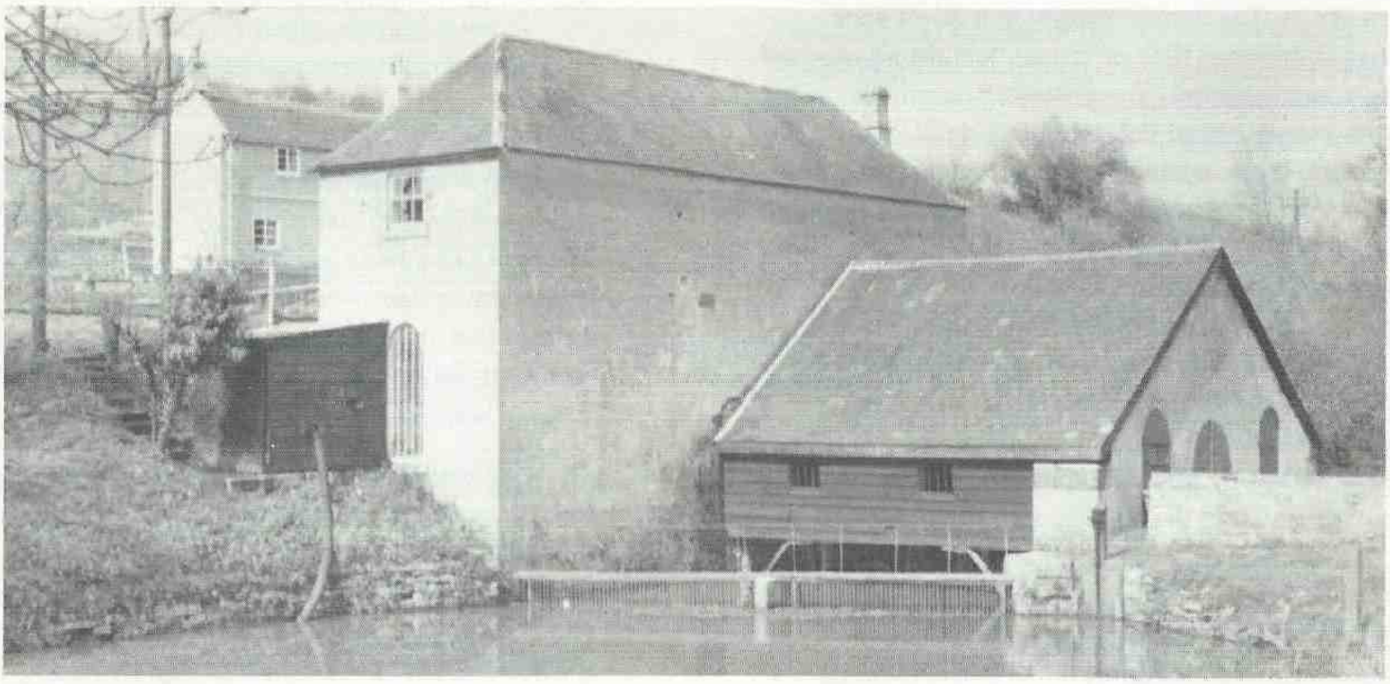
Claverton Pumping Station
R. A. Buchanan



CLAVERTON PUMPING STATION

David Rivers

History

The waterwheel-powered water-pumping station at Claverton, near Bath, is an important industrial monument not only because it is now a unique example of this application for a waterwheel, but it is also an essential feature in the operation of the Kennet and Avon Canal in the Limpley Stoke valley.

The pumping station was built between 1809 and 1813 to supply water to the Nine Mile Pound which extends from the top of the Widcombe flight of seven locks in Bath to the next lock at Bradford on Avon. The canal has been hampered ever since its construction by leakage on the short section from Limpley Stoke road bridge to Avoncliffe aqueduct, and the flow from higher up the canal was not considered adequate to compensate for this loss. The ideal site for the pumping station was found at Claverton where the river passes close to the canal alignment, although on a much lower level. There had been a mill on or near the site since Saxon times and there were in existence a weir and leat. The design of the pumping station is credited to John Rennie, the canal company's engineer. The construction was undertaken by two firms of millwrights, one of which is known to have been Messrs. Fox of Bristol who were also iron founders. Construction began in 1809 with the re-alignment and deepening of the leat and raising of the level of Warleigh Weir. The pumps did not come into operation until 1813, three years after the canal was open to through traffic.

During 1843 and 1844, while Thomas E. Blackwell was the engineer in charge of the Bath to Devizes section, certain improvements were carried out by Harvey and Sons of Hayle. The pumps' pistons and valves were modified to improve their efficiency and the waterwheel structure was lightened. These alterations coincide with the work carried out at Crofton Pumping Station on the Boulton and Watt engines where the pump pistons and valves were similarly modified by the same firm. During the period of operation in the ownership of the G.W.R. a great deal of important work was carried out. In 1902 - 3 a centre bearing and pedestal were installed to support the massive waterwheel shaft which was some 25 feet long between bearings. This has given the waterwheel its present appearance of being two twelve foot wide wheels side by side. The opportunity was also taken to reconstruct the hatches above the neat little Bath Stone bridge over the leat.

As the result of an accident in the early 1930's six of the rim segments were smashed. This has resulted in a slightly different pattern of rim to spoke fixing being adopted for the replacement segments manufactured by the G.W.R. The original type of junction can be seen on the two old segments. During the period when shut down for this repair, the main shaft journals on the water wheel were machined and new brasses fitted. The eastern journal was supported on pads and the shaft turned using water power.

Following this, the pumping station gave its regular service, operating for 24 hours per day through 9 months of the year; until in 1952, due to lack of maintenance about 50 of the wooden gear teeth were sheared off the pit wheel. These wooden teeth were almost certainly those fitted when the new rim was fitted and had thus given over 20 years service. As replacement of the wooden teeth was deemed to be too expensive, a small diesel pump was installed adjacent to the pump house in order to maintain the statutory water level. The fabric of the building had been maintained in reasonable condition since then as the pump house has been used as a work shop and store for canal workmen.

This is how it remained for nearly 20 years; probably its longest period of idleness since it was built 160 years ago.

Technical details

The building is constructed of ashlar Bath stone with a slate roof. In plan the building is L shaped, one arm housing the water wheel and the other housing the gears on the lower level and beams on the upper level. The pump cylinders are vertical from the lower level through to an intermediate floor level.

Originally access to the pumphouse must only have been through the door in the North face of the building, but when the railway came through in 1857 an upper floor window was converted into a doorway and a wooden staircase run down to the embankment. The high flood levels experienced in this valley make it essential to have this higher entrance. An interesting point is that flood levels and the dates are scribed into the beam wall so that it is possible to study the flood levels of over 150 years ago.

The roof timbers in the pump buildings are believed to be original but the level of the roof over the water wheel has been raised at some time. The wall supporting this roof at the Eastern end has also been slightly altered as the two single doors are in original window spaces as can be seen in the drawings by Thomas

Blackwell. All these arched window spaces were well shuttered.

The water wheel is a fine example of a massive breast shot type using Rennie's own design of depressing sluices. This type of sluice allows the maximum head of water available to be utilised. The sluice takes the form of an arc of a circle whose centre lies on the axis of the water wheel. The sluice is raised and lowered manually by means of curved racks driven through a series of shafts and reduction gears. There are two separate sluices side by side operating together with two racks apiece. The wheel is started by lowering the sluices allowing water to flow over the top of the sluices, over the copper facing and into the buckets. The buckets are in the form of open ended rectangular troughs formed by one 11" wide plank bolted to the wheel rim and a 13" plank bolted to three oak starts set radially in the wheel rims. There are 48 buckets on each wheel and the overall diameter of the water wheel is 17' 7".

Each water wheel section is made up from the boards mounted on three cast iron spoked wheels. The wheels are cast in halves and bolted together at the hub and rim. Incidentally, it is said that some of the original casting was done in the adjacent field. In its original (pre 1902) form, when the wheel was a full 25 feet wide, there were only five cast iron wheels. On the spokes of the two innermost wheels are the bosses remaining from the internal bracing beams fitted originally to overcome sag in the structure. When the G.W.R. built in the centre bearing an additional wheel was cast of a slightly different design at the root of the spokes. The original casting pattern for the wheels, showing clearly the later modifications is hung on a wall in the pump house. Together with the patterns for the centre bearing and bracket and sundry other items, there are some fine examples of the pattern-maker's craft.

The wheels each have a square hole cast through the hub for mounting on the square section cast iron drive shaft. The wheels are held to the shaft by wedges driven well into the space between hub and shaft. This method of fixing is commonly used throughout the machinery, precision fitting is obtained by manual skill rather than with precisely machined components. Nuts and bolts are generally little used in load carrying situations, a wedged joint being preferred. The massive drive shaft has at its western end a large universal coupling joining it to the pit wheel shaft. The coupling compensates for small irregularities in the alignment of the two shafts.

C.P. Weaver has written in his Kennet and Avon Canal Trust publication ‘The Pumping Stations of the Kennet and Avon Canal’ that this coupling is meant to permit 'rapid disconnection from the gear train' in the event of flood water rising over the sluices. This is unlikely since one must have the mechanism absolutely stationary to be able to disconnect the drive and flood water backing-up from lower down the river would prevent the wheel from running at all before water could flow over the sluices.

The main water wheel shaft runs in three plummer blocks (bearings). The journals at its extreme ends are machined directly from the shaft material while the later centre bearing is very large casting made in two sections bolted around the shaft and wedged on in similar manner to the wheels. The other shaft bearings are of a similar pattern to the two older bearings, all having gun-metal as the bearing material.

The pit wheel has an interesting form of construction in which the 'spider' formed by eight spokes and the hub is cast in one piece and the eight rim segments, mortised to carry the teeth are each cast and fitted separately. The eight segments are of two types having 25 and 26 rows of mortices fitted alternately. The 408 wooden gear teeth, in two rows of 204, are fashioned from oak. Traditionally the timber used in mill gearing is beech, hornbeam, apple, white thorn, acacia, box, ash, elm or oak; oak being preferred where damp conditions are met as in this building due to floods. The tenon part of the tooth can be roughly machined to the taper form but each tooth has to be individually shaved to fit its slot.

The pit wheel meshes with a smaller cast iron gear with 64 teeth spur to give a step-up ratio of 3.18: 1. By this means it is possible to keep the peripheral speed of the water wheel quite low and so minimise the kinetic energy lost in the water flow through the tailrace. This second gear shaft carries two cranks set at 180° and a large flywheel weighing 4 tons. The flywheel is cast in two halves which are only bolted together at the hub, the rim only butting together. The cranks drive through tapered cruciform section connecting rods to the two 24' long cast iron beams. A finely executed example of Watt parallel motion linkage connects the beams to the piston rods. The pistons' valves are of the double beat type which have a large opening area. The pumped water is carried by a segmental cast iron pipe up to the canal level. There is a large air reservoir on the pipe just outside the building which serves to smooth the flow in the pipe and reduce the shock loading on the piston valves.

When the water wheel is running at its operating speed of four to five revolutions per minute, the pumping capacity is 77.000 gallons per hour. This represents a power output of 26 horsepower (20 kw.). The maximum potential power input is of the order of 40 horsepower.

Thus, The Pump is capable of supplying the equivalent of one lockful of water to the nine mile pound per hour. This is almost certainly greater than the amount of water lost through normal locking operations. There is no spill weir on this length of canal so either the wafer must therefore pass through the locks at Widcombe or be lost by leakage.

Restoration

During the winter of 1967/68 a survey of Claverton Pumping Station was carried out by a group of interested students and members of staff of Bath University of Technology. A 35 page report was compiled, describing the machinery's condition and putting forward a detailed plan for its restoration. This report was circulated to the Kennet & Avon Canal Trust and British Waterways Board in May 1968. In November 1968 permission‘ was given by B.W.B., who own the pumping station, for restoration work to be carried out by students of Bath University. A fund for this purpose has been set up by the K. & A. Trust.

Restoration work started in earnest in January 1969. The first phase of the work was to remove the rotten timber from the water wheel and strip down the depressing sluice, in order to carry out a detailed inspection. As a result of this, it was decided to renew the fixed curved sluice and this was set as a design project for second year engineering students. Using an amalgamation of the solutions put forward, the decision was taken to replace the fixed sluice with one of cast in-situ reinforced concrete. During this time, the mezzanine floor level, at the top of the pumps, was rebuilt with new timber, together with both of the staircases. This work occupied the whole of 1969.

During 1970, the main work in hand was the reconstruction of the fixed sluice. As a result of the design study it was decided to organise a one-week working party during the summer. This involved considerable organisational work by John Walton-Griffiths and John Butt so that all the necessary plant and materials would be available on time. We were fortunate in receiving a great deal of help from local firms with donations of materials and work-shop assistance.

Starting on Sunday 19th July, the first job was to dam the race and the bed was dried with a sludge pump. The next job was to prepare the foundations and an obstacle was encountered in the form of two 15' elm beams let into the bed which had to be removed. This took until Wednesday lunch time. Next the complex curved shuttering was set up, together with the guides and reinforcing bars on the first sluice. The concrete was poured on Thursday evening. Work then continued on setting up the second sluice which was cast on the Saturday evening. All shuttering was removed on the Sunday. A total of 720 man-hours had been worked in the seven days by nine students. During the week the three large 28' timber beams for the sluice raising gear arrived. These weigh ½ ton apiece and had to be manhandled across the level crossing which required the assistance of British Rail in supplying men with flags to control the trains.

The reconstruction of the sluices had been one of the most important parts of the work so far undertaken. Their reconstruction is likely to be the most time consuming of operations, due mainly to the unwieldy nature of the major components. The sluices are very important as any maintenance work would require a major dismantling operation.

The moving section was fabricated from four inch thick elm baulks with the mating edges machined off at an angle so that, when assembled, a regular curve was formed. The assembly is held together with long galvanised steel bolts passing through the full height of the sluice. After assembly the sluices were laid flat on concrete blocks behind the new concrete sections. As a result they were kept wet and this has helped prevent distortion, as in operation they are completely submerged. Each sluice weighs over 12 cwt. when wet so great care had to be taken when winching them into position.

In the autumn of 1972, Work started in earnest on the reassembly of the sluices. The first sluice was lifted into position in one Sunday, the second was fitted after one unsuccessful attempt as a small amount of trimming was required to make it fit correctly. The second attempt was made easier by modifying the lifting rope angles after lessons learnt from fitting the first sluice.

At this stage regular fortnightly working parties were organised and advertised throughout the University in the daily news sheet. As a result we now have not only engineering students actively concerned but also some students from other schools within the University.

We found it necessary to clear excess concrete from the sluice guide slots and chisel down irregularities in the curved face of the concrete. A number of snags were encountered with the fitting of the steel guides to the copper sheathing. These had to be rivetted to the sheath so that the sheath would run smoothly over the waterwheel side of the concrete while the elm sluice ran against the upstream side. Unfortunately, the steel guide slots in the concrete had not been set out to the original spacing. Consequently, new holes had to be drilled for the rivets and to ensure correct alignment a technique for this had to be devised. The method finally decided on was to drop each member of the set of ten guides into its slot. Then twelve foot long plates with slotted holes were bolted top and bottom of the guides forming a rigid framework. After setting each guide to the centre of its respective slot, the assembly was lifted out manually and laid onto the sheathing. The rivet holes were then drilled right through and ' the rivetting carried out. The jigging, drilling and rivetting operation occupied three weekends' working parties for each sheath. The completed sheath was lasted to the rim of the waterwheel and then moved into position by rotating the waterwheel with a winch. This was a very delicate operation as the wheel had to be revolved through 180° taking the sheath, weighing 3 - 4 cwt. over the top and then slotting into its guides. The top of the sheath curves over the elm sluice and is held down with coachscrews and bronze nails.

The main work in hand at the moment is the renovation of the Eastern section of the water» wheel. This is now well advanced, the oak starts which hold the paddle boards in position on the rim have all been fitted and pinned and work is starting on fitting new paddle boards. At the same time the cast iron structure is being de-scaled and painted. All bolts required for fitting the paddle boards have been donated by G.K.N. Although the waterwheel has not run under water power for over 20 years, the bearings are in very good condition making it a relatively simple task to rotate the Wheel manually in order to make all parts easily accessible.

While the main work has been proceeding it has been possible to undertake some of the less pressing jobs, together with a certain amount of 'housework'. The pumps have been inspected this year and found to be in surprisingly good condition. The foot-valves, hidden behind large rectangular covers, were firmly stuck on first inspection but freed off when tapped with a mallet while a lifting force was applied. The wooden seatings in these valves are in excellent condition and it is probable that no maintenance work will be necessary. The pistons' valves were similarly stuck. The pistons are sealed in the bore with a special type of square rope wound around a groove in the piston and this may need replacing after running trials have been carried out.

We have tested the pumping mechanism by winching round the crankshaft and after a few stiff strokes it is now relatively free.

Before the pumps can be run, the western section of the waterwheel will have to be reclad, the 408 oak mortice teeth will have to be fitted to the pit wheel and a new tooth form cut. These jobs involve a considerable amount of time and a fair degree of skill and patience in the work force. The tenon sections of the gear teeth are at present being machined for us, which will save an immeasurable amount of time.

One major task yet to be tackled is the complete reconstruction of the control hatches under the bridge on the leat. These are an essential part of the operation of the waterwheel as they allow the pond to be drained for work to be carried out on the sluices and waterwheel. Plans have been drawn up and the organisation of materials is under way, The major hold-up on this work is the long delivery period on the steel I-beam required.

In addition to the restoration of the machinery, essential maintenance work on the building will cost many thousands of pounds. It is hoped that grants from various bodies will go some way towards meeting this cost. A fair sized civil engineering job is required on the railway side of the tailrace as the retaining wall is collapsing under pressure from the embankment. It should be remembered that the railway came sixty years after the pumping station. The end wall of the building adjacent to the tailrace is also showing a large crack which seems to have spread during the last year. This is no doubt aggravated by the severe vibration from passing trains.

It is now possible to foresee the day when the pumping station will be back in operation. The Kennet and Avon Canal Trust is negotiating a lease of the pumping station with British Waterways Board, and then arrangements will be made for the general public to see the machinery in operation.