# *Combe Mill*

Restoration of the Line Shafting to working order

**Written by Richard Brown**

# Restoration of the Line Shafting to working order

Soon after opening the Mill to the public, it was thought that the line shafting should be made to rotate again. It had not turned since the mid 50s. One forge was worked on open days using the bellows which had been made to work. But how nice it would be for the forge to be blown by the fan driven by the beam engine.


Bellows


Slot in blacksmiths shop wall


Slot in engine room wall

A member borrowed surveying equipment from his employer and checked that the bearings were in line as the first floor supports were sagging. Obviously, they had been sagging for a long time as the line shaft had been installed to take care of the sag. But how to drive it? The water wheel would not turn it as Thames Conservancy, in their wisdom, had lowered the water level so that it was below the wheel. The beam engine would not turn it as the shaft under the saw mill had been removed and where the belt came through the wall, a toilet had been built. So there was no way we could restore that method of driving the line shaft.


Pulley on line shaft to drive forge fan


Forge fan

On the water wheel end of the shaft was a cast iron gear meshing with a wooden toothed gear on an intermediate shaft with a cast iron gear meshing with the wooden toothed pit wheel. Obviously, we would not be able to turn the line shaft with these gears in mesh. Furthermore, when the water wheel was unusable and the engine was to power the line shaft, the water wheel had to be disconnected. But how? On examination, fixed to the wood work was a piece of 2" pipe, the top of which was level with the top of the line shaft. This pipe could slide in line with the shaft and be locked in position with a pin. So the pipe was moved to touch the line shaft and locked in position. The key in the gear came out easily and was placed alongside the adjacent bearing. The gear then slid easily off the line shaft onto the pipe. The line shaft was now free to turn without trying to turn the water wheel. This gear wheel, weighing about ¼ ton, looked a little precarious, twelve feet above the floor, so we looked for ways to lower it. We had a ½ ton chain hoist so a young son was sent upstairs to locate a suitable board to lift. A voice came down from above "No problem Dad, there's a trap door here." So the hoist was rigged and the gear safely lowered to the floor where it still rests.


End of line shaft and support for disengaged gear wheel


Gear wheel which drives line shaft. Now on floor

So how to drive the line shaft from the beam engine? The crank shaft of the beam engine projected into the blacksmith's shop so we wondered if it would be possible to fit a coupling onto this, fit a pulley and drive the line shaft with a short belt. The flat pulleys from the shaft under the saw mill were still in the blacksmith's shop, bored to 3" and were of various diameters so we wondered if one of these could be used.

The engine runs at about 40 rpm and we thought that the line shaft ran at about 80 rpm which meant that we needed a two to one gain on the pulleys.  Looking at tables, it appeared that the centre distance of the pulleys was too short but it was decided that it was worth trying.

We selected a pulley of 60" dia for the crankshaft which meant that we needed a pulley of 30" dia to give the line shaft a speed of 80 rpm.  Looking around the Mill, the only pulley that could be found was one of 24" dia.  This would give a speed of 100 rpm and as this was considered acceptable, this was selected for the line shaft.  A coupling had to be made to fit the crank shaft and fit the new shaft of 3" dia.  A support pillar needed to be built to support the far end of this new shaft.


Wedges fixing flywheel to crankshaft

The beam engine crank shaft was as forged in 1852 and about 6½" dia with four flats.  When working on equipment of this age, one has to forget twentieth century techniques, let alone twentyfirst, and think 1852.  Look at the fly wheel on the beam engine and you will see that where it is mounted on the crank shaft, neither is machined and it is held in place by four wedges.  This is how we were going to have to fit the coupling.

The design showed that we needed a coupling of 14" dia and 8" wide to accommodate the wedges and flanges for bolting up.  Fortunately, one of our members worked at the local car body plant where there was an extensive scrap bin and he was able to buy a piece of scrap 8" thick boiler plate 28" X 14".  It was the scrap from the bottom plate of a press tool.  This was transported by fork lift truck to the oxy-acetylene cutting section where two discs, 14" dia, were cut.  These were then transported to the press millwrights department where they had machines of sufficient size to machine the two parts of the coupling.  They also machined four slots in one to accommodate and locate the wedges.  Four blocks of steel were machined to fit the slots and of sufficient thickness to allow for the gap between the crank shaft and the coupling.  The other part of the coupling was bored 3" dia with one slot for a key.  A piece of 3" bright mild steel was obtained and a slot milled in it for the key.  Also from the scrap store came a 3" pedestal bearing complete with phosphor bronze bush.


Brick lined drain under plinth carrying new bearing

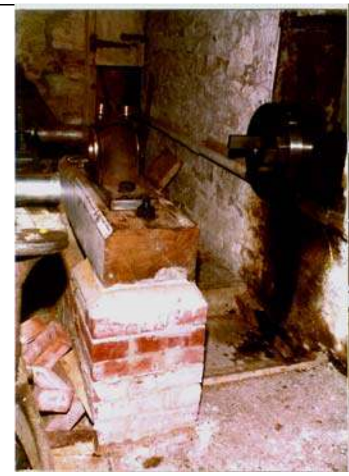
The next stage was to build a plinth to support the pedestal bearing.  We realised that there was a lot of power in the fly wheel and if the belt got caught up, it could easily rip out anything flimsy.  So it had to be robust.  We noticed that most bearings were supported on wood.  We had a piece of oak 11" X 7" which came from the lintel above the window alongside the boiler when we put the door in and decided to use that.  We dug a hole where the pedestal had to be 3 ft X 3 ft and 3 ft deep.  During digging an old brick lined drain was found but we were unable to locate where it started or finished. We made up two 1" dia holding down bolts 4 ft long bent a right angle at one end.  A frame was made to hold the bolts in the right place and we hand mixed the yard of concrete to fill the hole.  A brick plinth was built to the necessary height and the oak beam placed over the bolts.  Finally, the pedestal bearing was placed over two bolts through the oak ready for the stub shaft.

# Restoration of the Line Shafting to working order

Frame locating holding down bolts

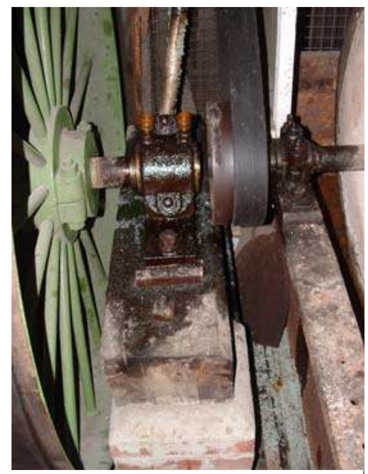
Plinth partly built

Completed plinth with the oak beam above



Plinth with bearing located and wedges in coupling being fitted

The new coupling was placed on the end of the crankshaft and fixed loosely with the four wedges. Two dial test indicators were set up to enable the coupling to be aligned. One measured the error on the face and the other the error on the register. No photographs were taken during this period. Over the next six months or so every Thursday evening was spent filing the wedges to correct the out of true and then barring the engine over to check what error remained. It was a long tedious job. Eventually the error was reduced to + 6 thou, - 6 thou, a total error of 0.012". As this could not be reduced, it was considered that this error was in the engine its self so it was decided to fix the coupling at that. Using a 14 lb sledge hammer and straddling the crankshaft, the four wedges were driven home, never to be removed. The out of true remained the same so the new 3" shaft and pulley could be installed.



New bearing and pulley installed

The 3" shaft was set into the other half of the coupling and the key driven home. The shaft was then passed through the 60” dia pulley, the clamping bolts tightened up and the rim screws fitted. The assembly was then rolled into position and lifted so that the shaft sat in the new bearing and the two halves of the coupling could be mated and bolted up with 6 X 1" dia bolts.

The previously selected pulley of 24" dia to give the line shaft a speed of about 100 rpm was installed on the shaft. Oil cups were made and fitted to the bearing and guarding made to enclose the belts. A suitable belt was obtained and fitted to the pulleys and all was ready for the next steaming weekend to test it.

Plinth, bearing, coupling, whet stone and belts fitted and ready to run

A suitable leather belt was fitted to drive the whet stone direct from the shaft. The bearings were checked and cleaned and filled with steam oil. The end of the shaft was rather long and had interfered with the end of the new shaft on the engine so a short section had to be cut off. It proved to be wrought iron.

# Restoration of the Line Shafting to working order

The new 24" dia pulley with flanges alongside the original pulley drive from the engine

The bearings on the line shaft were checked and filled with steam oil. The one nearest the water wheel was in the wall and difficult to get at so a container was fitted below the trap door in the upper floor and oil piped to the bearing. All was now ready for the first run.

The first run was a little disappointing as the belt came off and got tangled up with the pulley and was torn apart. A new cotton belt was fitted and wooden flanges fitted to the line shaft pulley to prevent the belt coming off. It was run again on the next open day and has run successfully ever since - nearly 30 years.

Having got the line shafting rotating satisfactorily, it was then necessary to overhaul the forge fan. It was impossible to strip so all cleaning and refurbishment was done in situ. It was found that the bearings were cast iron with a wrought iron shaft. Lubrication was from wells above the bearings and oil fed from these wells by wick. Having replaced the wicks and filled the wells with oil, the fan was found to turn freely. A suitable belt was fitted ready for a test run at the next steaming. The fan worked well and blew the forge fire to a white heat. So now the blacksmith no longer had to blow the fire with bellows but could let steam do the work. (see photo above)

The coupling after about 30 years use

Originally, the lathe upstairs was driven from the line shaft so this was the next task to refurbish. Suitable belts were fitted to take the drive upstairs to the lay shaft and then to the striking gear above the lathe. The bearings on the lathe were overhauled and a belt fitted from the striking gear to the lathe. It worked well and demonstrations of wood turning could now be given to our visitors.

Lay shaft taking drive from line shaft to lathe and bandsaw

Bandsaw below lay shaft

Striking gear for lathe to enable it to be started and stopped

Pulley on line shaft taking drive upstairs

The lathe

# Restoration of the Line Shafting to working order

This all worked very well until the boiler failed and the traction engine and steam roller we used to supply steam could not supply enough to keep the beam engine running.  The line shaft still ran from the engine, but the lathe and forge fan were driven by electric motors.

After commissioning the Wellman Robey standby boiler, it was found that it supplied sufficient steam to keep the beam engine running at full speed all day.  The lathe was re-connected to the line shaft and ran satisfactorily all day.

On Monday, 9 July 2007, the Estate Carpenters were clearing out their workshop and invited members to look at artifacts that they had discovered and were about to throw away.  Amongst them was the third pulley from the band saw complete with fast and loose pulleys which had been removed for renovation many years ago and thought to be lost.  This could now be renovated and again driven from the line shaft.

Richard Brown 2008