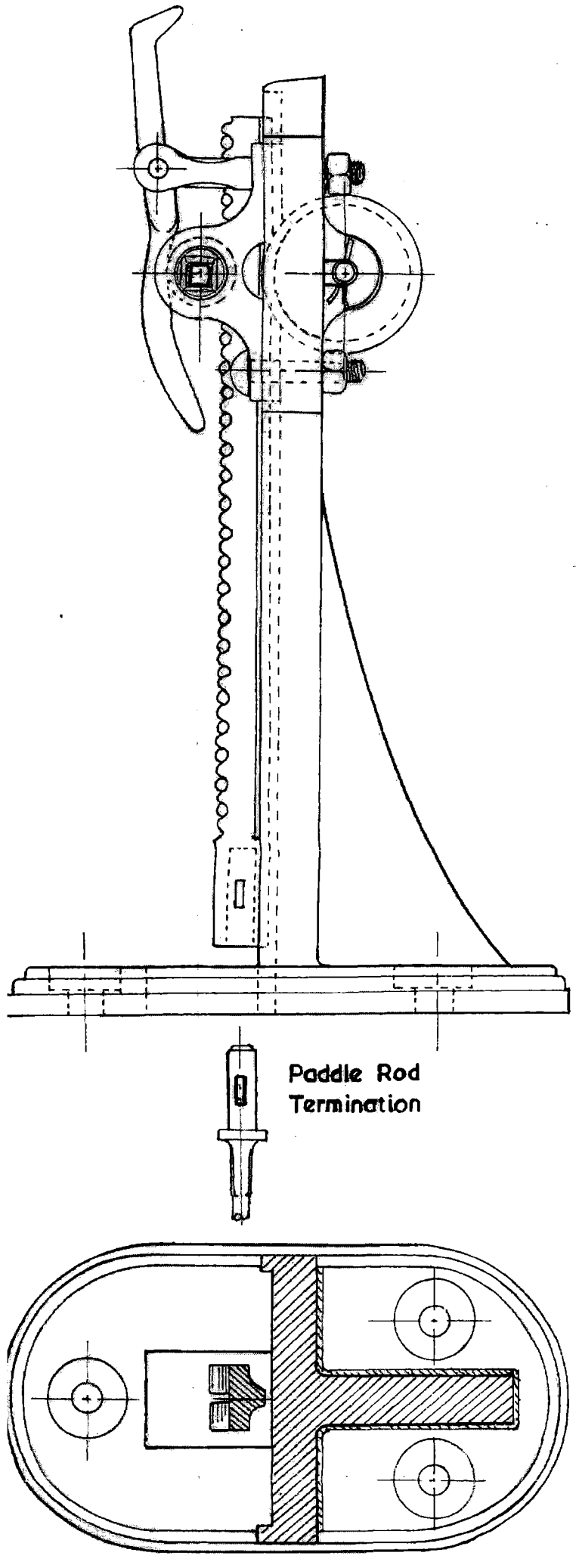
The opportunity to record components in detail should be taken when work on clearance is undertaken. It is suggested that further detail should be added to this document.

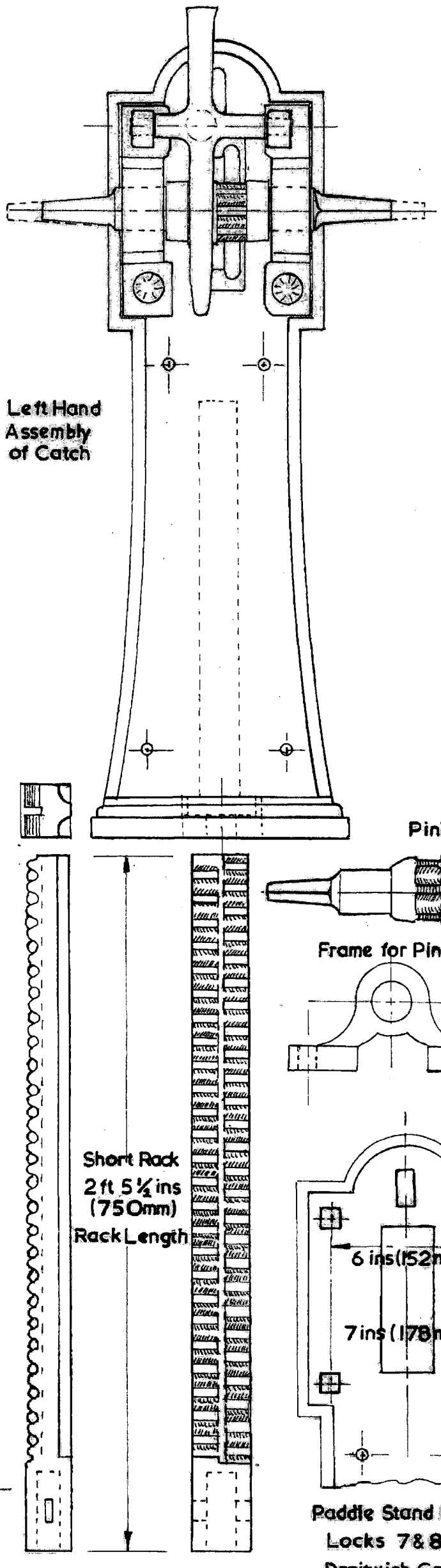
In particular, it has not been possible to record details of ground or gate paddles or the bars (paddle rods) to operate them. This is due to floodwater at the time of completion of this survey.

Cruciform walkway fittings not measured in Lock 7 above and top gate tie bar in Lock 8 require recording when clearance is undertaken

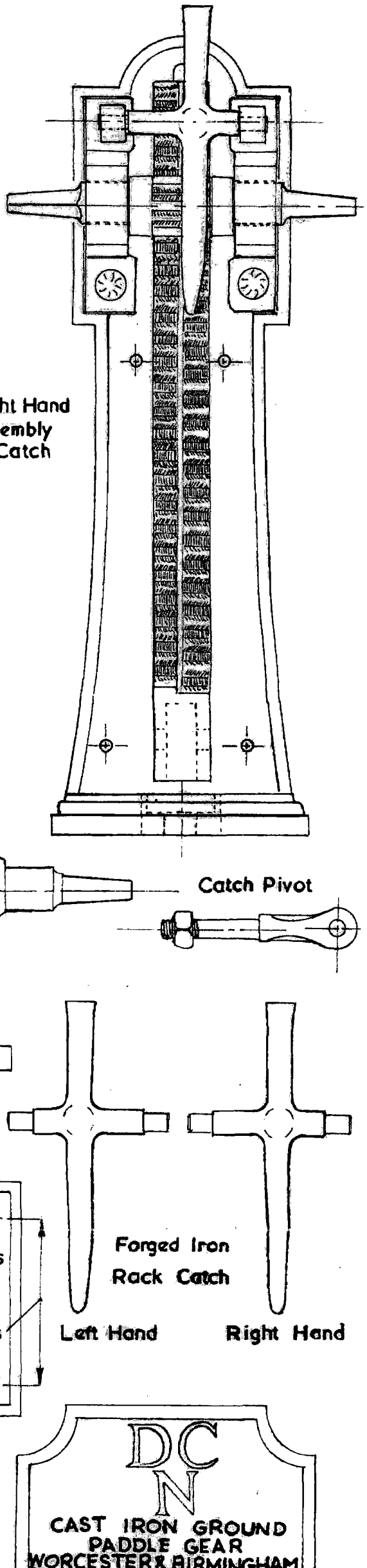
Droitwich Barge Canal Ground Paddle Gear

Assembly Worcester & Birmingham Canal Pattern



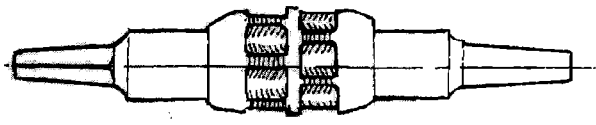


Left Hand Assembly of Catch



Right Hand Assembly of Catch

Short Rack
2ft 5½ins
(750mm)
Rack Length



Pinion

Catch Pivot

Frame for Pinion

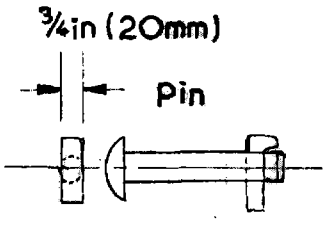
Forged Iron Rack Catch

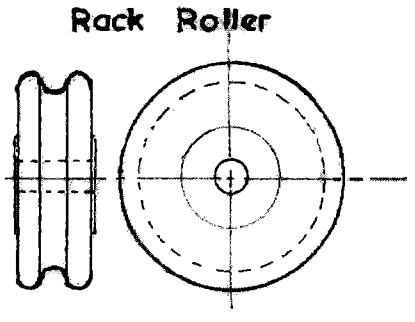
Left Hand Right Hand

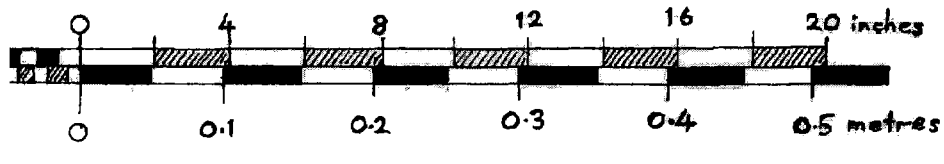
Paddle Stand Head
Locks 7&8
Droitwich Canal

Paddle Rod Termination

Section A-A







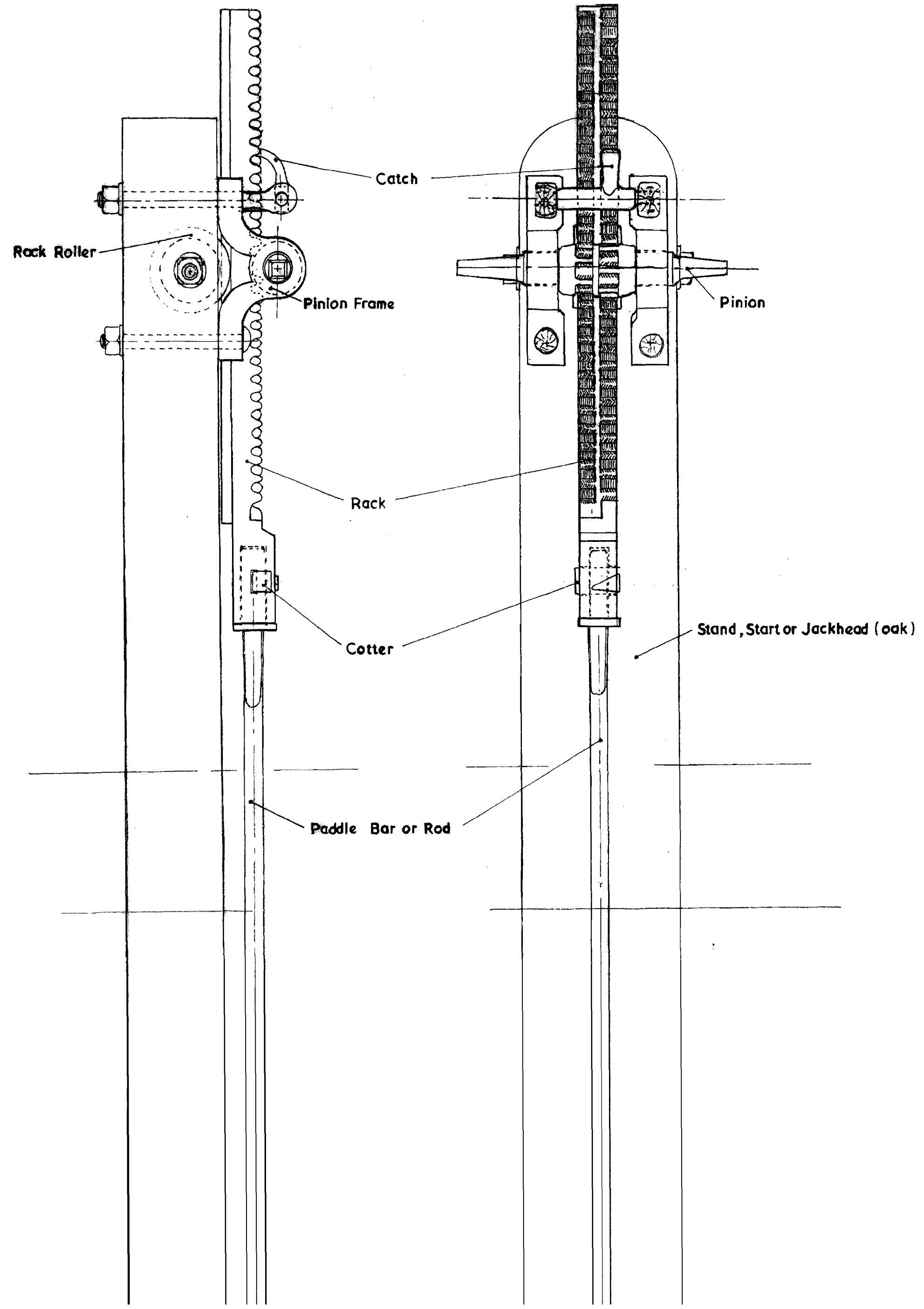
DC
N

CAST IRON GROUND PADDLE GEAR
WORCESTER & BIRMINGHAM CANAL PATTERN
Scale 1:5

1

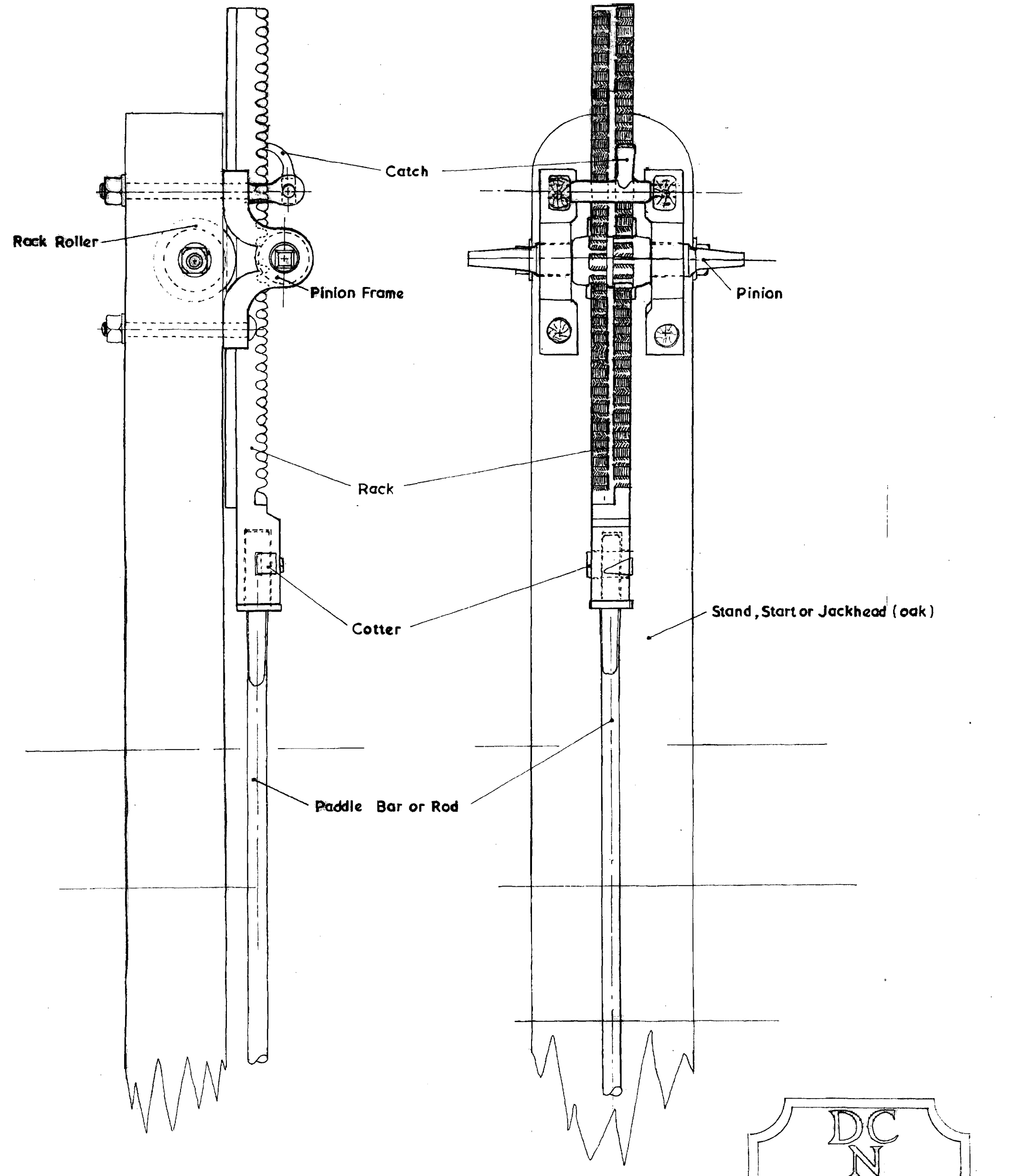
Droitwich Barge Canal

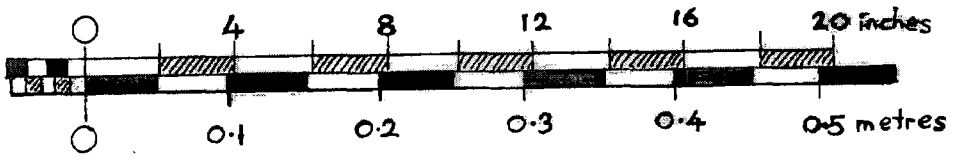
Wooden Ground Paddle Gear Assembly



Droitwich Barge Canal

Wooden Ground Paddle Gear Assembly





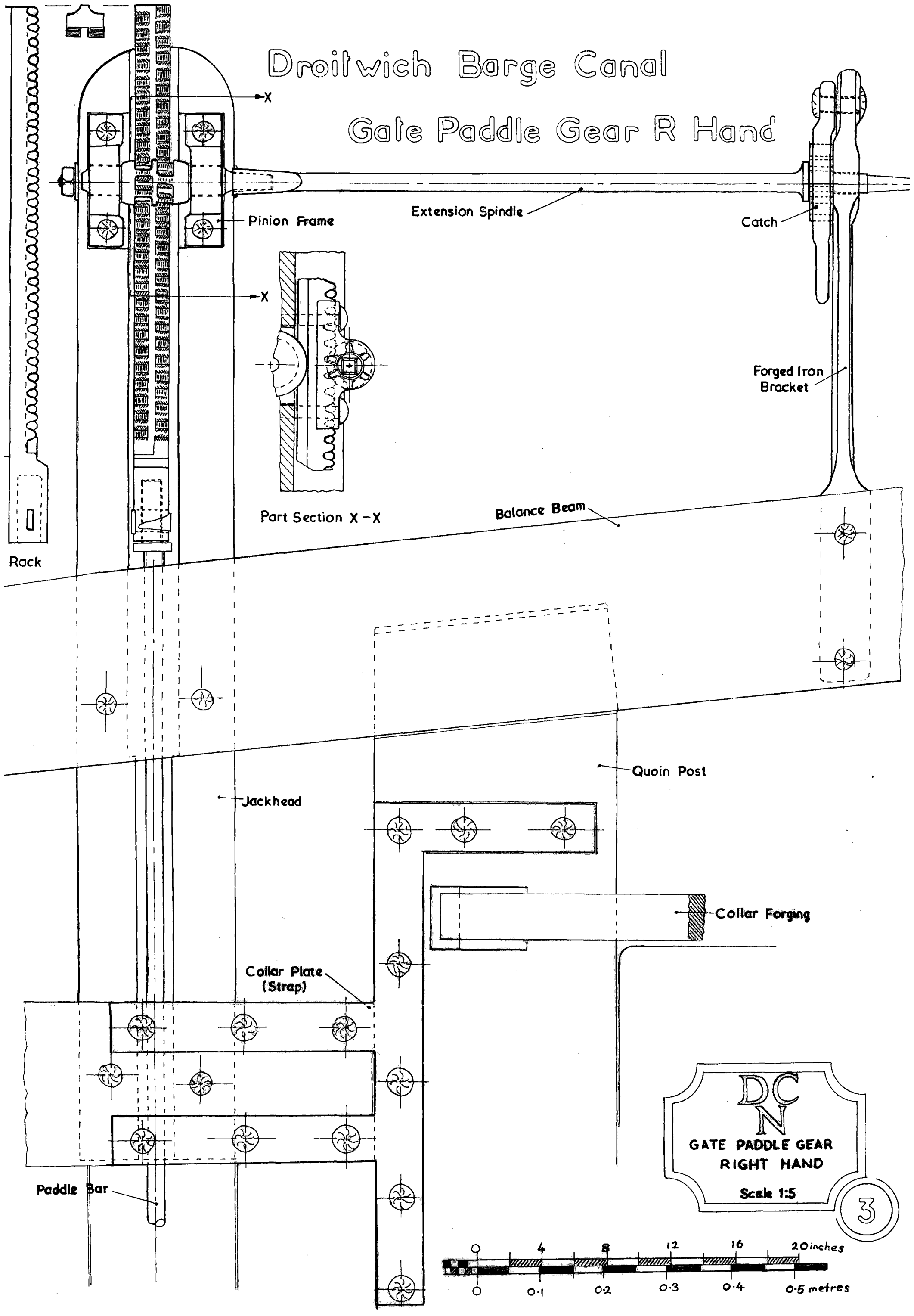
DC
N

WOODEN GROUND
PADDLE GEAR
ASSUMED DESIGN
Scale 1:5

2

Droitwich Barge Canal

Gate Paddle Gear R Hand



Droitwich Barge Canal

Gate Paddle Gear L Hand

Extension Spindle

Catch

Forged Iron Bracket

Balance Beam

Quoin Post

Collar Forging

Y

Pinion Frame

Y

Part Section Y-Y

Rack

Jackhead

Collar Plate (Strap)

Paddle Bar

DC
N

GATE PADDLE GEAR
LEFT HAND

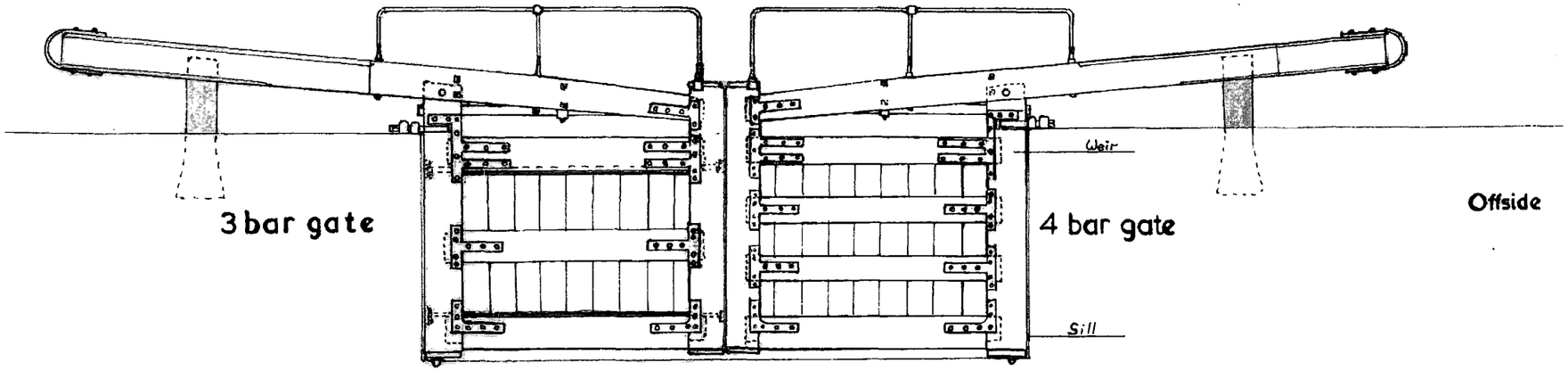
Scale 1:5

4

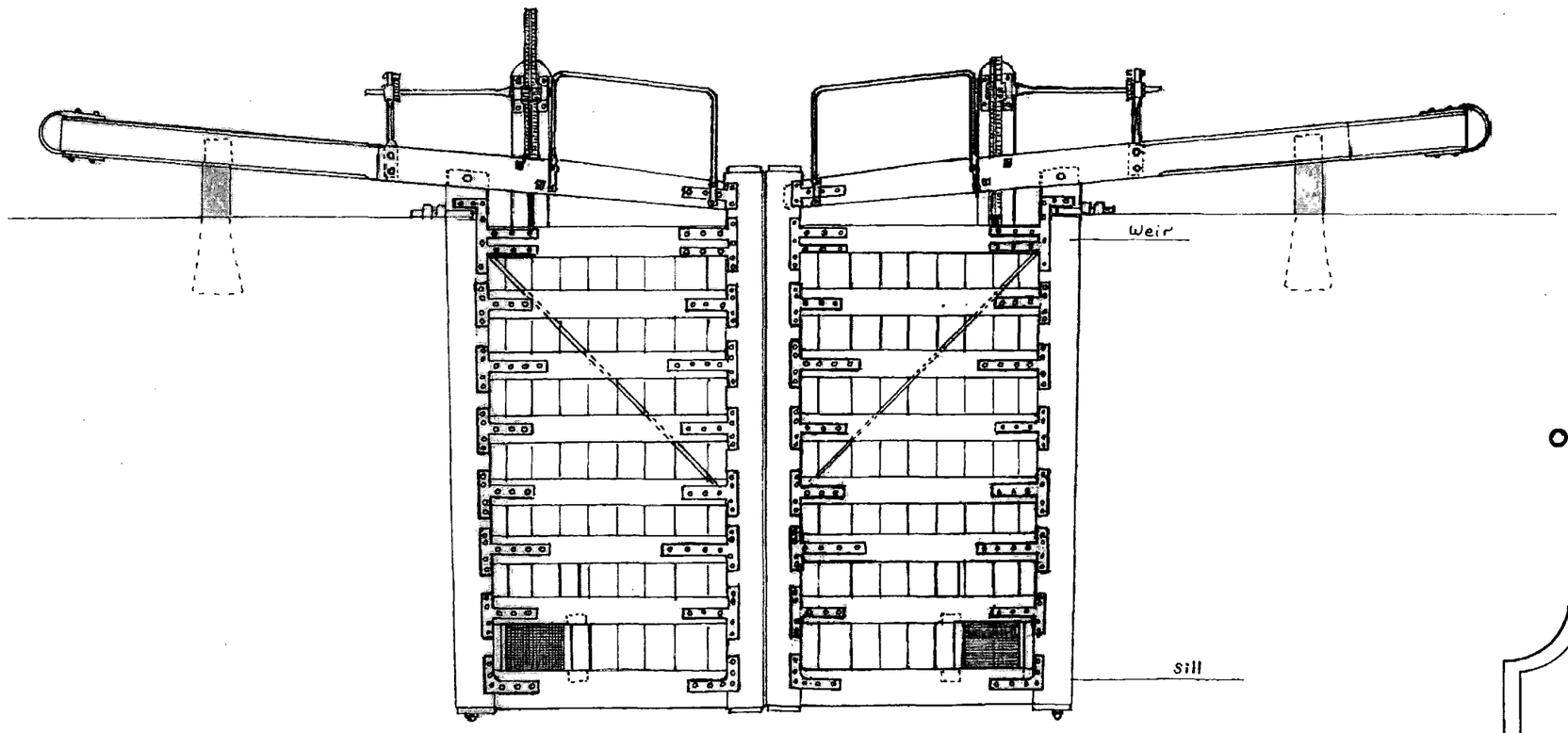
0 4 8 12 16 20 inches

0 0·1 0·2 0·3 0·4 0·5 metres

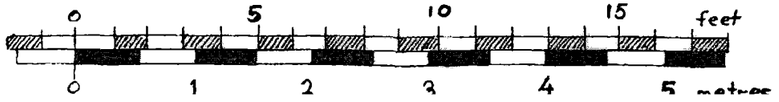
Droitwich Barge Canal Top & Bottom Gates



Top [Upper] Gates (view uphill)



Bottom [Lower] Gates (view uphill)



DC N

TOP & BOTTOM GATES
BARGE CANAL LOCKS

Scale 1:50

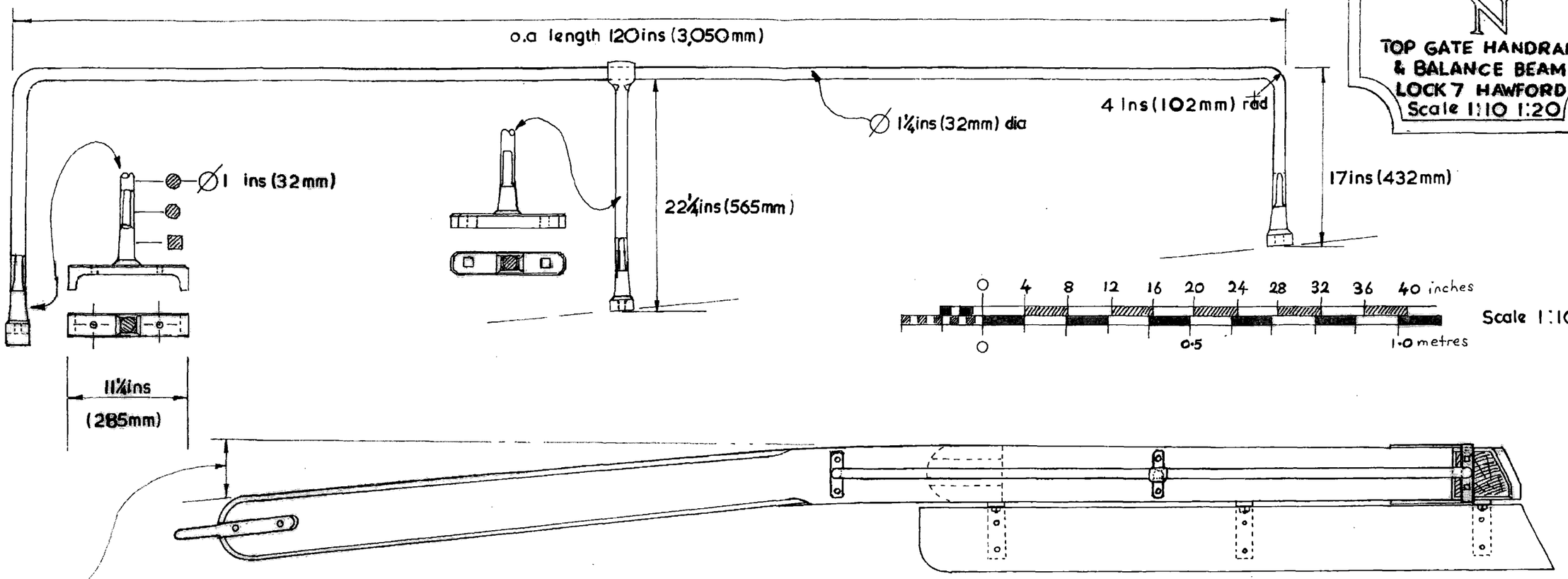
5

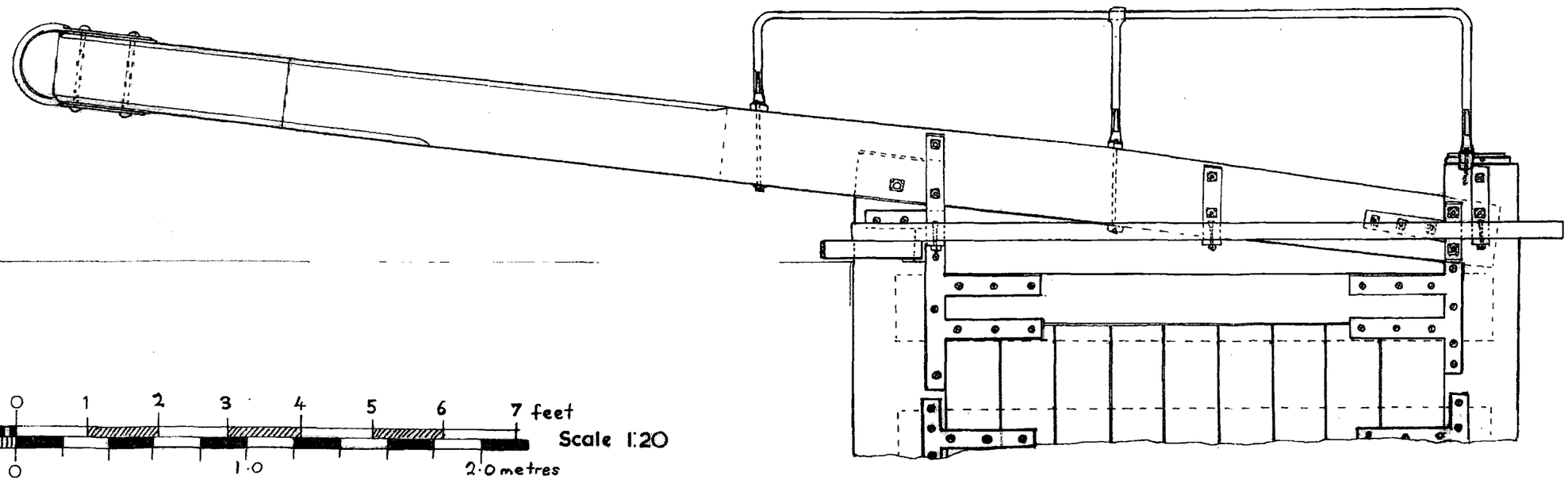
Droitwich Barge Canal Balance Beam / Handrail Lock 7

DC N

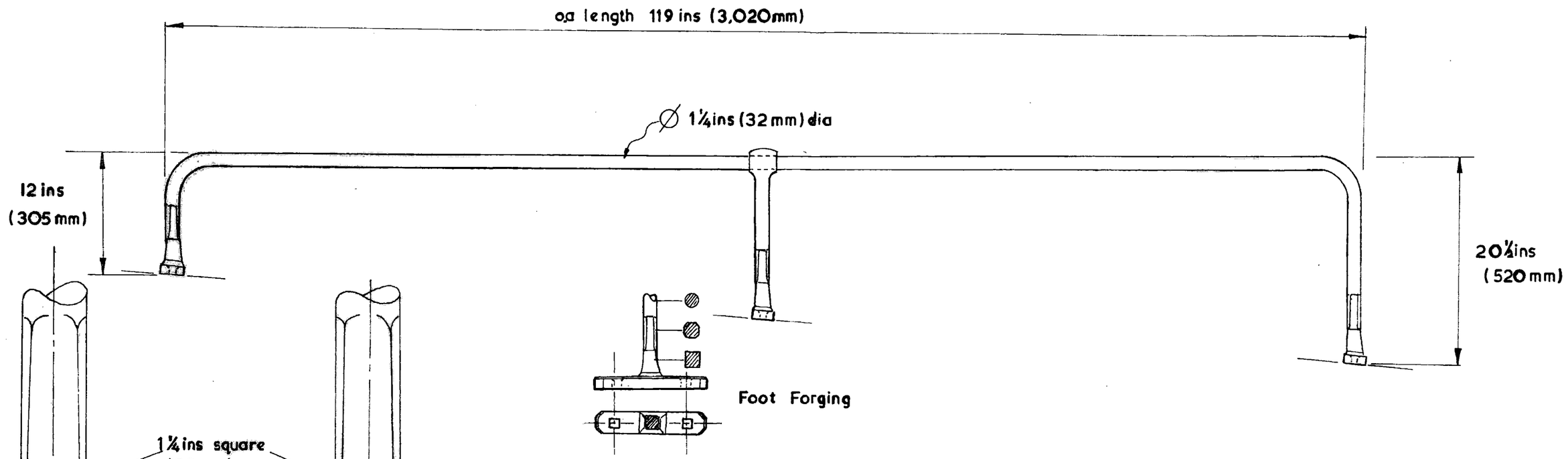
TOP GATE HANDRAIL & BALANCE BEAM LOCK 7 HAWFORD Scale 1:10 1:20

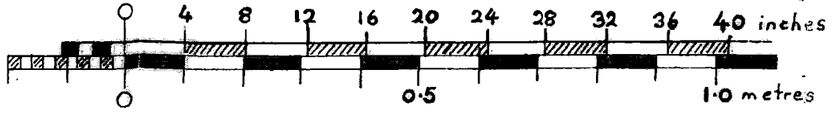
6





Droitwich Barge Canal Top Gate Handrail Forging





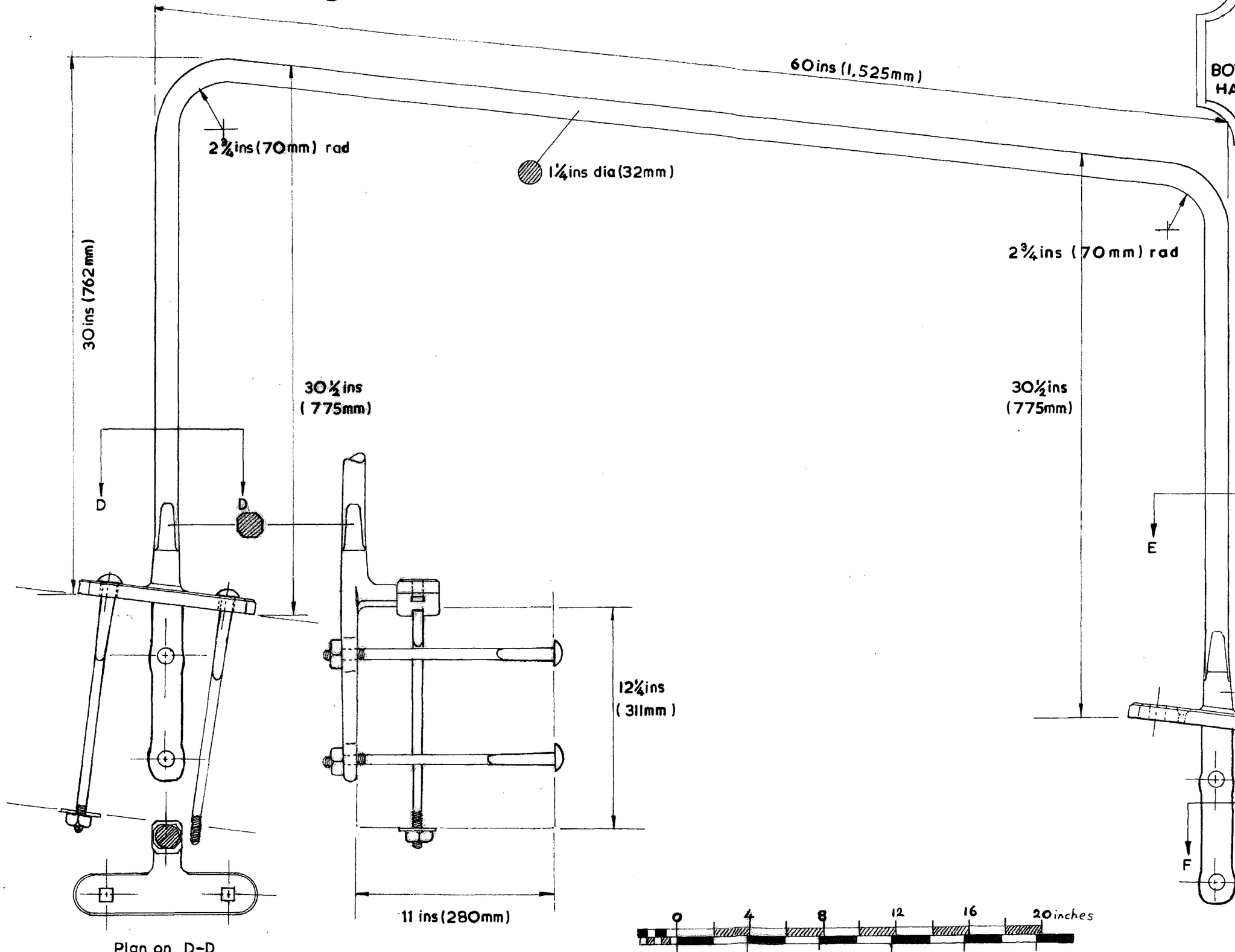
DC
N

TOP GATE HANDRAIL
FORGING
WROUGHT IRON
Scale 1:10 1:2

6a

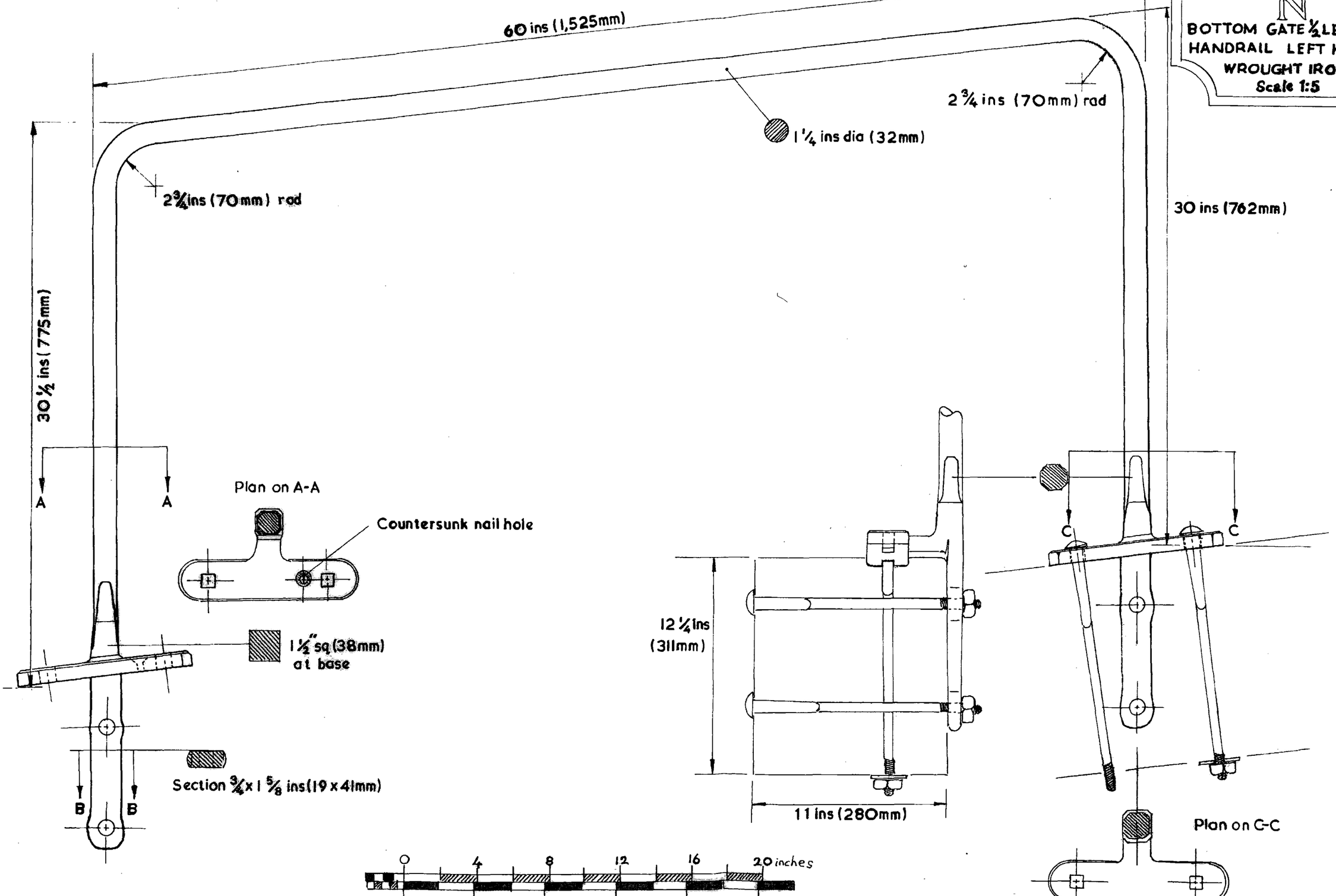
Droitwich Barge Canal Bottom Gate Handrail R Hand

DC
N
BOTTOM GATE ½ LENGTH
HANDRAIL RIGHT HAND
WROUGHT IRON
Scale 1:5
7



Droitwich Barge Canal Bottom Gate Handrail L Hand

DC
N
BOTTOM GATE ½ LENGTH
HANDRAIL LEFT HAND
WROUGHT IRON
Scale 1:5
7a



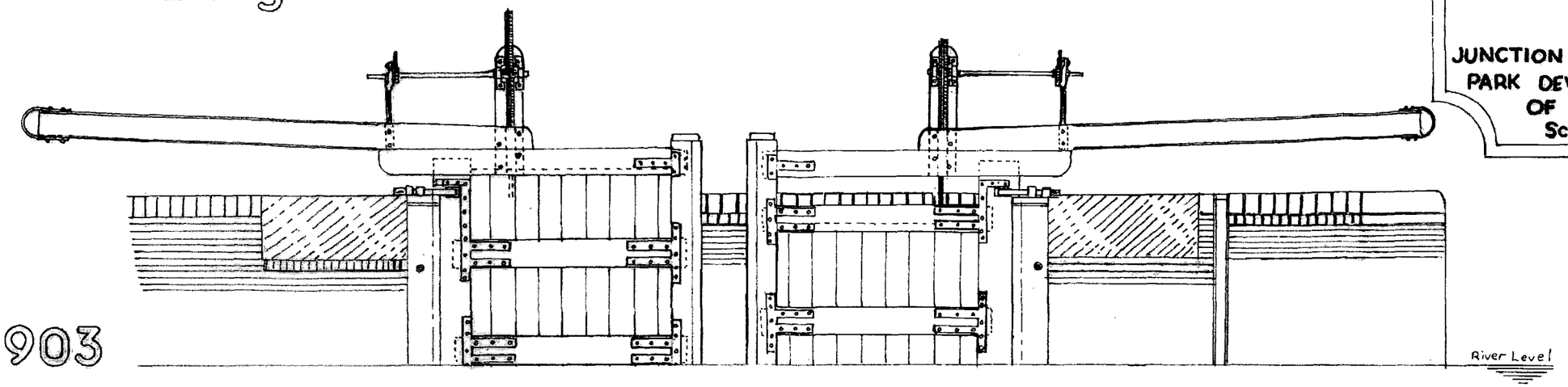
Droitwich Barge Canal Junction Lock Vines Park

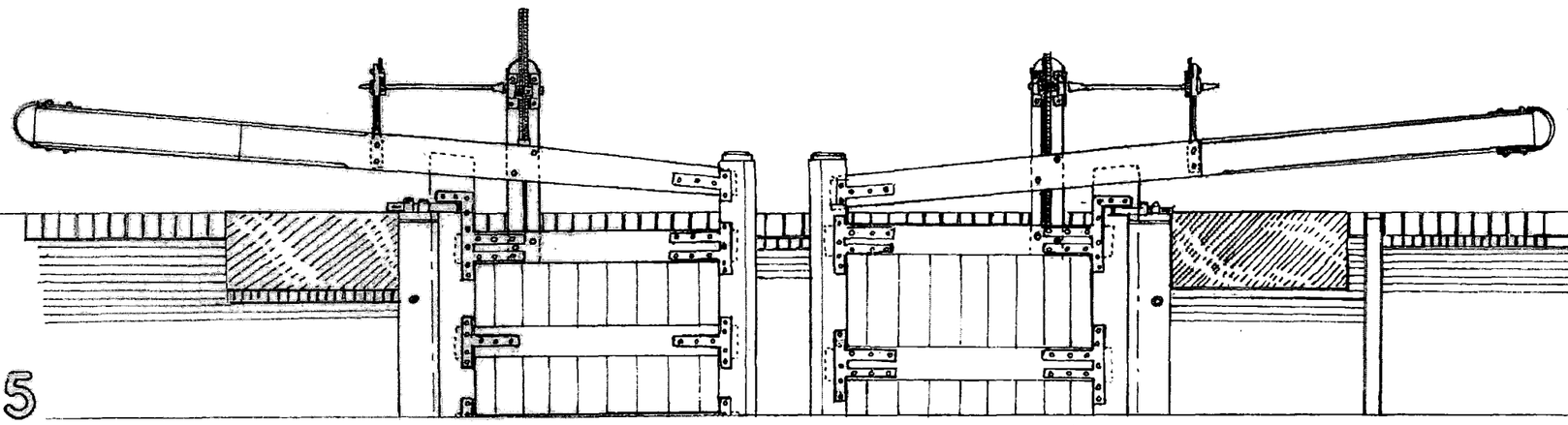
DC
N

JUNCTION LOCK @ VINES PARK DEVELOPMENT OF GATES
Scale 1:50

8a

pre 1903

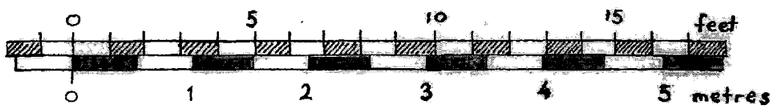




8b

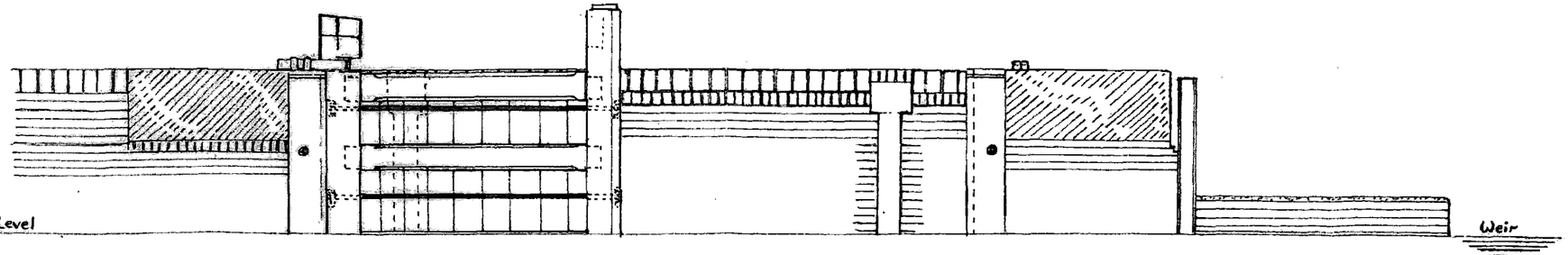
post 1905

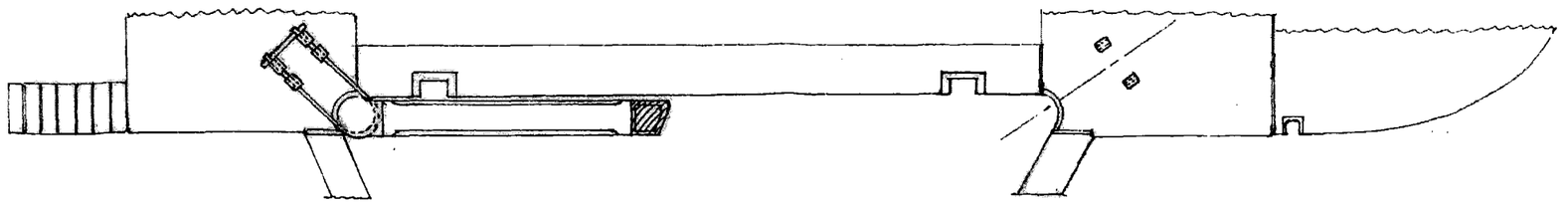
River Level



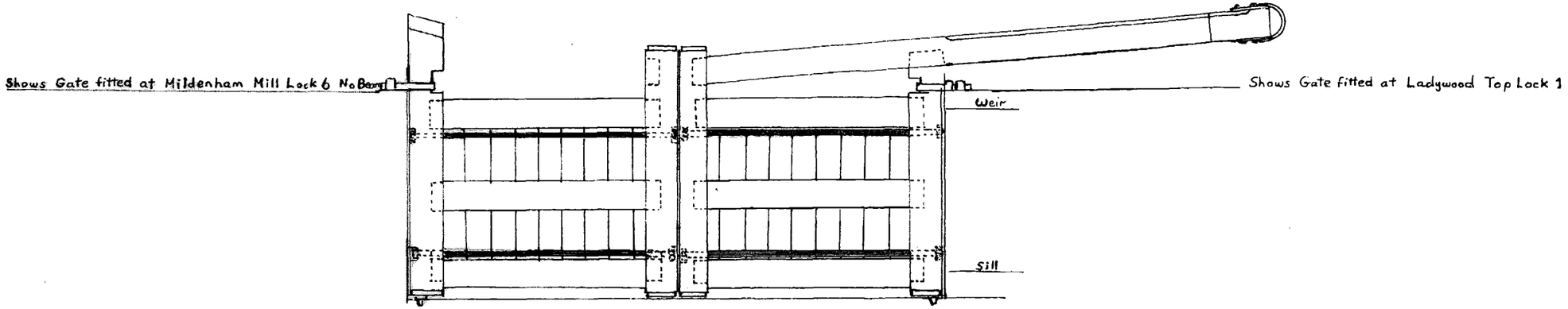
9

2007

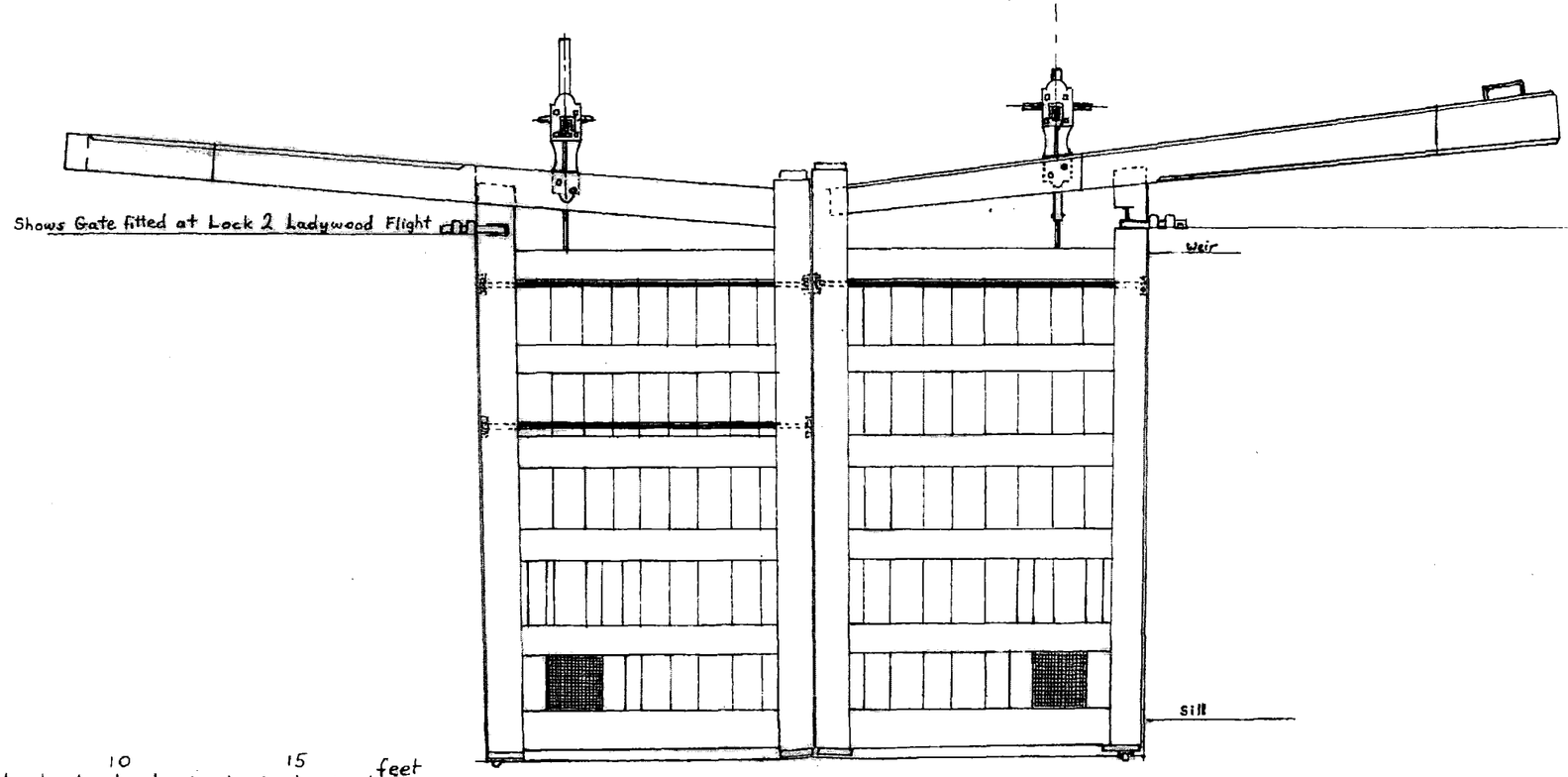




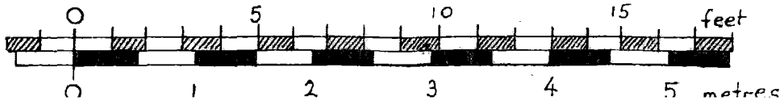
Droitwich Barge Canal Replacement Gates Locks 1-6



Top [Upper] Gates(view uphill)



Bottom [Lower] Gates (view uphill)



DC
N

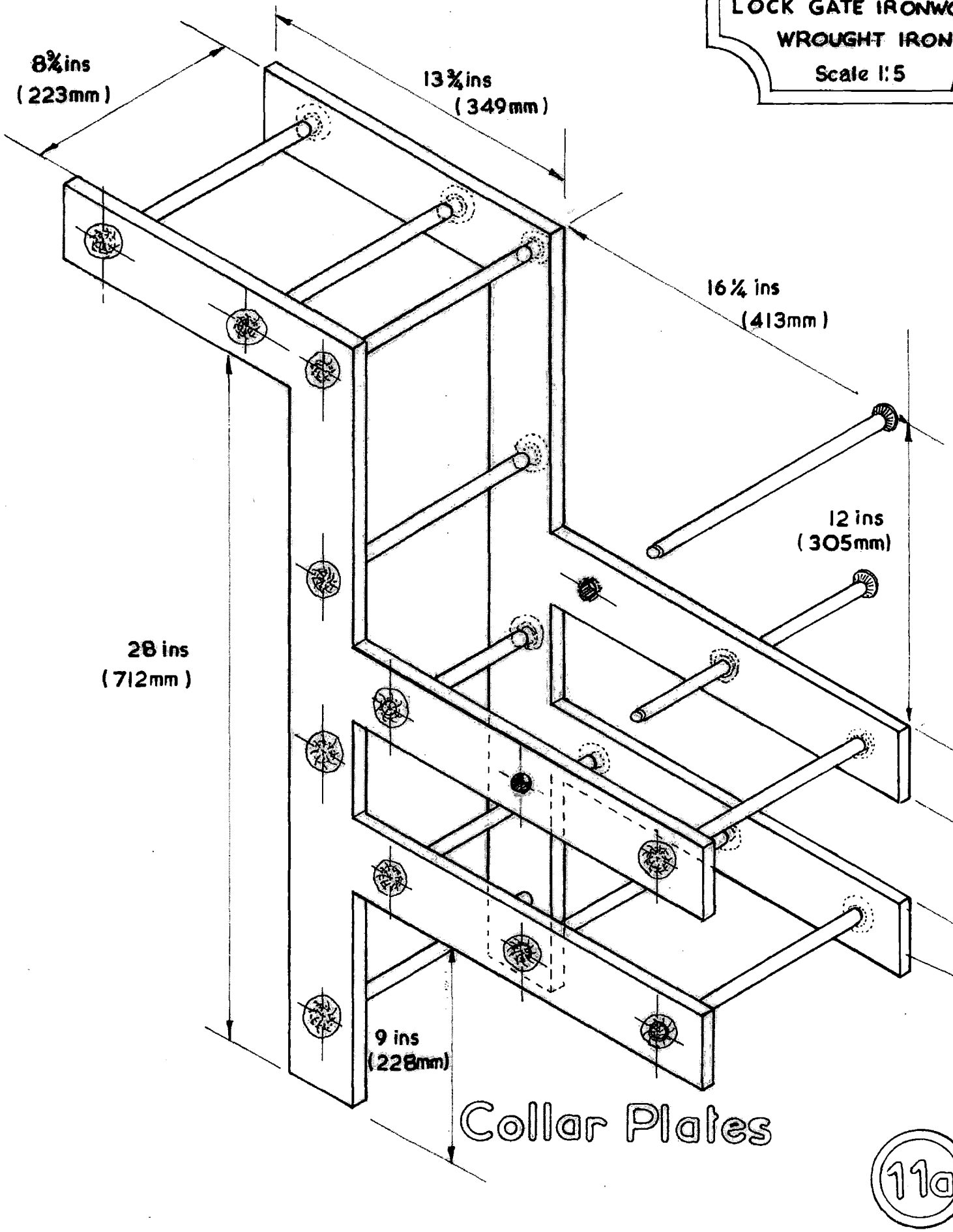
REPLACEMENT GATES
TOP & BOTTOM
LOCKS 1-6
Scale 1:50

10

Droitwich Barge Canal

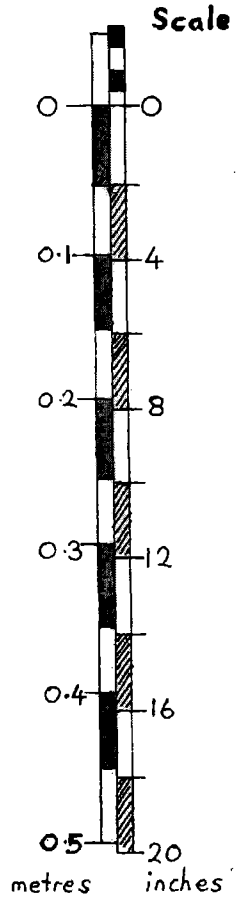
DC
N
LOCK GATE IRONWORK
WROUGHT IRON
Scale 1:5

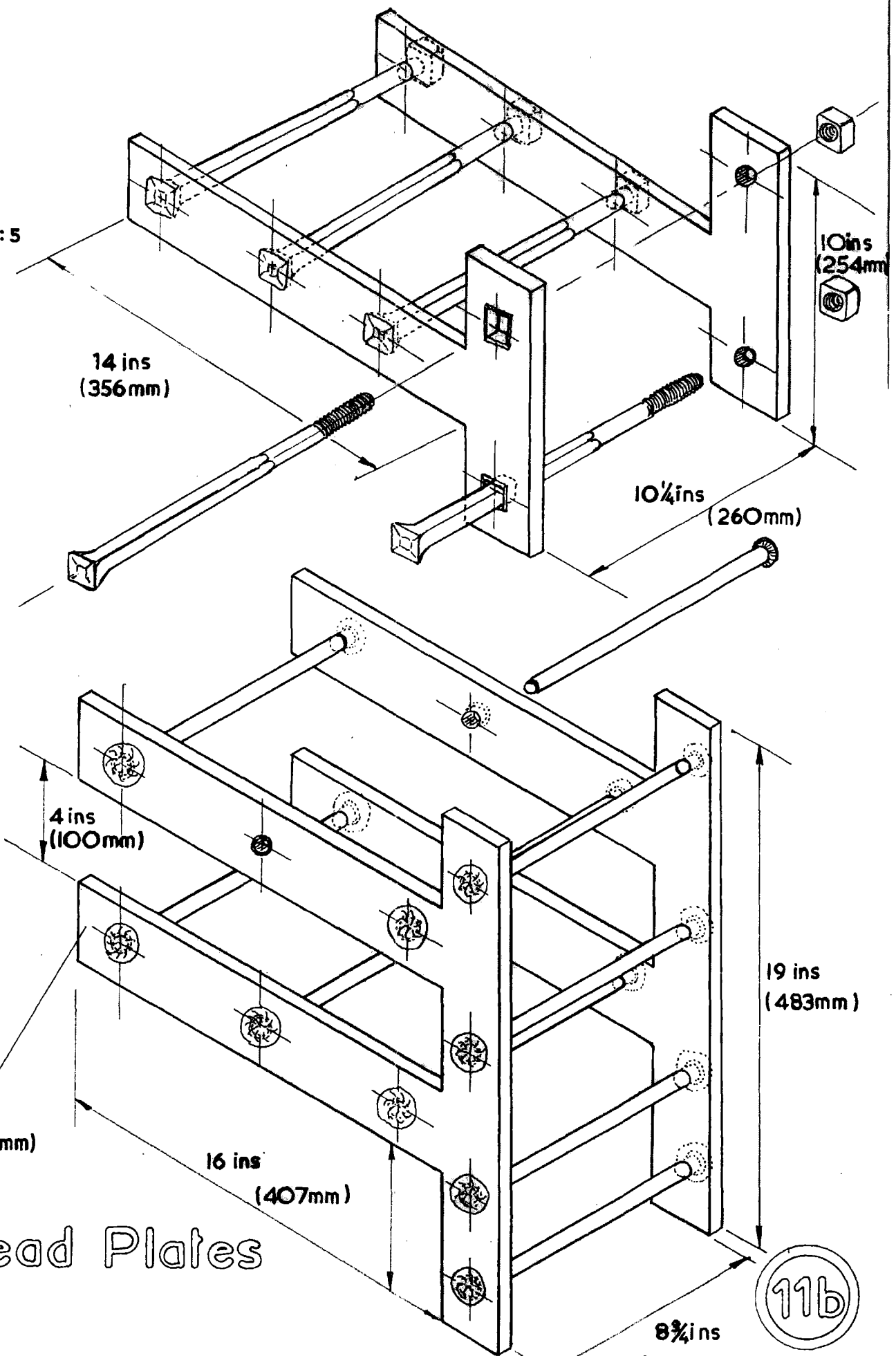
Tee Plates Balance Beam End



Collar Plates

11a

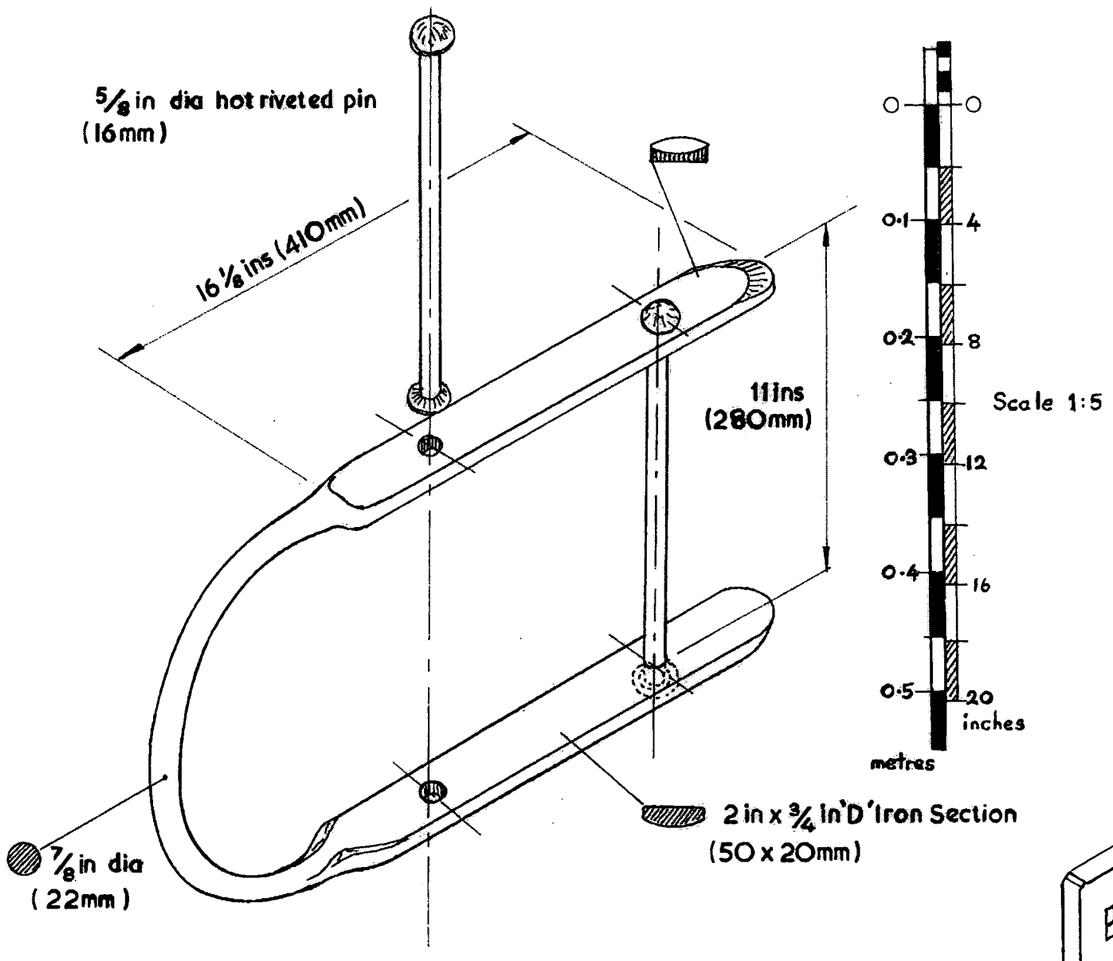




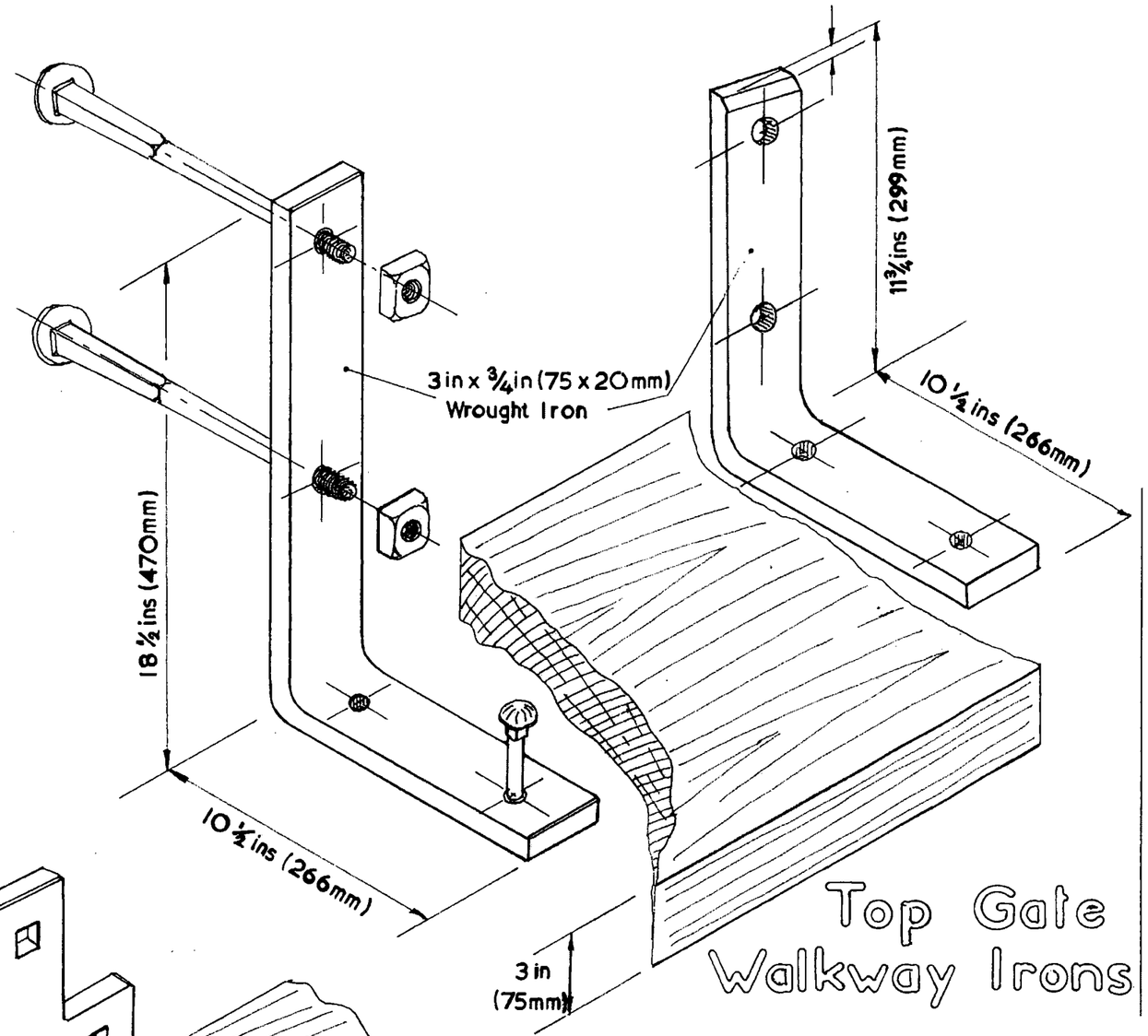
Head Plates

11b

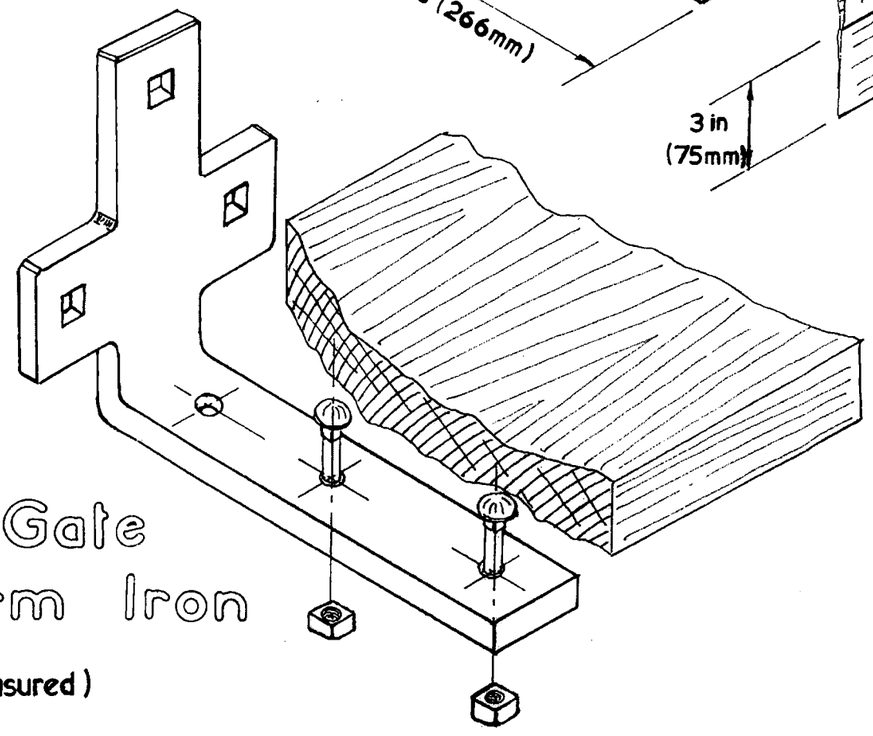
Droitwich Barge Canal



Beam Handhold Forging Wrought Iron



Top Gate Walkway Irons



Bottom Gate Cruciform Iron

(Not Measured)

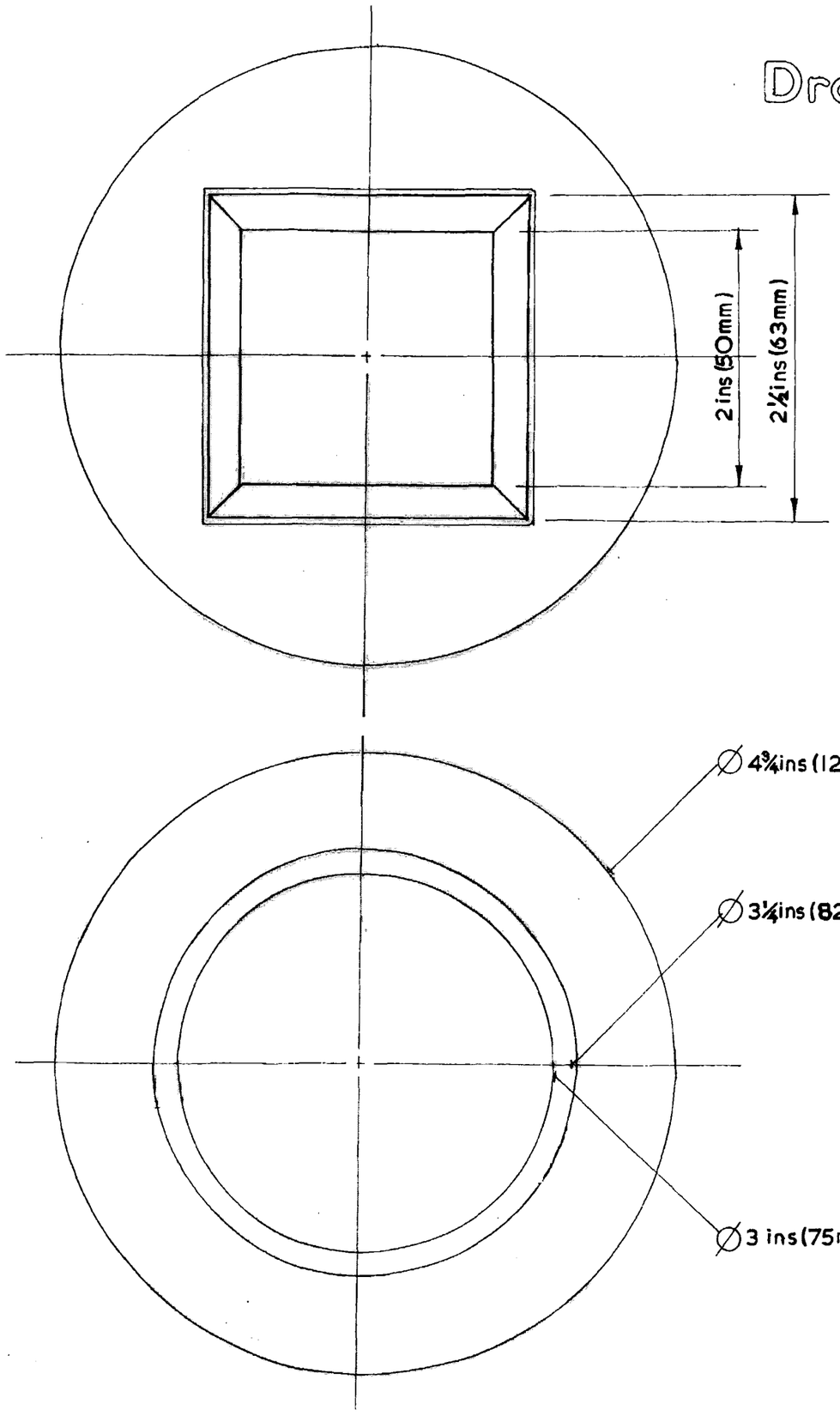
DC
N

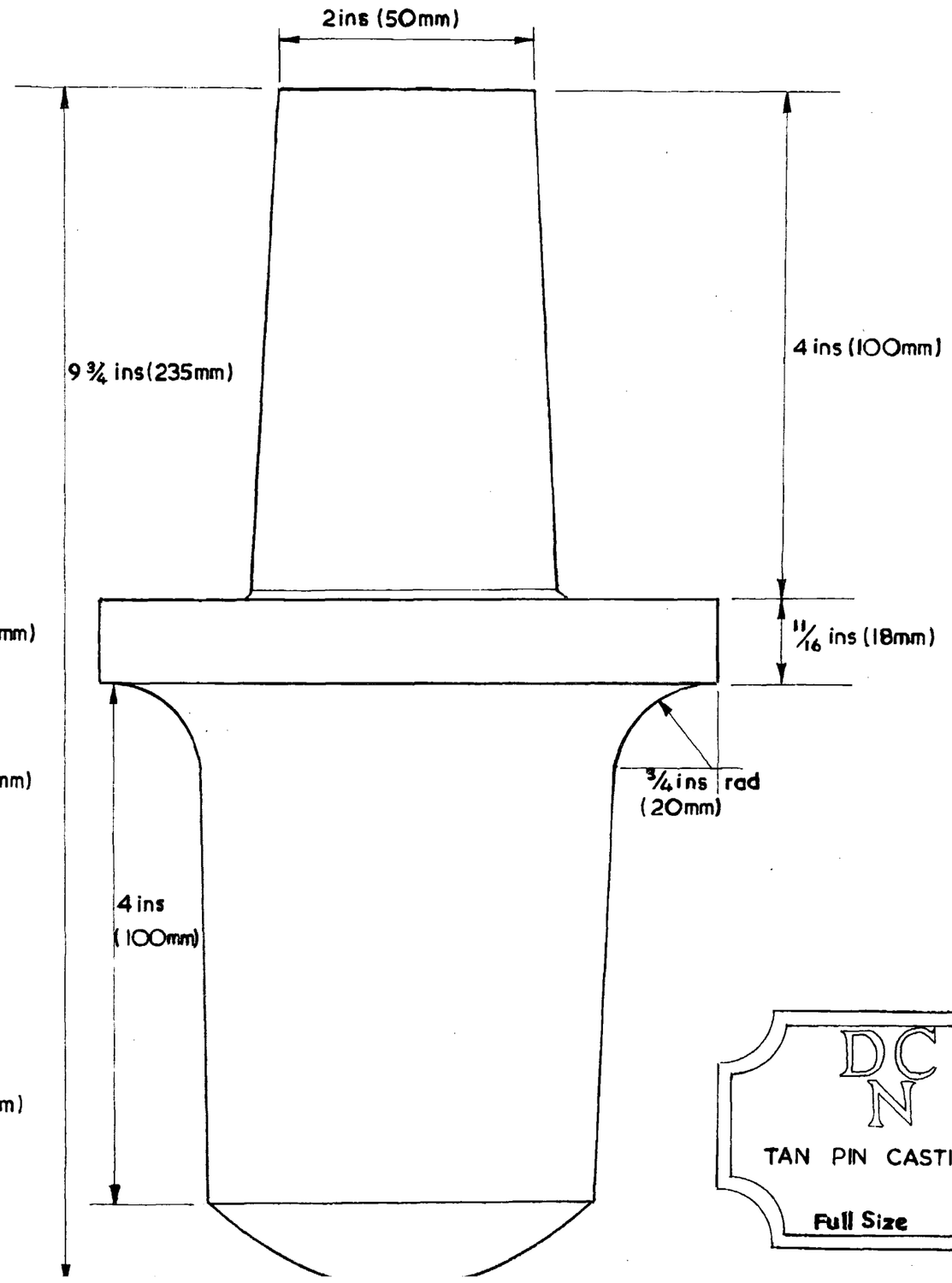
BEAM HANDHOLD FORGING & TOP GATE WALKWAY BRACKETS

Scale 1:5

12

Droitwich Barge Canal — Tan Pin



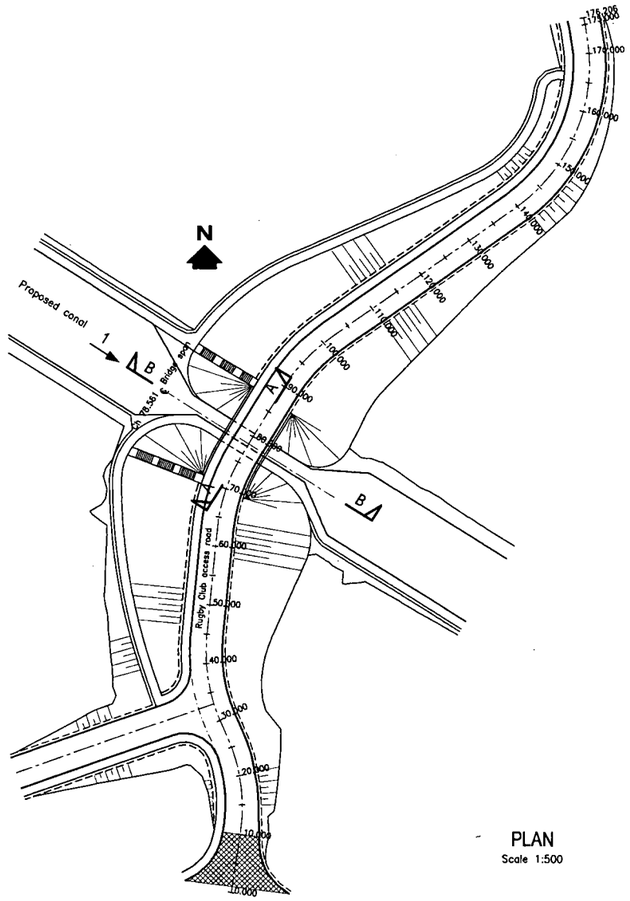


DC
N

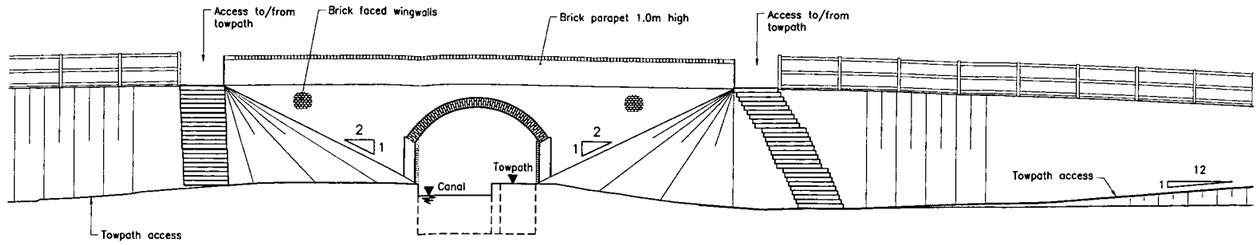
TAN PIN CASTING

Full Size

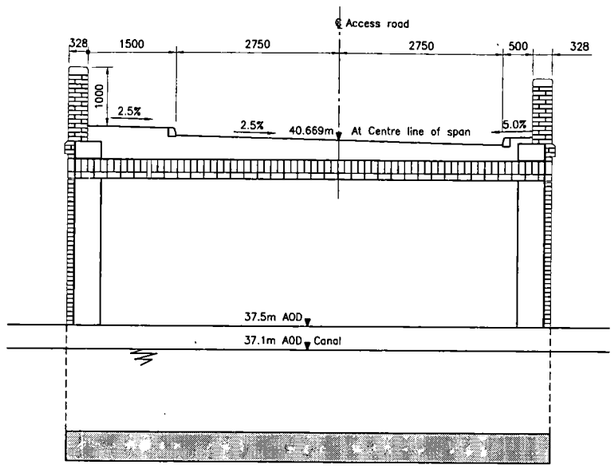
13



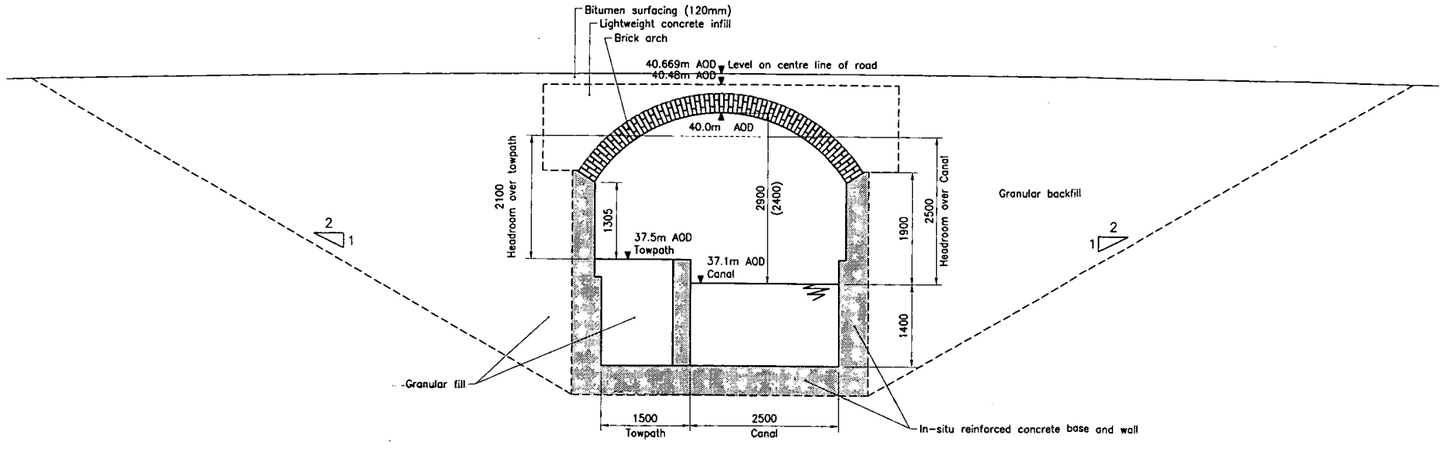
PLAN
Scale 1:500



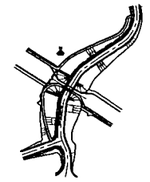
ELEVATION 1
Scale 1:100



SECTION B-B
Scale 1:50



SECTION A-A (BRICK ARCH OPTION)
Scale 1:50



Notes

Rev	By	Chkd	Apprvd	Date	Description

Client

BRITISH WATERWAYS

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Halcrow

Project

DROITWICH JUNCTION CANAL
RUGBY CLUB BRIDGE
RESTORATION

Drawing

RUGBY CLUB ACCESS BRIDGE
GENERAL ARRANGEMENT FOR AIP

Drawn by : PK	Date : 23.03.2007
Checked by : VS	Date :
Approved by : JS	Date :
Drawing No. TB/BWFB/061/SK101	Revision -

Drawing Scale : VARIES

Drawing file path & name : L:\GITTCAD\Digitech Junction Canal\Rugby Club Bridge\Detailed Design\Working\TB_BWFB_061_SK_101.dwg
Drawing plot time : Tuesday
User and Plot Date : 10 Apr 2007 - 4:14 pm