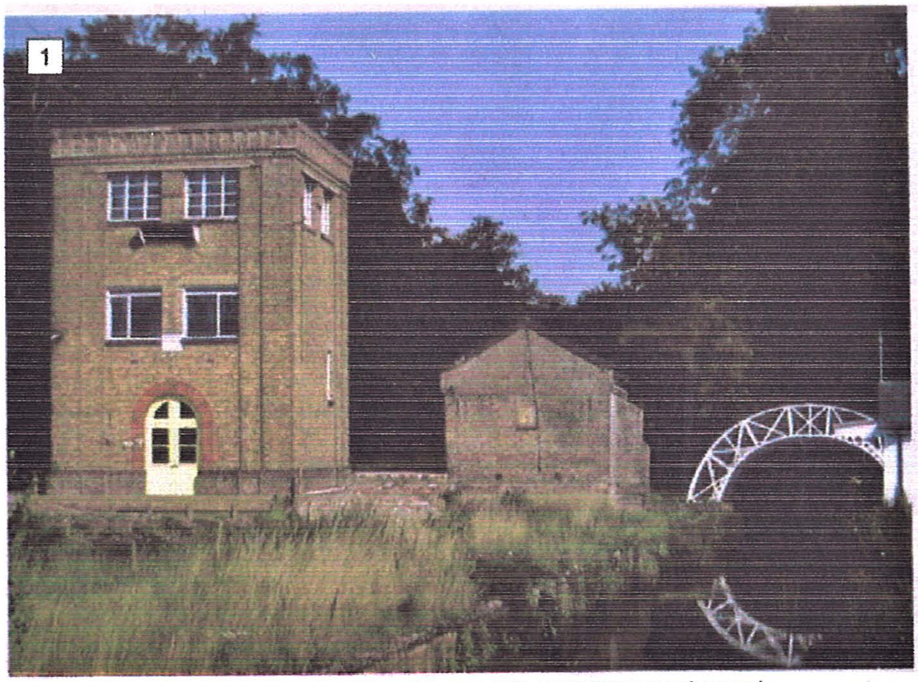
WASC 2287
WAI 626

Article by John Wilson for 'Model Engineer' 19-9-2003
Hydraulics at the Royal Gunpowder Mill.



Left: North Accumulator Tower; centre: Magazine, and right: Footbridge over the canal.

HYDRAULICS AT THE ROYAL GUNPOWDER MILL

John Wilson

explains how he made a model to demonstrate the use of hydraulics at the Royal Gunpowder Mill, Waltham Abbey

Having taken early retirement in the Spring of 2001, I decided to offer my services as an unpaid volunteer to the Royal Gunpowder Mill, Waltham Abbey since when I have had a very interesting time with them. In early 2002 the Education Manager asked me to develop some simple projects to demonstrate the use of hydraulics, particularly in respect of their use at the Mills.

Before I go any further, perhaps I should explain how hydraulics were used at the Royal Gunpowder Mills. To do so we have to go back to 1364 and the battle of Crecy which was the first recorded use of gunpowder by English troops. At this time the powder (charcoal, Saltpetre and Sulphur) was mixed by hand in mortar and pestles, but this limited the amount and quality of the powder produced.

Leaping forward to 1665, the production of gunpowder at the site of what is now the Royal Gunpowder Mills, is believed to have begun under the ownership of the Hudson family.

In 1702 William Walton purchased the site and production continued unto 1787 when William Congreve, realising the importance of a consistent quality of gunpowder, persuaded the Government to purchase a number of private mills to guarantee both supply and quality. Thus the Royal Gunpowder Mills was created.

Early in the development of gunpowder, it was found that pressing the powder in screw presses **(fig 1)** gave a considerable improvement in the quality of the resulting product. With the invention of the hydraulic press by Joseph Bramah in 1795 **(fig 2)** powder quality took another leap forward, so that tests carried out at Marlborough Downs by Congreve between 1809 and 1810 show the quality of the powder from the Government owned mills out-performed that from privately owned mills.

The test consisted of firing a 10in. naval mortar using 9lb. of powder. The Royal Gunpowder Mills consistently fired to 4,430 yards with the Royal Mills at Faversham coming a close second with 4,360 yards. The best private mill was Pigou of Dartford with 4,270 yards and the worst was Gorbridge in Scotland with 3,801 yards.

The next step forward was to turn Bramah's presses from hand power to water power by building two water wheel driven four-cylinder piston pumps to deliver a pressure of 70tonf./ft.^{2} to their respective presses **(photos 2 and 4)**.

The final stage was the introduction of steam power to the hydraulic system, and with it a network of hydraulic pipes spread out around the site to power various presses. No information can be found on the engine other than it was probably a horizontal compound, possibly of 30hp.

Obviously it is desirable to give a steady and constant pressure on the hydraulic main, and to this end two accumulator towers were built, the first to the north **(photo 1)** and the second about a quarter mile to the south. Again, no records can

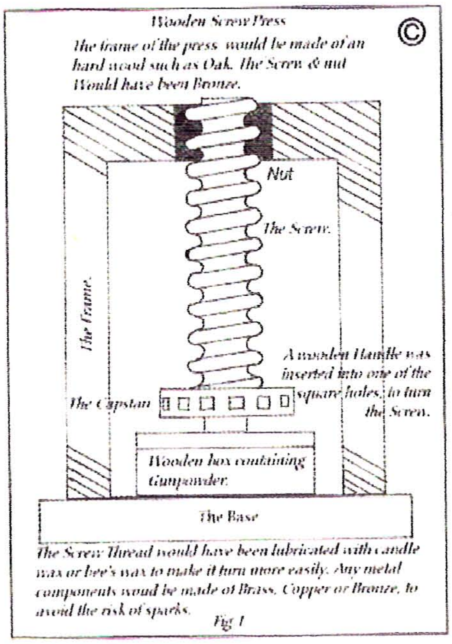
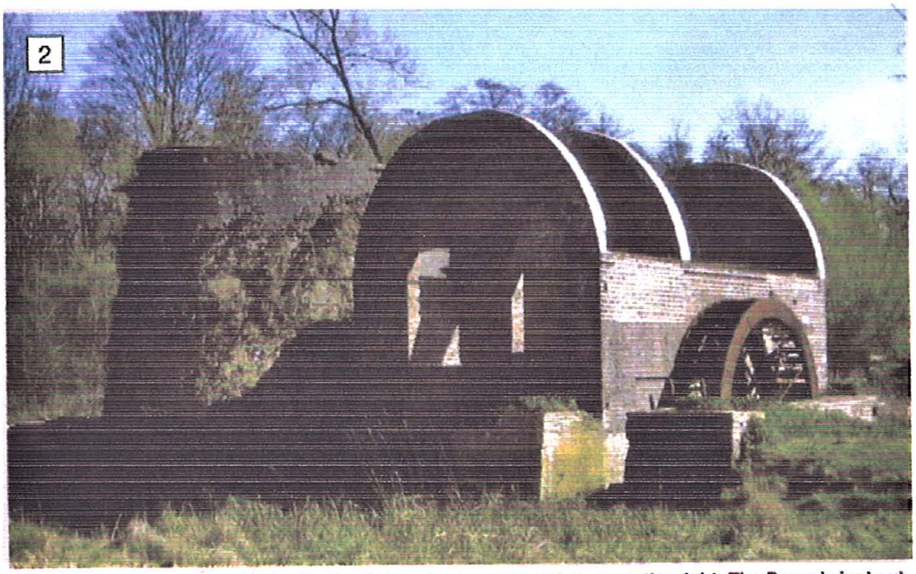


Fig 1



Left, the Traverse or Blast Wall with the Waterwheel and Pumphouse on the right. The Press is just out of sight behind the Traverse.

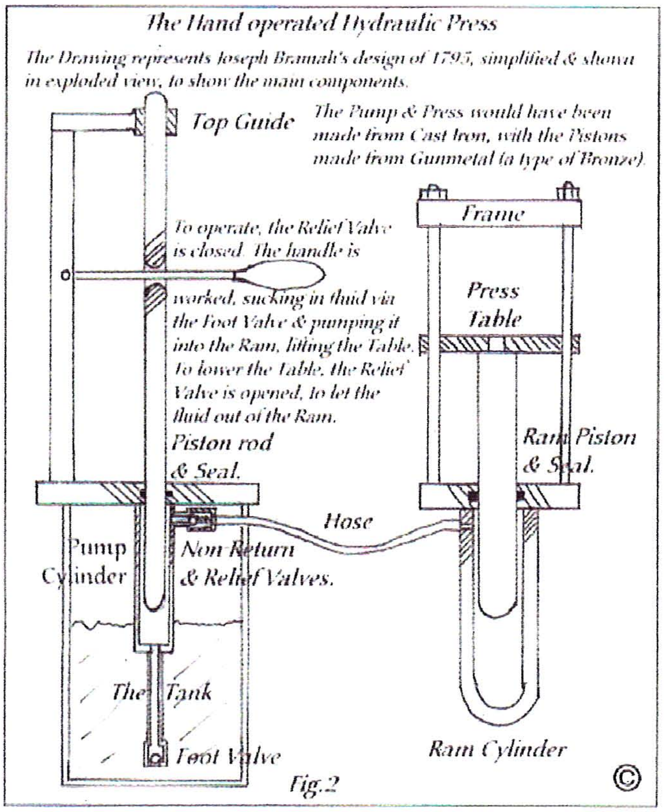
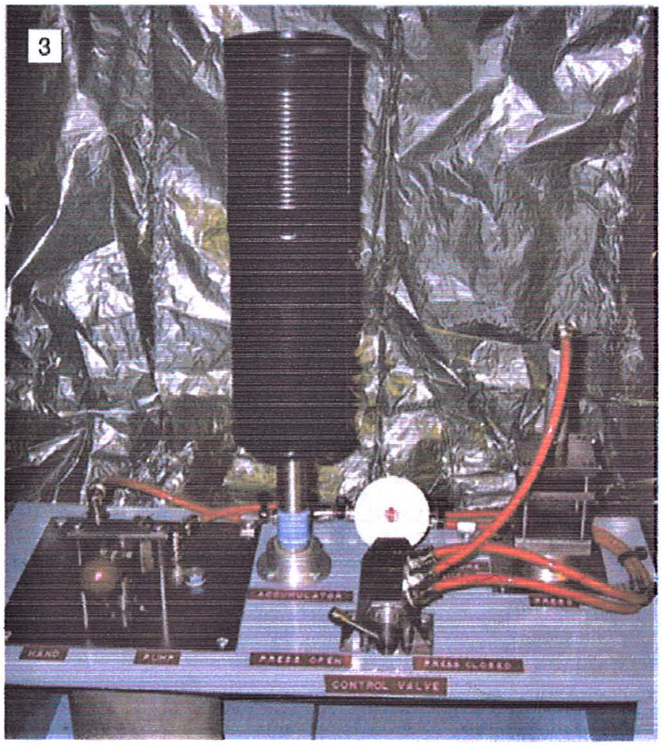


Fig.2



The Author's completed model. Left: the Pump and Reservoir; centre: the Accumulator, Gauge and Control Valve and right: the Press.

be found to suggest how big the accumulators were. The bridge to the right of the tower in photo 1 is for foot access across the canal.

For those not familiar with the principle of the accumulator tower, it is basically a large cylinder with a free moving, weighted piston sliding into it. The hydraulic fluid (usually water) is pumped into the base of the cylinder, lifting the piston and weight. Once under pressure, the accumulator serves two purposes. First, it acts as a 'battery', storing energy until required; secondly it also acts as a damper to smooth out the action of the piston pumps as they reach the end of their stroke, when there is a pressure fluctuation. The tower also damps the action of valves being opened and closed.

The project

We now come to the project I decided to build to demonstrate the described principle. Wherever possible I used scrap materials; the only things purchased were 9 off 6mm x 1/8 BSP hose fittings and 2 metres of nylon tube.

Photograph 3 shows the model at rest. The single acting hand pump is to the left and consists of a piece of 1/2in. silver-steel for the pump and a piece of 1 1/4in. mild steel hexagon for the cylinder. To the right of the pump is the accumulator consisting of an old air cylinder of 3/4 bore by 4in. stroke mounted vertically in an aluminium alloy flange and secured with Loctite.

The weight was constructed from two baked bean cans soldered together after first cutting out the bottom of the lower can. Into the baked bean cans are inserted two tins which once held new potatoes, pre-soldered and again with the base of the lower can removed. To centralise the potato cans inside the baked bean cans, packing pieces were inserted and the gap between the cans then filled with lead shot. To keep the shot in place I then ran a blowtorch over the lead to melt the top layer and used soft-solder and flux to bond the lead to the walls of the cans to a depth of about 1/2 inch.

Finally, an aluminium alloy plug was made to a sliding fit over the stepped end of the piston shaft and a tight fit in the weight. This allows the weight to be removed for transport. I don't know what the final weight of the accumulator was as I haven't any kitchen scales with a large enough range to weigh it, and my bathroom scales died years ago from the abuse of my weight on them.

To the right of the accumulator is the pressure gauge rescued from an old foot pump, and in front of the gauge is the control valve, again made from 1/2in. dia. silver-steel for the spindle

The Press was driven by a water wheel powered four-cylinder piston pump.

and 1 1/4in. hex. for the body. The valve ports are simply two flats cut 90deg. apart on the valve spindle. So, as you see it now, with the spindle turned to the left, the press cylinder is venting back via the central port to the rear port and then to the reservoir. With the valve lever turned to the right, the central port to the cylinder is connected to the accumulator (front port on valve body) and the press will then close, assuming the accumulator has pressure stored in it.

The last item is the press. For the ram, I used an old 5/8in. by 1/2in. bore air cylinder with a spring return. I should point out that all the presses used on the site had rising tables, with the early types, such as is shown in photo 4, being single acting and using gravity to open them. The more modern cordite presses were double acting, using pressure to open as well as close them. The sliding and fixed parts of the press were made from some 2in. by 1/4in. plate and the base was odd bits of scrap from other jobs, all mild steel of course. Beneath the wood frame which carries the components you can just see the reservoir for the oil (an old tin). I had no light hydraulic oil to hand, so I made up my own mix *al la* Sharp and Brown surface grinders, one part lubricating oil oil to one part paraffin.

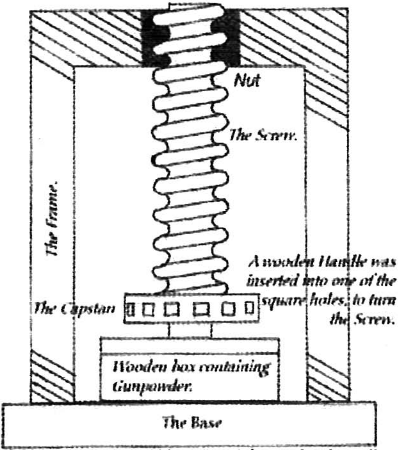
The base, by the way, is a piece of old whitewood shelving. The whole rig works very well, with no oil leaks and the accumulator holds a pressure of 18psi which is ideal as we don't want the youngsters sticking their fingers in the press and squashing them do we? As regards pressure a heavier weight on the accumulator piston would raise the pressure considerably. While experimenting I got it up to 25psi with only a small additional weight.

Addendum

For anyone interested in finding out more about hydraulics and/or the UK Gunpowder industry, I can thoroughly recommend two Shire publications: *The Gunpowder Industry* by Glenys Crocker and *Hydraulic Machines* by Adrian Jarvis.

Wooden Screw Press

The frame of the press would be made of an hard wood such as Oak. The Screw & nut Would have been Bronze.



The Screw Thread would have been lubricated with candle wax or bee's wax to make it turn more easily. Any metal components woud be made of Brass, Copper or Bronze, to avoid the risk of sparks.

Fig 1

The Hand operated Hydraulic Press

The Drawing represents Joseph Bramah's design of 1795, simplified & shown in exploded view, to show the main components.

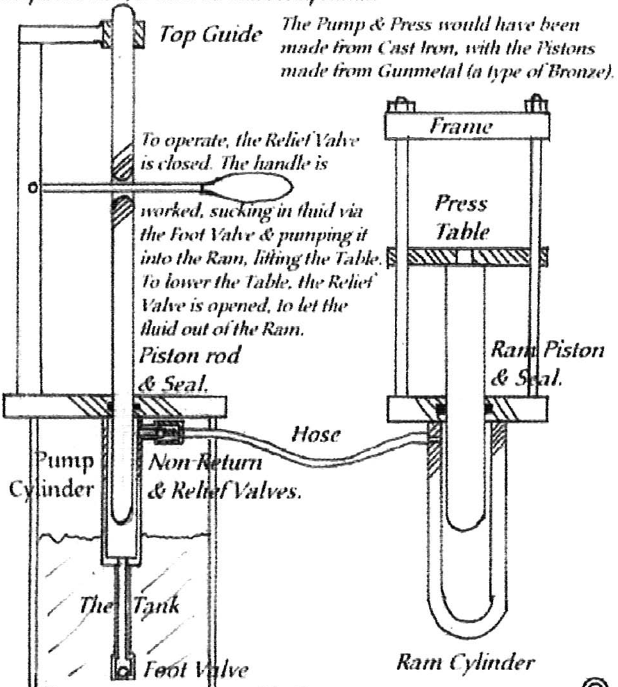
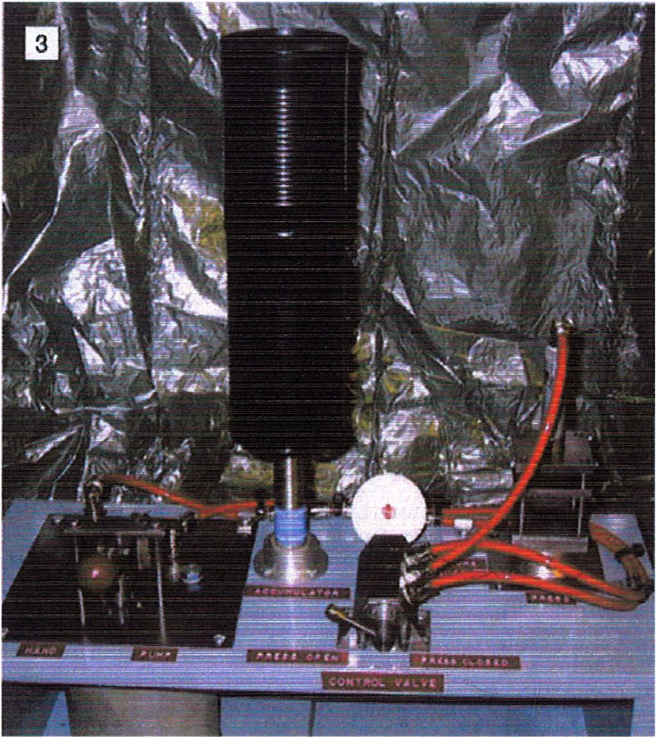


Fig.2

©



The Author's completed model. Left: the Pump and Reservoir; centre: the Accumulator, Gauge and Control Valve and right: the Press.