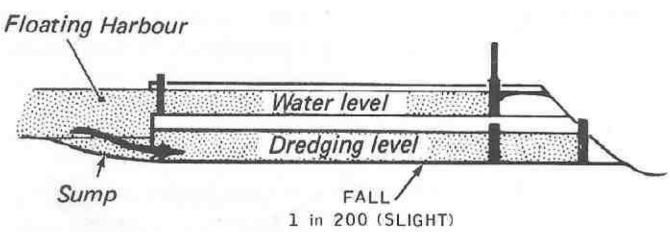
THE PORT OF BRISTOL UNDERFALL YARD WORKSHOPS

Tom Fisher, David Jones and Roy Day

William Jessop's scheme for the Floating Harbour, completed in 1809, provided an overflow, near the Junction Lock to Cumberland Basin, which was known as *The Overfall*. It was a dam over which any excess water flowed from the harbour into the New Cut, and was incorporated into a sturdy embankment on which part of Cumberland Road was later constructed. The water then ran from the harbour just below the road level, as portrayed by T W Rowbotham in his watercolour of 1827 in Bristol Art Gallery.

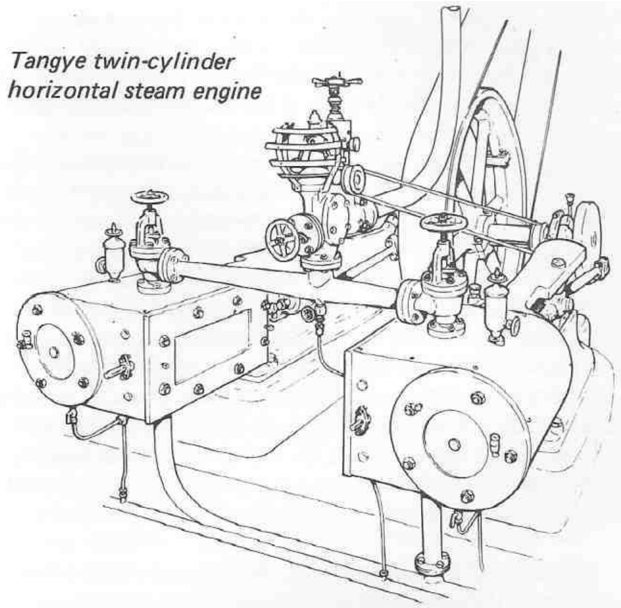
In the early years of the Floating Harbour the difficulty of silt disposal emerged as one of the problems of operation. In 1832, the young I K Brunei was invited to put forward proposals to alleviate this, and subsequently he made suggestions which included modifications to Jessop's Overfall Dam. The work was carried out some two years later, when the dam was pierced by four culverts, three at high level to control the water level in the harbour, and one at low level for the disposal of silt. Brunel also designed a steam spoon-dredger to scrape silt from the harbour, depositing it at the mouth of the low-level culvert, where it could be scoured through to the New Cut. Sluice gates in the culvert were opened periodically according to the state of the tide. The dam overflow was no longer required; the name Overfall was no longer appropriate. The new installation soon became known as *The Underfall* and it still remains in operation.

Each of the four culverts had sluices, and today each sluice has two separate controls. The original set of four, hydraulically operated, were situated in small workshop alongside Cumberland Road and they, or their successors, are still there, (cross hatched on site plan, figure 1) but there is a further set of later electrically-operated gates some short distance away. Three of these secondary controls are situated in a building of Second World-War origin, (see figure 1) with two of the controls actually linked to operate together. The fourth is in a small brick building between the railway line and the New Cut, a few yards away from the Underfall Yard Gates in Cumberland Road. All are used regularly and, unless replaced by a modern system, will continue to be as long as there is a Floating Harbour, whatever the situation regarding shipping in the docks.



When the dam was converted to an underfall there was a surplus of clay which was backfilled to reform a reclaimed area adjacent to the culverts in the harbour. This eventually became a useful piece of land under the control of the Dock Company, and from about 1845 offices and workshops began to be built in this area which was to become known as the Underfall Yard.

In the Yard, over a period of years, offices, stores, a small ship-repairing slipway, an hydraulic pumping station and the Underfall Yard Workshops were constructed. In 1882, when John Ward Girdlestone was appointed engineer to the Port of Bristol, a considerable expansion of the workshop facilities was contemplated. In 1884-5 much new plant was purchased and, in the main, this equipment is still in the machine and blacksmiths' shops, (figure 2). Although not working at the time of the BIAS Survey in October 1977 or for many years prior to this, most of it is capable of being worked.



Adjacent to the machine shop, and connected by a small heavy-duty door, is the 1885 horizontal twin-cylinder Tangye steam engine (see BIAS Journal 9 for details), which drives to a continuous lineshaft running the entire length of the machine shop at high level. immediately inside the shop, there is a 36 in dia pulley which drives across the width of the shop to a similar pulley, proving a second longitudinal length of lineshafting. The first lineshaft (x - x on figure 2) has take-off pulleys for machines 1, 2 and 3, whilst the second lineshaft (y - y) provided a source of power for machine number 4.

Machines 5, 6 and 7 are all machine tools installed during the last war and have individual electric drives. They are the only machine tools in the shop which are operating today. In the blacksmiths' shop, the only machines used currently are 13, 14 and 15, all modern tools with individual drives. The items of plant acquired during the Girdlestone era, and after, which require a supply of live steam are those numbered 8 and 11. Although they are immobile at present, they also are capable of being worked.

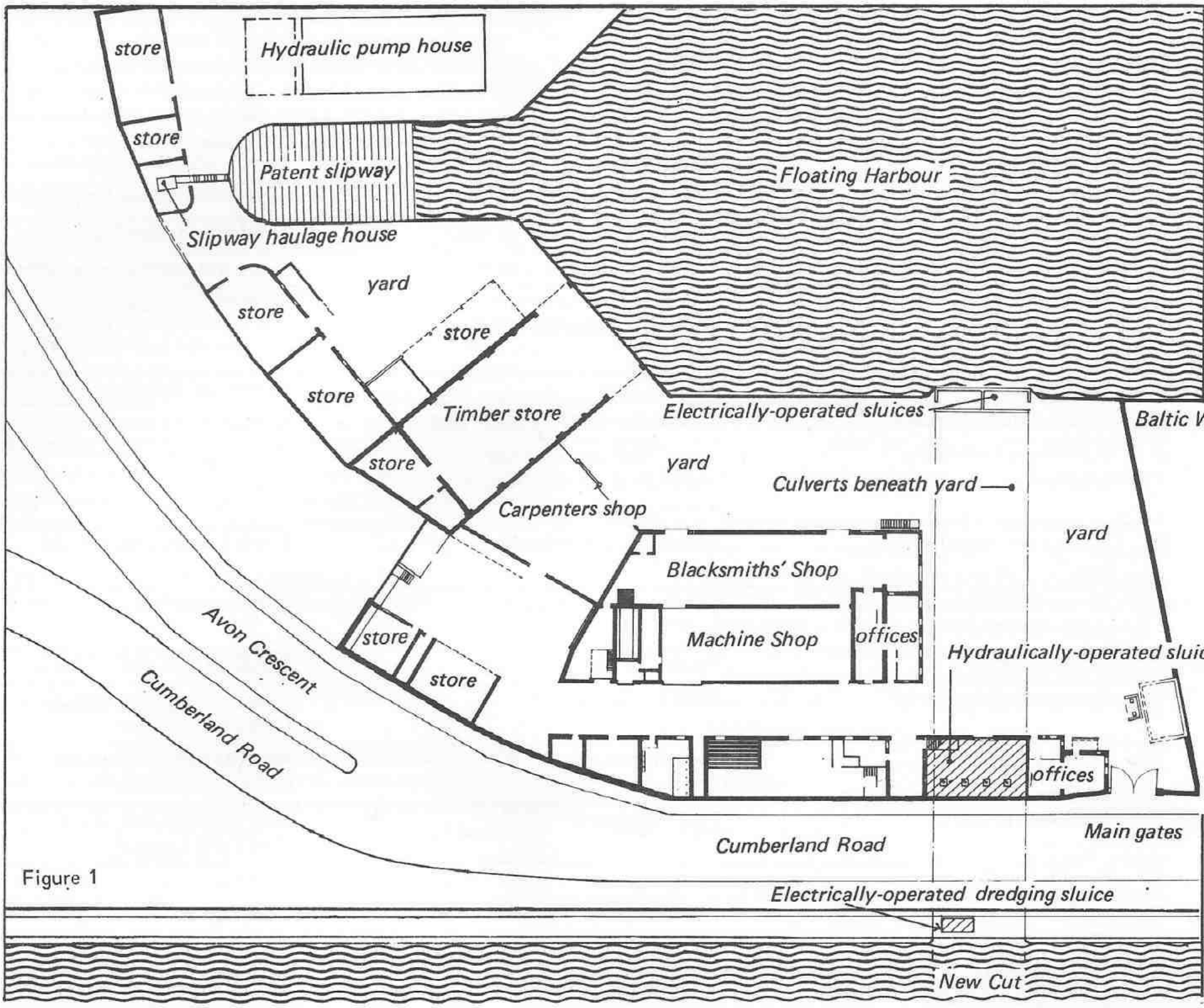
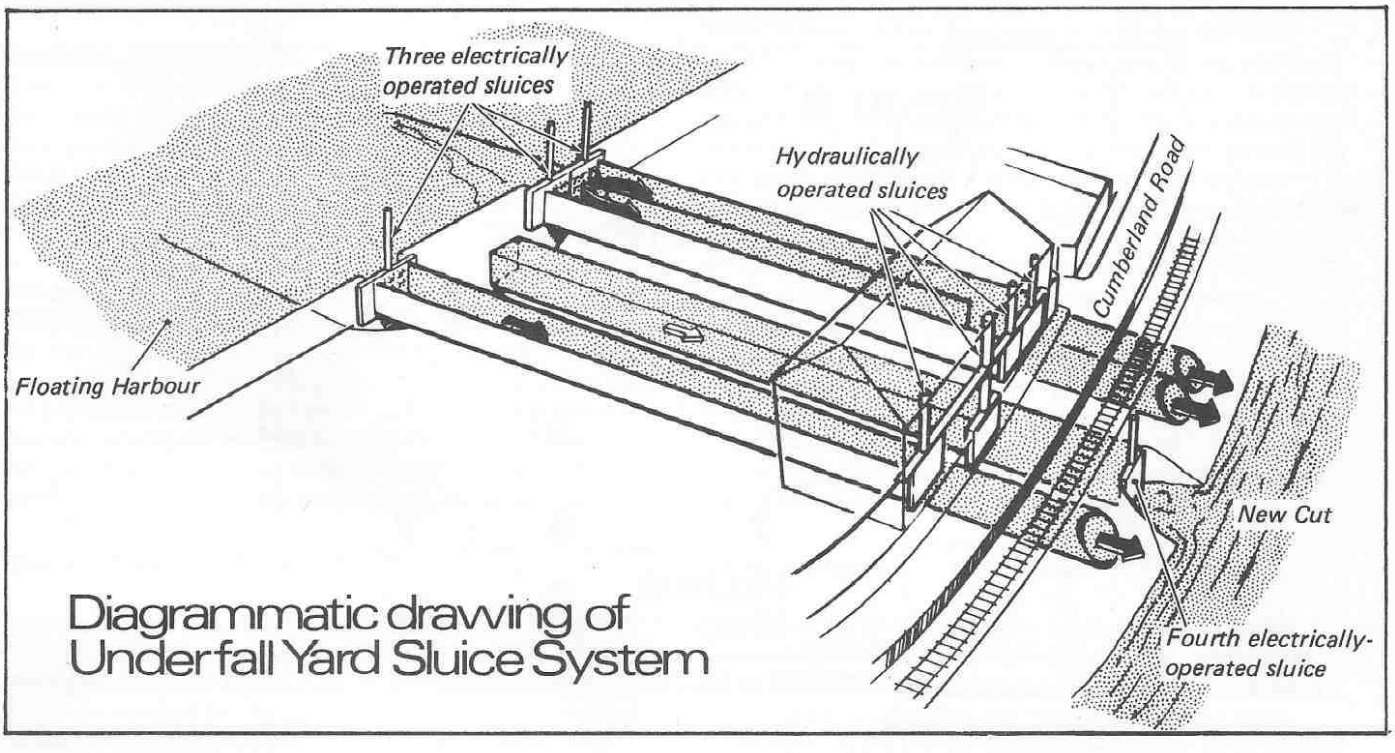


Figure 1



Diagrammatic drawing of Underfall Yard Sluice System

Number on Plan	Type of Machine	Details	
1	Planing machine	Dated 1884	Joseph Whitworth Manchester
2	Slotting machine	Dated 1884, Numbered 258	Joseph Whitworth Manchester
3	Long bed lathe	Dated 1884, Numbered 1037	Kendall and Gent Manchester
4	Shaping machine	No date or number visible	Hulse and Company Manchester
5	Centre-lathe	14½ in NM1 type 15 HP 1445 rpm motor by Wright of Halifax	Mitchell of Keighley
6	Centre-lathe	8½ inch type	Mitchell of Keighley
7	Radial drilling machine	Type OD1-7537, Number 19477	William Asquith Halifax
8	Punching-and-shearing machine	Dated 1885 and supplied by Joseph Pugsley, Cattybrook Ironworks, Bristol	John Cameron
9	Three-tuyere heating hearth	Not dated or numbered	B and S Massey Manchester
10	15 cwt hand-operated pintle-type crane	Not dated or numbered	Stothert and Pitt
11	Steam hammer	No date or number visible	Possibly Davis and Primrose
12a	Blacksmiths' hearth	Type Number 2	Andrew Handyside and Co. Derby and London
12b	Blacksmiths' hearth	Type Number 5	Andrew Handyside and Co. Derby and London
12c	Blacksmiths' hearth	Type Number 5	Andrew Handyside and Co. Derby and London
13	Powered hack-saw		no details
14	Double-headed power grind-stone		no details
15	Single-headed power grind-stone		no details

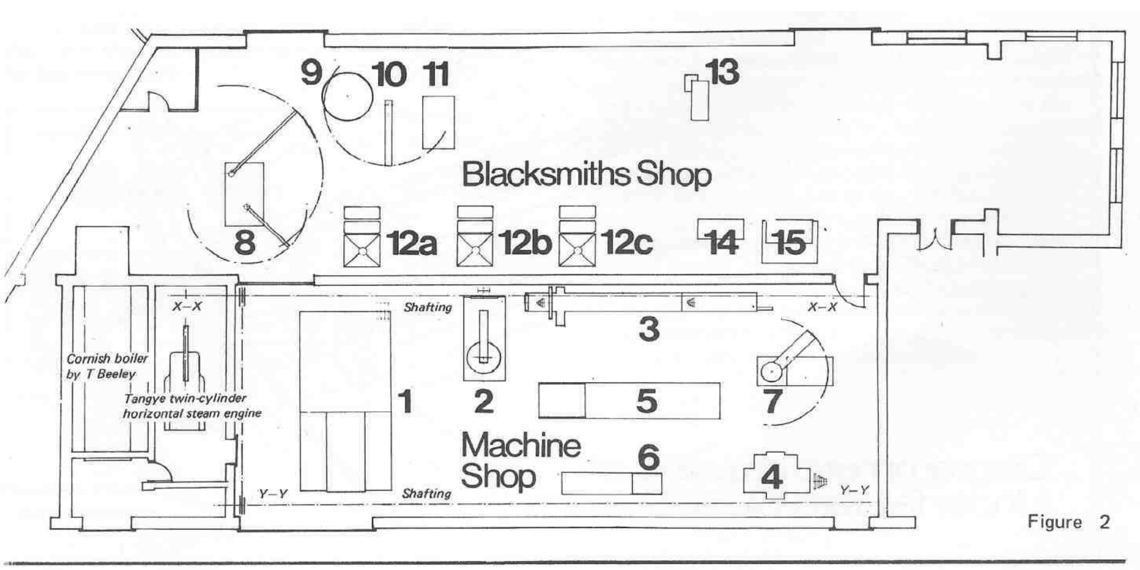
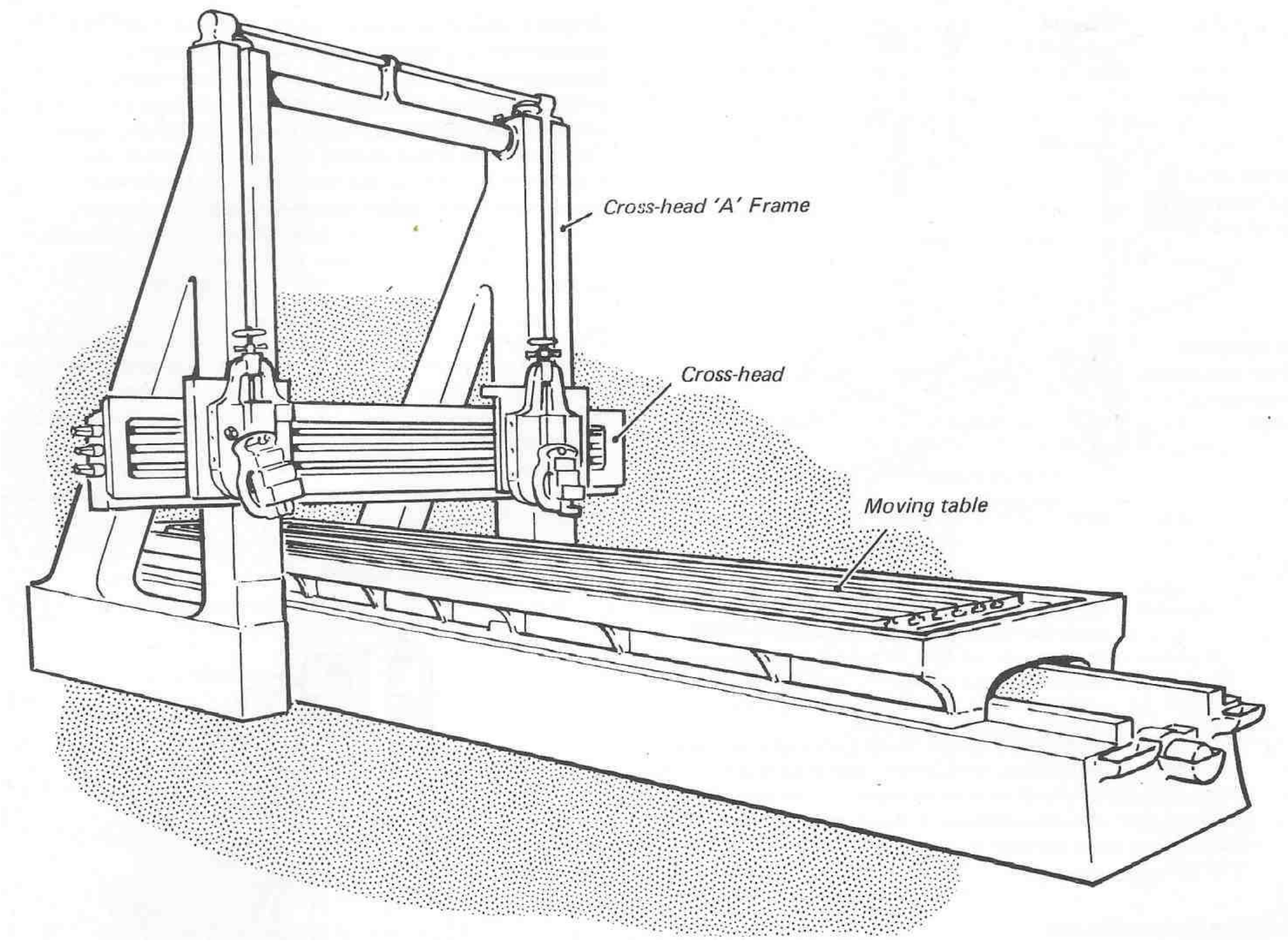


Figure 2



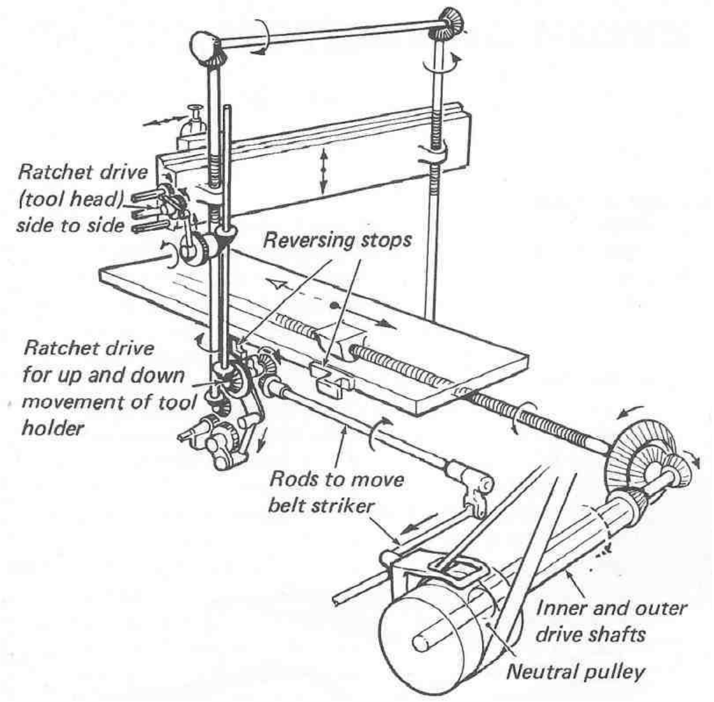
The Whitworth Planing Machine

The Whitworth planing machine, dated 1884, appears to have been used mainly for machining sluicegates and guides, frames of various kinds and railway-point switches although, undoubtedly, it had many other uses. By generally accepted standards it is not a large machine but it is fairly rigidly constructed and apparently in good order. As evidence of this the table, although very heavy, can be quite easily moved by hand when pulling the belt drive.

In general terms, the engineers' planing machine has one thing in common with its woodworking counterpart in that the workpiece is made to move past the cutter. This is a single point very much like a lathe tool, held stationary whilst the work is made to move back and forth beneath it, or alongside it. Mounted on a reciprocating table which moves on slides, the tool is arranged to cut in one direction, so that in a complete cycle only one movement does useful work. To reduce idle time on the return stroke, the machine is made to run more quickly.

The Whitworth planing machine at Underfall Yard has a table 4ft 6in wide by 14ft 6in long which completes, on average, two cycles per minute and can accommodate work up to 6ft in height approximately. It has two tool positions which, in certain circumstances, can be used simultaneously. The tools can also be made to move upwards or downwards (called feed) on individual slides which can be rotated to angles of up to 90º from the vertical. In addition, automatic feed can be provided in moving the cross-slide bodily up or down at a pre-set rate. The tools can be fed across the machine in a similar manner.

The table is propelled by means of a lead screw which runs from end to end of the machine. This screw is 4 in dia with a two-start square thread of 3 in lead and engages a nut attached to the underside of the worktable, which is propelled by rotation of the screw. This is driven via bevel gearing at one end with two pairs of gears providing differing ratios. The change of direction in screw rotation is accomplished by an automatic device called a 'belt striker' which guides the driven belt from one pulley to another, (whilst maintaining the driven pulley's rotation through the different gear ratios) thereby providing a slow cutting action and a fast return. The length of stroke can be set by the machine operator who clamps 'stops' to the side of the worktable where required to operate the belt-strike mechanism. On-off control of the machine is by the familiar method used in 'line-shaft' drive workshops, the main belt drive being moved from a loose to a fast pulley, (the loose pulley is free to rotate on its shaft whilst the fast pulley is keyed firmly to the driven shaft). The belt striker used for this purpose is separate from the reversing belt striker shown on the drawing.



The lead screw is arranged always to take only tension loads. Bearings to accommodate axial thrust exist at each end of the screw. The one at the drive end carries loads due to cutting, and is of the multi-collar type, lubricated manually. The machine can accommodate a stroke variation of 18in up to 11ft 6in approximately.

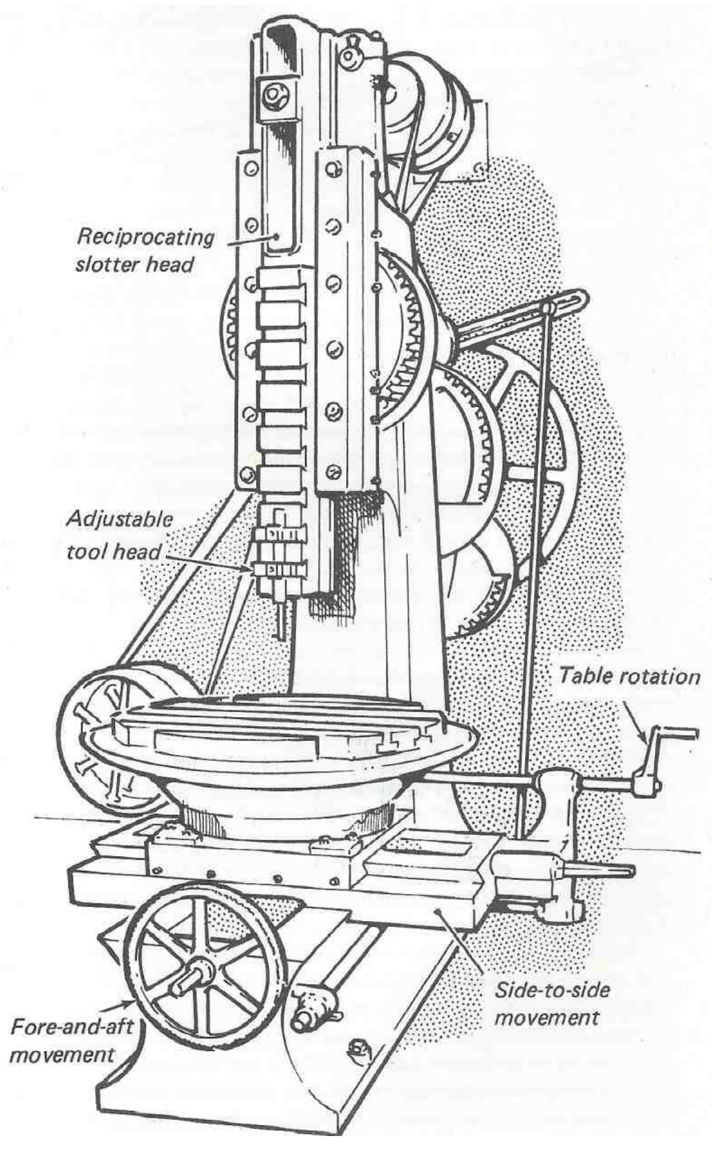
The Slotting Machine

The slotting machine at the Underfall Yard is of medium size, made by J Whitworth, dated 1884 and numbered 258. Such a machine performs its function by using a single-pointed tool with a reciprocating action with an up and down movement, the cutting being on the down stroke. Generally, no quick-return mechanism is used.

The drive to the Underfall Yard machine is from overhead shafting via a crossed belt. This is to provide clearance for the flywheel which is shown at the rear of the machine, the direction of drive being corrected by use of another crossed belt from the shaft at the top of the machine to the main gear shaft. This drives via a gear system to the slotted wheel, to which is clamped the main connecting» rod pin,(not visible in the drawing) which may be fixed at selected radii to vary the length of stroke of the tool. As the wheel rotates, the connecting rod moves up and down. The top end of the rod is attached in a pin, which is held by a large nut to the reciprocating tool-slide of the machine, (as clearly shown). The position of the slide can be adjusted vertically through a range of approximately 22 in.

The workpiece is clamped to the circular table by means of the usual 'tee-slots', all of which can be clearly seen, and the table movement controls the shape of the hole being cut. The movements can all be made automatically by means of gears, which can be placed on the appropriate ends of the three shafts. One such gear is shown at the front of the machine. A number of gears are available for providing different rates of movement, which is termed 'feed', and is derived from an ingenious system of slotted levers, plus a pawl and ratchet. The initial step in the feed mechanism train is a face cam on the rear end of the main drive shaft which causes the slotted link to reciprocate up and down. This movement is transmitted through the vertical rod to a similar slotted link at the foot of the machine which causes a pawl and ratchet to provide intermittent rotary motion to a shaft which can be seen beneath the worktable slides. This shaft can be geared to drive the wheel shown and can also be used to drive the other feed shafts.

The most common use for slotting machines is the production of keyways in holes such as those in marine propeller bosses. The action of these machines also enables them to produce holes and similar shapes of non-circular outline. This gives a clue to the derivation of the name 'slotting machine'. Particular uses to which the Underfall Yard machine was put, were rail points for cross-over junctions and collar bands for lock-gate heel posts, the bands which retain lock-gate hinges in position. Operating speeds were usually set at approximately fifteen cuts per minute.



The long-bed gap lathe

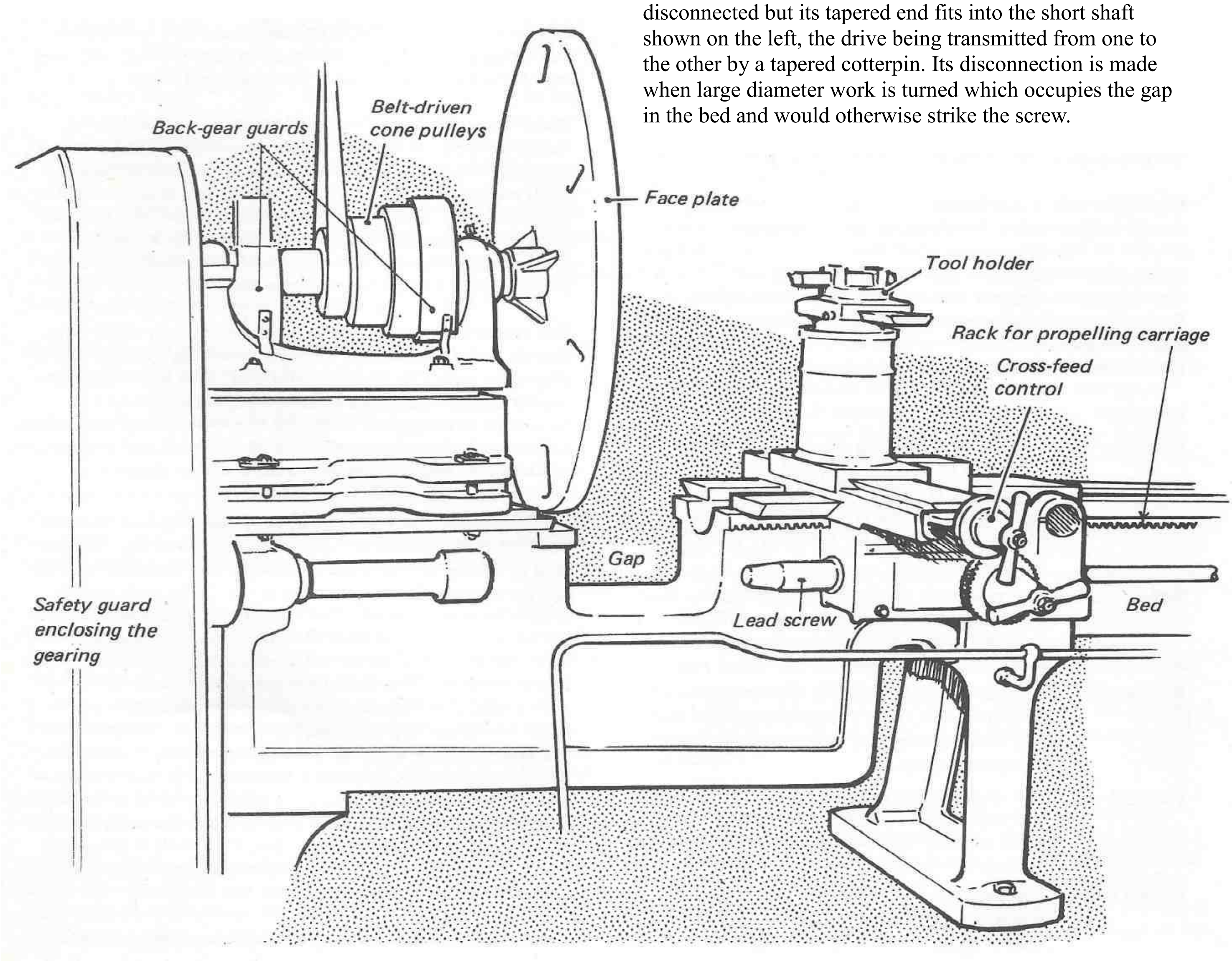
This lathe is an interesting machine, made by Messrs Kendal and Gent of Manchester in 1884 and numbered 1037. To engineers of today it presents an unusual appearance with first impressons of its great length compared with other dimensions. The bed over its extremities is 25ft 10in long with a usable 23ft 6in from the faceplate surface to the opposite end, which enabled it to be used for long slender workpieces such as propeller shafts.

The machine has a number of features which are unusual. The height of the headstock centre above the bed, usually called the centre height, can be varied by placing special packing pieces under the headstock and such a piece can be seen in the drawing. Similar packing can be interposed between the tailstock and the bed to adjust the height to that of the headstock. This facility allowed the machine to accommodate work of a very large diameter and also enabled it to be used for boring. When so used, open-ended cylinders were bolted to the saddles and a bar carrying a single-point tool was placed in the chuck and supported by the tailstock at the other end. The work moved along the bed whilst the tool and bar rotated, thereby producing a straight bored hole.

Another unusual feature is the removable secondary head-stock and tailstock. This additional headstock is placed halfway along the bed and is driven in a similar manner to the main one, that is by belts from overhead shafting via a countershaft and beltstriker. When required, these extra head and tailstocks enabled the machine to accommodate two workpieces at the same time.

The main carriage, or saddle, contains a mechanism for moving the tool automatically parallel to the bed and across it, a movement called 'feed'. The secondary carriage has no automatic or longitudinal feed but has the usual hand-operated cross feed and a compound slide. This is a small hand-operated movement, placed above the carriage, making it possible to rotate the slide and so enabling tapers to be produced.

Two horizontal shafts run the length of the machine, one in front and the other behind the bed. The front shaft is threaded throughout its length and is used for propelling the main carriage to produce screw threads. The shaft at the rear of the machine transmits movement to the main carriage for the purpose of automatic feed, in contrast to the modern machine where such a shaft would be at the front alongside the lead screw. The drawing shows the lead screw disconnected but its tapered end fits into the short shaft shown on the left, the drive being transmitted from one to the other by a tapered cotterpin. Its disconnection is made when large diameter work is turned which occupies the gap in the bed and would otherwise strike the screw.



The drawing shows a horizontal bar in the foreground similar to a handrail in appearance. This, in fact, is a belt-striker control, extending just over halfway along the machine, and it eliminates the need for the return of the operator to the headstock each time a start or stop is required. Owing to the machine's length, this control is more than a convenience; it is an essential item.

The machine was installed too close to the brick wall behind it and in consequence, a neatly-cut segment of a circle was removed from the brickwork to enable large work to be undertaken. This was the preferable alternative to moving the machine, as such movement was likely to cause distortion Once installed, it was practically immovable.

The feed shaft and the lead screw are driven from the head-stock shaft (usually called the spindle) by an arrangement of interchangeable gears, about twentyfour being available. Various forms of positional adjustment are provided to enable meshing to take place under all conditions of centre height and shaft speeds which may be required.

The machine was used for the turning of propellor shafts, hydraulic rams, sluice cross-heads, dredger-bucket tumblers (the wheels over which the bucket chain runs at the top of its travel) and as a boring machine for hydraulic cylinders. A typical size of ram machined on this lathe was 15in dia by 15ft in length. A machine as versatile as this was obviously used for many other items, such as dredger parts of many kinds, as well as a variety of components which have gone unrecorded.

Bed: 25ft 10in long overall
Centre height: main, 16½in up to 22½ n or more
secondary, 10in.
Normal maximum work dia: 5ft 6in into gap
Speeds: approximately 3 or 4 rev/min to 120 rev/min
Each headstock had a cone pulley with four belt positions and back gearing.
Lead screw: 2½in dia, 2 threads per inch.

Glossary

Back Gear — A device for running very slowly, used on machines driven by belts but seldom seen nowadays. It should be noted here that a slow speed facility is a useful feature in machines not used for repetitive production purposes.

Bed — Aptly named, this is the long straight horizontal frame of a lathe on which everything else rests. It has to be accurately made and straight.

Belt Striker — A hand-controlled sliding fork which moves a running belt from a loose pulley to a fast one and vice versa; ie from a free running to a driving pulley.

Carriage — The sliding device which moves along the bed and supports the cross-slide and tool. The main carriage is clearly shown in the drawing. A commonly-used alternative is the 'saddle'.

Centre Height — The height of the centre line of the headstock measured above the bed or the carriage, (either measurement is used but unfortunately which of the two is not always specified) American specifications double this dimension and call it 'swing' the maximum diameter of workpiece which can be accommodated.

Headstock — The part of the lathe in which the main drive is placed and the chuck or faceplate is held. In most machines its position is fixed.

Lead screw — A long screw, usually having a square section thread used to convert its own rotary motion into longitudinal of a mating part.

Tialstock — The part at the opposite end (usually) of the bed to the headstock. It is used to provide a support for long workpieces and for supporting a limited range of tools. It has to be precisely aligned with the headstock centre.

Shaping Machine

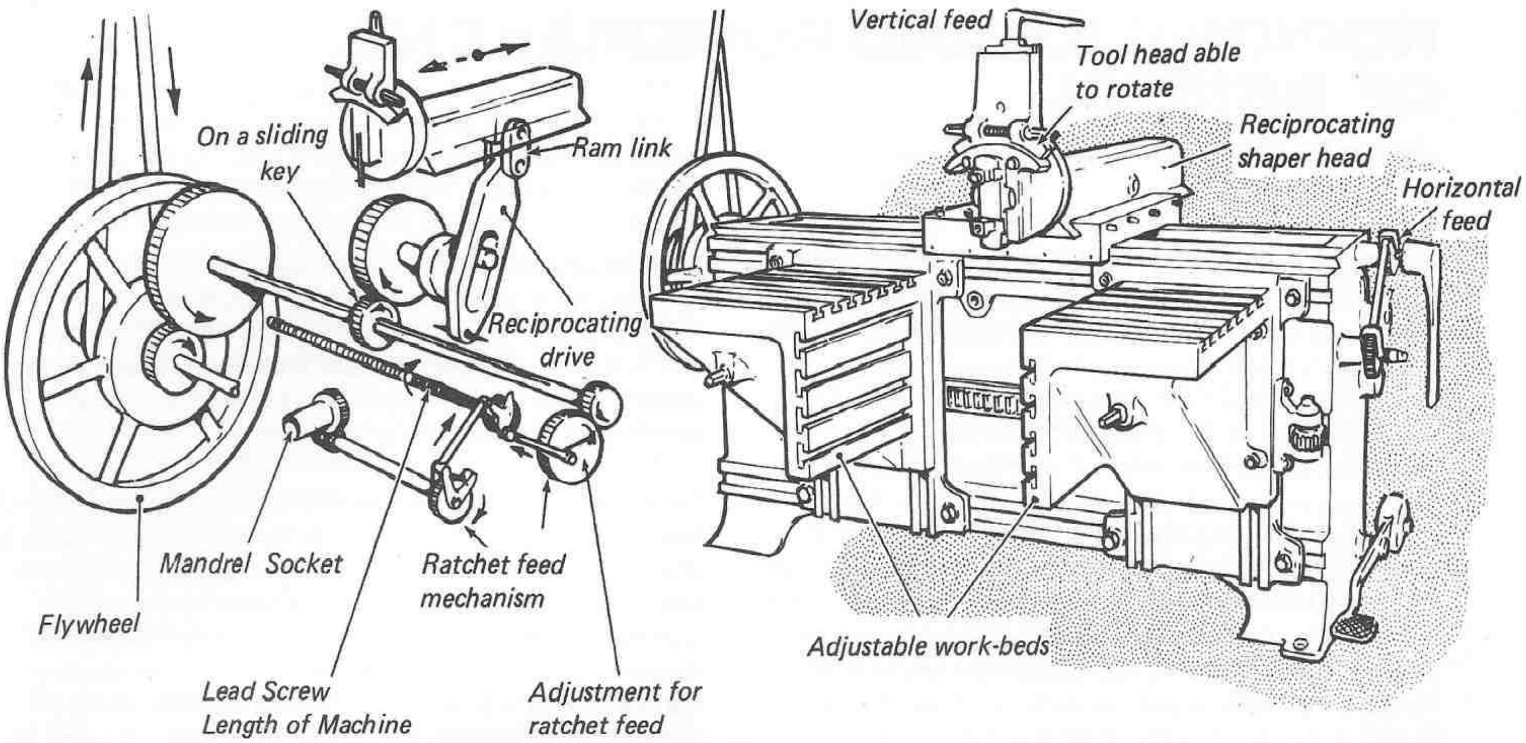
The shaping machine at Underfall Yard was made by Hulse and Company of Manchester, in the 1880-90 era although no date plate is visible, and from a contemporary point of view it is very interesting. Such a machine is versatile and suited mainly to the production of single pieces of work and, in its normal form, is seldom found in a production workshop but was fairly common in workshops used for maintenance purposes, as at the Underfall Yard.

Shaping machines are the small relatives of the planing machines but, unlike their larger counterparts they have a reciprocating tool, (similar in shape to a planing-machine tool) mounted on the end of a ram which moves back and forth in slides. The work is mounted beneath the tool on a table, the position of which can be varied. In simple terms, a planing machine reciprocates the work but a shaping machine reciprocates the tool.

The Underfall Yard machine is approximately 10 ft long overall and is belt driven from line shafting through a four-step cone pulley at the left-hand end. Two worktables are placed on the front, one at each side, and these can be moved to any position along the machine during the setting of the workpiece, by means of a simple rack and pinion mechanism. The pinions are rotated with a spanner.

The ram moves back and forth in slides placed across the body of the machine, the drive mechanism being incorporated in the same casting as the slides. The length of stroke can be varied by the slackening of two large nuts on the drive eccentric. The ram assembly differs markedly from the usual type of machine found normally, in that it, and its slides, are mounted on other slides which run the length of the machine. The two slides are therefore set at 90° to each other. The ram can thus be moved across the work-piece whilst cutting takes place, whereas normally, modern shaping machines work in the reverse manner to this. On the Hulse machine, the ram is fed along the machine by a lead screw which can be rotated either by hand or by a pawl and ratchet mechanism driven from the same shaft which powers the ram mechanism. This shaft is driven by a pair of spur reduction gears from the stepped pulley, and runs behind the machine along its full length.

A very unusual feature of this machine, which emerges



from the front of then machine between the two tables, is the rotating socket which can accept a shaft, called a mandrel, on which work can be mounted. The machine can thereby cause the tool to reciprocate above the mandrel, but parallel to its axis, whilst the mandrel is slowly rotated. It was thus possible to shape a cylindrical form, a facility which was used to produce splined bushes. (Splines are a form of teeth, placed around a shaft, which are parallel to its axis).

The ram can have its speed varied between 10 and 30 strokes per minute, approximately. Like the planing machine, it has a quick return mechanism but of a different type which is in production today in almost identical form. A footbrake which is operated from the right-hand end of the machine was added by the PBA to stop movement quickly. Without the brake, the machine 'ran on' for up to half a minute, which was inconvenient and a temptation for the operator to use dangerous methods to achieve a quick stop.

In general, this machine is interesting due to its unusual lay-out. It is possible that similar machines are in production today, but this is unlikely. Its condition appears to be good and its versatility indicates that it could still be of considerable use.

The future

The plant and equipment in the Underfall Workshops, and other items of historical interest on the site, are in remarkably good condition. Considering their age, they show considerable evidence of the care with which they have been treated, but it is ominous that the steam engine and ancillary items of plant have not run for a considerable time. There will come a time when the workshop complex is no longer viable as a repairing unit of the Port of Bristol and a decision will have to be made as to the eventual destination of these machines.

They could be transferred to a museum of technology but we are convinced that this is undesirable. The considerable historical value of the Underfall Yard Workshops lies in the fact that they are complete and provide an extremely well-preserved example of a steam-powered, shaft-driven work-shop of the 19th century. One of the enthusiastic docks amenity groups active in the City has suggested that they could be opened to the public as a living example of a small workshop at the turn of the century. This would be splendid but it has many practical difficulties. Another suggestion has been the use of equipment in the workshops to do the type of repair jobs for which it was designed. At least one small specialist firm would like the opportunity to do just that. As we enter 1978 the future of the City Docks as an amenity for the people of Bristol has never seemed brighter. The Underfall Workshops surely have a part to play in that future.

This Survey was carried out in three parts. David Jones measured the individual items and made three-dimensional drawings of the planer, shaper, slotter and long-bed lathe. He also produced diagrammatics of the planer and shaper mechanisms and of the Underfall sluice systems. Tom Fisher recorded the workings of the planer, shaper, slotter and the long-bed gap lathe. Roy Day made a plant-layout drawing of the Machine and Blacksmiths' Shop and a site plan of the Underfall Yard. Joan Day co-ordinated the material.

Acknowledgements: The BIAS Survey Unit is indebted to Mr Evan Warren at Underfall Yard and David Neale, City Docks Engineer, for their valuable co-operation. It also has been helpful to refer to 'The Port of Bristol Workshops at the Underfall Yard', by F D C Jeffery and S J Jacobi in *BIAS Journal 1*, 1968; to 'I K Brunei and the Port of Bristol', by Angus Buchanan in the *Newcomen Transactions, Vol 42*, 1969-70; and to the same author's *Nineteenth Century Engineers in the Port of Bristol*,, published by the Bristol branch of the Historical Association, 1971. More general information was obtained from L T C Rolt's *Tools for the Job: a short history of machine tools*, published by Batsford in 1965.