Ancient Cranes and Hoists

by: S.B.P. Haag

The Roman writer and architect Marcus Vitruvius Pollio (see article on "The influential architect" in Labyrinth, Jan. 1981, no. 19) describes a number of cranes and hoists which must be provided, he says, for building temples and other public works. In Book ten of his On Architecture he asserts that of the three types of machine (for climbing, powered by air pressure and for hoisting) "the climbing type, or ladder is remarkable for its boldness, rather than its brilliant design... whereas the pneumatic type achieves neat results by the elegance of its design. But the hoisting types, the cranes and derricks, have better and showier opportunities to display their usefulness and, if used with care, are of the greatest value".

Vitruvius' hoisting machines fall into two groups - those with two legs and those with only one. But Vitruvius himself prefers to use a classification which is more valuable to the engineer who needs to employ the equipment. He calls the cranes trispastos or "three-puller", pentaspaston or "five-puller" and polyspaston or "many-puller" because they use 3, 5 and more than 5 pulleys in varying types of block and tackle arrangement. Lighter models were operated by a simple pull-rope, heavier ones by a windlass set against the base of the legs of the crane, or by a drum and capstan to give added control. In this case there was, as we learn from Vitruvius, a double set of pulleys in the upper block, the rope being passed around at the top of the crane before being divided into two separate systems and passed down to the axle on either side of the drum which replaces the windlass on the simpler trispastos. "The ends of the rope are kept under equal tension and so raise the load smoothly and safely" remarks Vitruvius (Figures 1, 2, 3).

The heaviest crane of all required a large treadwheel to give the maximum power and control. A famous sculptured relief from the tomb of a family of building contractors, the Haterii, depicts just such a heavy-duty machine. The sculptor has chosen to show us the crane in action from dead-centre side view. We can only see the side of one leg of the machine. The weight being lifted cannot be seen but must lie behind the treadwheel in the centre of the space between the crane's legs. There are at least five men in the treadwheel, one of whom is carefully balancing the movement of it with his knees bent as he stands on one of the spokes rather than the circumference. Perhaps it is his duty to do the fine control work in cooperation with one of the foremen below the wheel on the ground. The bracing of this crane is extensive. There are at least seven stays visible, each with its own block and tackle of 3 pulleys; adjustment of these stays would be essential to give the crane mobility. The two men at the top are barefoot, apparantly quite at home on the ropework high up in the air. They have, it seems, just completed some sort of lashing with a clearly visible reef knot, perhaps an additional safety device ensuring that the all-important joint at the top of the legs and attachment of the upper block are secure (Figure 4).

The claws used to grip the load are not visible. Vitruvius calls them "iron pincers," forfices ferrei, whose teeth are adjusted to grip holes in the stone blocks. Holes of this kind can still be seen in the unmortared granite blocks used to build a Roman aqueduct in Segovia. But as Landels observes in his Engineering in the Ancient World (p.89) "it seems highly probable that the weak point of the whole apparatus was the attachment between the lower pulley block and the load."

The single-leg derrick described by Vitruvius has a minimum of 9 upper pulleys, 9 lower pulleys and a further set of 3 below those to enable 3 sets of men working without a capstan to draw a load quickly up to the top. "Only skilled workmen can handle the polyspaston, which with it numerous pulleys is very easy and quick to work", he says. "Since this derrick can put its load down to the right or left by the adjustment of the 4 stays as needed, it can be used for loading and unloading

ships with complete convenience."

Hero of Alexandria also describes a crane with 3 legs. This of course would have virtually no mobility at all, except what could be obtained by pulling the load to one side a little, but might compensate for that by its sturdy and safe balance. Vitruvius indirectly comments on the hazards of operating the other types of crane which the 3-legged one might help to avoid in emphasizing the skill required in the workmen who are to set them up.

It is apparent that the loads of immense size and weight which Vitruvius refers to were often handled by Roman building contractors who would have been unable, no doubt, to achieve so much without the heavy duty machinery invented by their ingenious Hellenistic predecessors. As far as I know, no physical remains of these huge cranes have yet been found, so that the relief sculpture of the Haterii tomb and Vitruvius' careful discussion are both very valuable material to the historian of ancient technology.