Sixteenth-Century Spanish Cranes and Lázaro de Velasco's Translation of Vitruvius

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Quite a number of studies, such as those by Íñiguez (1963, pp. 193-211), García Tapia (1990, pp. 172-181) and Lorda (1997), have discussed the cranes used in the construction of Spanish Renaissance buildings. All these papers deal with the surviving evidence about the construction of the Escorial complex, in particular the main church or *basilica*, such as a large number of contracts and other documents, a manuscript by Juan de Herrera called *Architectura y machinas*, and the outstanding drawing of the Escorial building site now at Hatfield House, England.

Another source for studies about Spanish Renaissance cranes is Lázaro de Velasco's translation of Vitruvius' *De architectura libri decem.* Velasco was the grandchild of a wood carver, Juan López de Velasco, and the son of Jacopo Torni, a Florentine painter and sculptor who was master mason of Murcia cathedral and architect of the church of San Jerónimo in Granada. Velasco followed an ecclesiastical career, holding a post as *beneficiado* in the chapter of Granada cathedral. However, his artistic interests show up in his work as illuminator of choir books, in his ill-fated attempt to obtain the office of master mason for Granada Cathedral in 1577 and in his complete translation of Vitruvius into Spanish, about 1564.

Of course, Velasco translates the passages of Vitruvius' tenth book about machines, such as the tryspast and the polyspast, adding drawings of these hoisting devices. Furthermore, Velasco interpolates a long passage describing a big crane, similar but not identical to the ones in the Escorial, with a pyramidal frame, a windlass or *mástil*, moved by men treading inside a wheel, a rotating pole, ropes and a tryspast, but does not furnish a drawing of this big, non-Vitruvian crane.

After a brief review of Velasco's career, I shall try to reconstruct the big crane in Lázaro de Velasco's text, comparing it with the Escorial cranes, as depicted in the Hatfield drawing and described in the studies of Íñiguez, García Tapia and Lorda. I shall also discuss the possible sources of Lázaro de Velasco expertise on cranes; on the one hand, classical sources such as Vitruvius or Greek mechanics, on the other, the traditional and empirical lore of carpenters and masons, embodied in the *ingenio* or crane put up in Murcia cathedral in the years of Jacopo Torni, or the cranes that Velasco may have seen in Granada cathedral.

LÁZARO DE VELASCO'S CAREER

In the introduction to his translation of Vitruvius, Lázaro de Velasco states that his father, Jacopo Torni, called l'Indaco, arrived in Spain in 1520. Torni was a Florentine painter, apprenticed with Ghirlandaio, who worked with Pinturricchio in the Stanze Borgia and with Michelangelo in the Sistine ceiling, and carried on a number of independent paintings. Immediately after his arrival in Spain, Torni worked as painter and sculptor in the Royal Chapel in Granada. After a short period in Jaén, probably working with López de Velasco in the cathedral choir, he accepted, in 1522, the post of master mason of Murcia cathedral. The main task that Torni had to face was the construction of the cathedral bell-tower, begun in 1519. In 1523 a big crane or *ingenio* was put up to lift ashlar blocks for the walls of the tower that had risen to the height of 13 metres by 1525. It should be noted that no smith in Murcia could make the iron pulley of the crane, and thus the cathedral chapter requested the help of the Marquis of Vélez and his smith in the mines of Mazarrón. (Vasari 1568 [1973], vol. 3, p. 680; Velasco c. 1564, f. 8; Sricchia Santoro 1993; Gómez-Moreno Martínez 1925, pp. 68-73; Gómez-Moreno Martínez 1926, pp. 101-110; Gallego 1931, pp. 66-67, 69, 70, 97; Gómez-Moreno Calera 1989, pp. 75-77; Calvo Castellón 1994, pp. 218-222; Gutiérrez-Cortines 1987, p. 117; Vera 1994, pp. 87-88)

Since Lázaro's mother was Juana de Velasco, daughter of the woodcarver Juan López de Velasco, and Jacopo Torni died in 1526 in Villena, Lázaro must have been born between 1520 and 1526, probably in Granada in 1520 or 1521. After Torni's death in 1526 the post of master mason in Murcia cathedral was offered to Jerónimo Quijano, another sculptor that had worked in the Jaén choir, and Lázaro de Velasco went back to Granada with his mother. Little is known of the career of Lázaro de Velasco from that moment to 1550. From that year on, he appears as a prolific choir-book illuminator for the cathedral of Granada. In his translation of Vitruvius, written between 1564 and the mid-seventies, he describes himself as a theologian and a mathematician, living in Granada. In fact, he had a university degree and was the rector of the Colegio de los Niños or Royal College. Around 1570, Velasco was a second-rank member of the chapter of Granada cathedral or *beneficiado*. In 1577 he engaged in a well-known contest or *oposición* for the post of master mason of Granada cathedral, against Juan de Orea and Francisco del Castillo. After an initial tie, Velasco won by eight votes, against six votes for Orea. However, Orea claimed that Velasco had bribed one of the jurors, and Velasco resigned the post. Some studies of this complex episode can be misleading, since they stress the practical and professional side of Velasco's arguments. Nevertheless, Velasco was no professional architect, as his own translation of Vitruvius and Orea's counter arguments in the *oposición* make clear, but a member of the chapter that was trying to secure the substantial wages of the master mason's post. He only carried on real architectural work in the big altarpiece in the church of San Jerónimo in Granada and in the Jesuit church in the same city. Even in this later building, Velasco executed a plan by Bartolomé de Bustamante, along with the stonemason Martín de Baseda. (Velasco c. 1565, note to f. 6; Rosenthal 1961 [1990], pp. 237-239; Moreno 1989, p. 66-68; Gómez-Moreno Calera 1989, pp. 86; Álvarez 1992).

The exact date of the translation of Vitruvius remains uncertain. García Salinero (1964, pp. 459) dated the work to 1564, taking into account that the text refers to Pedro Mexía's *Historia imperial y cesárea [...] vidas y hechos de todos los césares [...]* published by Sebastián Trujillo in that year. However, Velasco hints that he had been working on the translation for more than ten years. Furthermore, Velasco initially wrote that the edition of Vitruvius by Fra Giovanni Giocondo was published "fifty years ago", but he corrected this remark to, "sixty". Since Fra Giocondo's edition was published in 1511, all this suggests that Velasco begun the translation in the early 1560s but kept working on the text until the early 1570s. Other internal evidence points this way; the translation must have been written after Quijano left the post of master mason in the cathedral of Murcia in 1562 and after Siloé's death in 1563, but before Juan de Orea quit his office as master mason of Almería cathedral and went back to Granada in 1572. (Velasco c. 1565, f. 5 v., 8 - 8 v.; Pizarro and Mogollón 1999, p. 39; Rosenthal 1985 [1988], p. 113, 135; Moreno 1989, p. 66).

The text has remained unpublished until 1999. It begins with a preface on the sources of classical architecture and its introduction into Spain by Torni, Machuca, Siloé and Quijano and is followed by a complete annotated translation of Vitruvius' ten books. This may be the first complete translation of Vitruvius into Spanish, for the contemporary translation by Hernán Ruiz, between 1558 and 1565, only deals with the first book. The first printed translation by Miguel de Urrea dates from 1582, although the manuscript by Urrea must be earlier, since the translation was published on behalf of his widow. The earlier studies on Velasco's translation considered it a draft for Urrea's translation, but it is now clear that Velasco and Urrea are completely independent authors. (Velasco c. 1564, note to f. 6, f. 6 v., ff. 8-8 v.; Catalina 1899, p. 531-534; Gómez-Moreno Martínez 1949, pp. 10-11; Gómez-Moreno Calera 1989, pp. 75-76; Jiménez 1998, pp. 16-18; Pizarro and Mogollón 1999, pp. 41-42)

VELASCO'S HOISTING DEVICES

Velasco's translation is reasonably faithful to the Vitruvian original. He occasionally departs from the standard text of *De architectura libri decem*, but he does so following the editions of Fra Giocondo or Daniele Barbaro, the best ones available in the sixteenth century. Thus, the translation itself is not very informative about Spanish building practice of the period. By contrast, Velasco includes a fair number of notes and comments, describing contemporary building practice and trying to link it to Vitruvian concepts. Furthermore, Velasco includes drawings of some hoisting devices, both Vitruvian and contemporary. As I shall explain, some of the drawings of Vitruvian instruments are quite interesting, since they differ from the text of the translation and suggest that Velasco was struggling to understand the principle of the polyspast. Thus, I will discuss in this section a number of hoisting devices and instruments included in either the translation or the notes to chapters 2 and 3 of book X of *De architectura libri decem*, starting with auxiliary elements such as ropes or fastenings and ending with the big crane.

Ropes and fastenings

In his comments to chapter 2 of book X, Velasco (c. 1564, f. 147) states that the ropes should be neither too short nor too thin, but he does not seem to be concerned with tensile strength; he rather says that, if "the rope is too thin it will be bent by the wheel". He also advises the builder to verify that the ropes are not worn and that no edge may cut them. He also instructs the crane operators to moisten the ropes, since wet ropes "endure the fire that originates as the rope winds around the wheel". Thus, the builder should wash the ropes with vinegar, or at least with seawater, but never before tying a knot. Velasco's translation came a few years earlier than the well-known episode of the lifting of the Vatican obelisk by Domenico Fontana in 1586, which was made possible by wetting the ropes at the suggestion of a sailor. Thus, we can assume that this practice was not in general use, but was rather a trade secret.

Concerning hooks and load fastenings, Velasco (c. 1564, f. 147 v.) states that the ancients used pincers hanging from a rope to fetch stone blocks by a pair of holes bored in the block; the weight of the block causes the pincers to close and secure the block. However, it is not easy to ascertain if Velasco's source on this point was Antiquity or contemporary practice. In fact, a number of these pincers have been preserved in the Architecture Museum at the Escorial complex. Velasco approves of the use of the pincers for hard stone. However, he remarks that if the stone is soft, the block can crack at the holes and fall. Thus, he advises to make a wedge-shaped cut in the block, and to put inside this socket three wedge-shaped pieces of iron with holes. Then, a hook can go through these holes fastening the three pieces together inside the block. Again, the device seems to be a classical invention rediscovered by the Renaissance: it is described by Heron of Alexandria, and about 1575 at the Escorial the pincers were being replaced by triple wedges (Fleury 1993, p. 119-121; Lorda 1999, pp. 91-92).

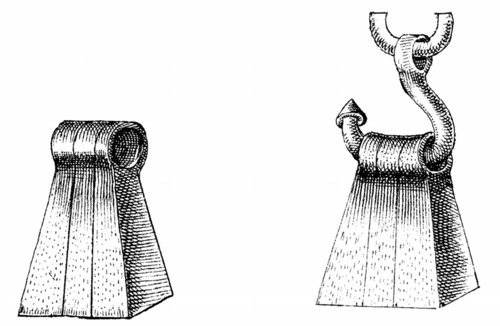

Figure 1. Wedge-shaped fastenings. (Velasco c. 1564, f. 147 v.)

The hoist and the capstan

Velasco (c. 1564, f. 156) includes a note to the third chapter of Vitruvius' Book X, describing a hoist supported by two pairs of timbers, eight feet long. Each pair of these struts lies on a crossbar, forming "an almost equilateral triangle". These timbers are joined also by a smaller crossbar and, in turn, both pairs of struts are joined by another pair of timbers. The lesser triangle between both struts and the smaller crossbar forms a socket that supports the end of the windlass, which is 1 foot in diameter and carries two pairs of handspikes that allows a person to operate the machine. Velasco stresses that a number of planks should be laid over the timbers that join both triangles and covered with loose stones, to stabilize the hoist.

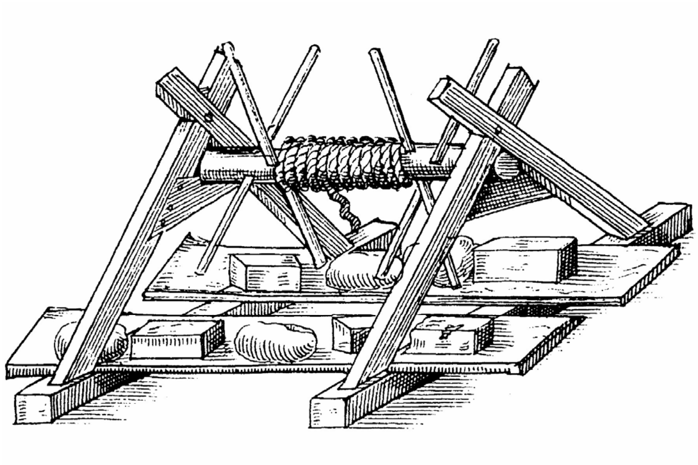

Figure 2. Hoist or *torno*. (Velasco c. 1564, f. 156 r.)

Along with this familiar hoist, Velasco (c. 1564, f. 156) describes a capstan, the "torno encarcelado", which may be literally translated as "prisoner windlass". The machine is built on two chestnut or evergreen oak planks, 18 inches wide, assembled in "T" fashion and securely fastened to the ground; Velasco states that the longest plank should be 9 feet long and the crossing one 7 1/2 feet long. From each of the "arms" of the "T" starts a strut; the three timbers are joined over the crossing point of the "T". Velasco makes clear that these struts can be straight or curved and indeed includes both curved and straight struts in his drawing. Anyway, the capstan is fastened by one end to the crossing point of the "T" and by the other end to the three struts and carries two handspikes.

Velasco makes clear that, after winding around the capstan, the rope must pass through two pulleys. The first of these pulleys must be fixed to the ground, far from the capstan, while the other pulley should be set high. This arrangement fits one of the uses of the instrument suggested by Velasco: he states that the hoist can be set in the centre of the courtyard of a building under construction, and in this way it can lift loads to any location in the building. Of course, it goes without saying that this is done with the aid of a pair of pulleys at each point where weights are to be lifted. However, Velasco mentions also another use of this device; apart from being employed in seaports, the prisoner hoist can be used in a "suelo de bobeda", literally "the floor of a vault". A passage in the manuscript by Rodrigo Gil de Hontañón (1540 [1991], f. 24 v. - 25 v.) that alludes to a strong scaffold made under vaults in construction. Thus, we can assume the "suelo de bobeda", where the prisoner hoist was to be set, is one of these platforms.

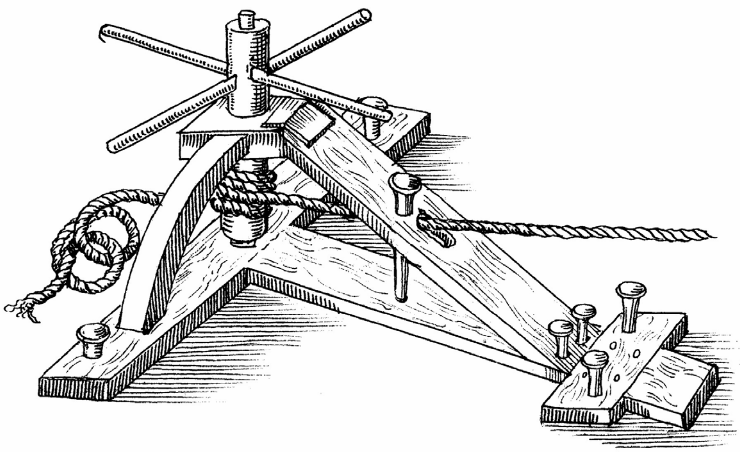

Figure 3. Capstan or *torno encarcelado*. (Velasco c. 1564, f. 156 r.)

The problem of the tryspast

Velasco refers to pulleys in a number of passages of his translation of Book X and its notes, but he is not really very informative. For instance, he does not make clear whether the pulleys are made of wood or iron, although both kinds were used in sixteenth century Spain and, what is more remarkable, he seems to be struggling to describe a tryspast, but is unable to grasp the concept. Velasco translates the Vitruvian description of a machine that includes a tryspast, a pentaspast or a polyspast, and identifies this classical machine with the *cabrilla*, a device used in Spanish building sites of the period. (Vitruvius, X, 2, 1-4; Velasco, 146 r. - 146 v.) The translation is quite obscure and it is not clear if there is one pulley or two pulleys, two sheaves or three sheaves. Velasco includes also a drawing of the machine. Here he cannot resort to the Vitruvian source, obviously, and draws a single closed pulley. The text states that the load, a stone block, is attached directly to the pulley by means of a pair of pincers; however, in the drawing the pulley is fixed to the machine, and the block is joined to the ropes that wind around it. Velasco comments on this passage in a long note, but he does not mention the pulleys. However, he includes drawings of pulleys with one, two and three sheaves. The pulleys with two and three wheels seem to belong to a pentapast, but

Velasco does represent both separately. All this suggests that Velasco knew of the existence of tryspasts and pentapasts, but could not describe the concept easily.

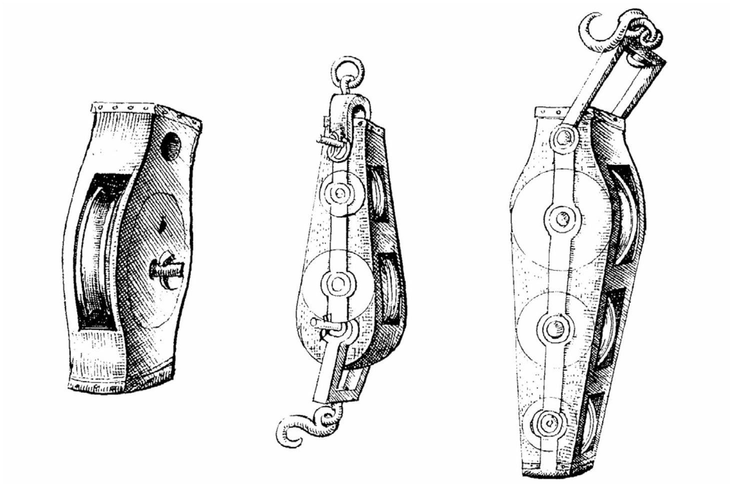

Figure 4. Pulleys. (Velasco c. 1564, f. 148 r.)

The *cabrita* or *cabrilla*

The hoisting machine in itself is quite interesting, since it was used in Spanish building sites of the period. This Vitruvian device consists of two timbers joined by their tips. To this vertex is also fixed a pulley with two sheaves. However, Velasco seems to follow Fra Giocondo's or Daniele Barbaro's translations, since Vitruvius refers to *two* timbers, held in place by means of four stays, while Velasco, like Fra Giocondo and Barbaro, talks about *three* timbers and makes no mention of the ropes that hold the struts in place (Fleury 1993, pp. 98). The machine includes a windlass joined to two of the timbers by means of iron sockets. The hoist carries two pairs of handspikes that allow two men to lift the load. The rope is in turn fixed at one end to the windlass, while the other end goes into the sheaves of the pulley. As I have remarked, Velasco's translation is not clear, but he seems to speak of an upper pulley with two wheels and a lower pulley with one wheel. All this suggests he is thinking of a tryspast. Velasco's drawing of this machine does not cast light on this matter, since there are important differences between the text and the drawing. In the text, Velasco states that the lower pulley is joined to two iron pincers that go into holes made in the stones that the machine are to lift. However, the drawing seems to represent only a single-wheeled pulley; the rope continues from this pulley downwards and is attached to the stone by means of a hook.

Velasco adds to his translation an interesting note which states that this instrument is called *cabrita* in Spanish and alludes to a number of variants of the device. The three struts can be joined by means of three timbers at the base with a number of intermediate crossbars to reinforce it; thus, the crossbars allow men to climb the device to the vertex. Instead of joining the three struts in the vertex, one of them can continue past the intersection point, and the pulley can be joined to the end of this projecting timber. The most interesting point of this note is, however, the term *cabrita*, which means “small goat” in Spanish. This is clearly an alternative form of *cabrilla*, the hoisting device used in the Escorial, which was improved by Juan de Herrera and contributed to his ascension in the complex organization of this huge building site and, in the long term, in Philip II’s court. Thus, Velasco furnishes us with an approximate graphic description of the Escorial *cabrita* and stresses its classical origin.

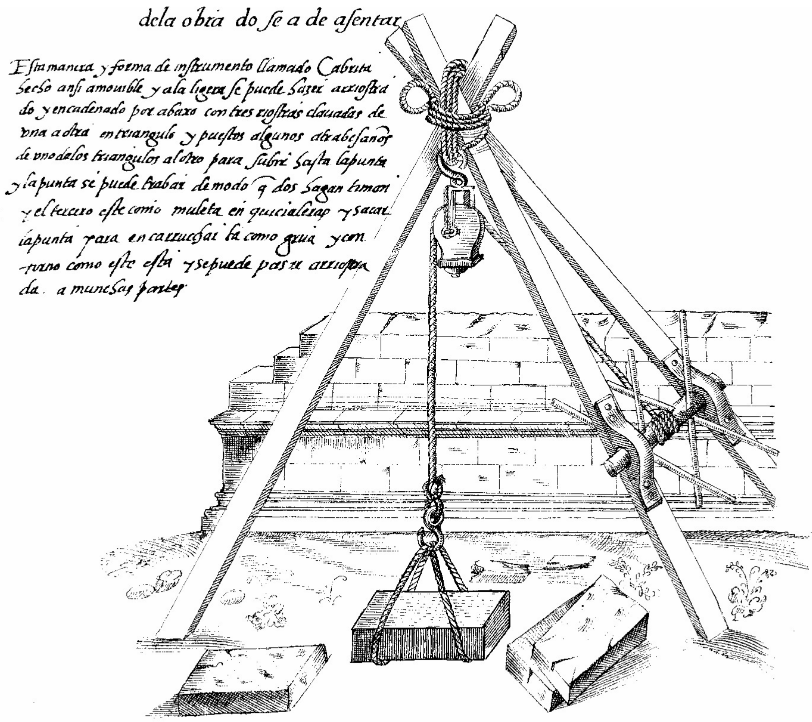

Figure 5. Pseudo-Vitruvian hoisting device or *cabrita*. (Velasco c. 1564, f. 146 v.)

The crane

In the notes to his translation of Vitruvius’ book X, Velasco (c. 1564, f. 154 r. - 155 v.) includes a description of a big crane. To start with, he praises the crane as the most wise, useful and swift device ever designed to lift loads. He stresses the frequent use of the crane in church building sites and seaports, its ability to turn sideways, its great weight that requires no counterweight, and its operation by two men walking inside the wheel of the crane. At the same time, Velasco points out that the crane features all the machines described by Vitruvius in the first chapters of book X, such as the pulley, the treading wheel and the "pulleys that help one another", that is, Velasco's notion of the tryspast. Of course, all this accounts for the inclusion of this non-Vitruvian device in the notes to Velasco's translation.

After this, Velasco gives a fairly detailed description of the crane. The machine is built around a pyramidal frame with two platforms and four struts. The lower platform should be 24 feet square while the upper platform is 20 feet square and the struts are 26 feet long, making the total height of the frame some 25 and a half feet. The beams in the lower platform should be one foot high by one *palmo* and a half wide, that is, 12 by 13 1/2 inches. Those in the upper platform are six inches high by nine inches wide, while the struts are nine inches square in section.

On this lower platform rests a post or *mastel* 37 feet high, with a section of 1 foot by 18 inches. Velasco stresses that this post should be made from a straight and healthy piece of wood, free of knots, and that it should be reinforced at the crossing point with the upper platform. This post attaches to the lower platform by means of an iron socket. Although Velasco does not say it in so many words, it is clear from his description that the socket allows the post to rotate around its own axis, like a modern tower crane. Velasco refers to a *timón,* which appears to be the bar that controls the rotation of the post.

To this post is attached the jib of the crane or *pescador*, 37 feet long, 1 foot by 9 inches in section. The jib attaches to the post by means of a socket. Velasco stresses that the socket should not be too big otherwise it will weaken the post. The jib is supported by a timber, 34 feet long, and 6 by 8 inches in section This strut is joined to the jib not only by its edge, but also by means of a number of crossbars, 4 1/2 inches square in section. Since the strut joins the jib close to its edge and the jib is just 3 feet longer than the strut, we can assume that the jib and the strut form an isosceles triangle and the jib slopes downwards, in the manner of the beak of a crane. In fact, the Spanish word for this machine is *grúa*, which is derived from *grulla*, the Spanish word for the bird.

Inside the frame, between both platforms, there is a wheel 15 feet in diameter and 3 feet wide. This allows a man to go inside the wheel to exert traction to lift the weights. Velasco states that the distance between the radii of the wheel should be enough to allow this man to go inside the wheel. The wheel is reinforced at the edges; the section of the wheel where the man treads joins these reinforcements by means of ribs. Velasco refers also to the "maderillos de mamperlanes que hay entre tabla y tabla", that is, to the joining pieces between the planks of this treading section. Since the *mamperlán*, in modern Spanish, is the projecting edge of a step, we can understand that these small members not only join the planks, but also allow the man to exert his traction more easily and safely.

The axis of this wheel is called *mastel*, just like the post, since both rotate. Velasco makes clear that this axis has two sections. The smaller part is 3 feet long and 1 feet square in section and goes inside the wheel, while the longer part is round in section and is more than 8 feet long, allowing the rope to wind around the axis. Thus it is clear that this axis or *mastel* is the windlass of the crane. It is also clear that the wheel is set aside of the post, while we can assume that the round section of the hoist crosses near the post. This explains why there is space for only one man inside the wheel. Of course, if we assume that the post is symmetrical with both platforms, there is space left for a second wheel, but in the description of the wheel Velasco refers always to *one* wheel and *one* man. It is true that Velasco alludes to *men walking* in his introductory passage; perhaps he is speaking generally and admits the possibility of a crane powered by a number of men but the crane that he describes precisely, is powered by only one man. Velasco refers also to a third vertical frame between both platforms, built around a strong timber, the *temon*, with the same cross-section than the post, that is, 1 foot by 18 inches. To this *temon* are joined a number of studs, and the frame is joined to the hoist by means of an iron fastening.

From the windlass, the rope goes to two pulleys, 1 feet in diameter and 3 inches wide. Of course, we can assume one of the pulleys goes at the end of the jib, but the location of the other pulley is not clear. In his introductory passage, Velasco states that these two pulleys help each other and the weight is divided between both pulleys and the jib is put sideways; thus, the rope is not subjected to a great stress and works more easily than a horizontal or "perpendicularly straight" rope. All this suggests once again that Velasco is struggling with the description of a tryspast. Thus, the machine lifts its load more easily with three wheels than with a "perpendicularly straight" rope. If this is true, the lifting power of Velasco's crane would be quite remarkable: the thrust of the treading man can be estimated at about 60 kg, but it is multiplied by the ratio of the diameters of the wheel and the hoist, 15 feet divided by less than 1 foot. That makes the ratio more than 15 and the lifting power more than 900 kg. However, the lifting power of the machine is multiplied three times by the tryspast; thus the crane can lift stone blocks around 2 400 kg, taking into account a 20 % power loss by friction. (Cf. Fleury 1990, pp. 107, 132-135).

Velasco gives also fairly detailed instructions about the assembly of the crane. First, all frames, the post and the jib should be assembled in the ground, without nailing them, to test their correct execution. Afterwards, the actual assembly should begin by the lower frame. Then, the post should be set straight alone, without the jib or its reinforcing strut. The next step is the assembly of the wheel, beginning with its sustaining frame and the windlass. Only then the jib and its reinforcing strut should be elevated by means of an auxiliary piece of lumber joined to one of the corner struts of the lower frame. Velasco stresses that the joint elevation of the post, the jib and the strut is very difficult. He states that a pulley should be joined to the end the auxiliary stud joined to the corners of the lower frame. A rope thus joined to the hoist and going through the pulley will allow the raising of the jib and the reinforcing strut. Of course, this is the reason why the wheel and the windlass should be assembled before the jib and the strut. To end his description, Velasco states that the crane can be moved around a working site with the aid of *zoquetes* or small cylinders. If this is not feasible, then the crane should be disassembled in reverse order.

VELASCO'S HOISTING DEVICES AND SIXTEENTH-CENTURY BUILDING PRACTICE IN SPAIN

After our examination of Velasco's passages about classical and contemporary machines, we can return to the problem of Velasco's sources. The difficulties that Velasco experiences when describing or drawing the tryspast contrast with the authority he displays when dealing with contemporary machines. He describes their parts, explains their function and methods of assembly and even gives all kind of measurements with remarkable ease. Although Velasco was no professional architect or builder, we should assume that he had first hand knowledge of the construction and operation of these machines.

Where does this knowledge stem from? It is not reasonable to suppose that it derives from mere recollections of the Murcia crane of 1523, since Velasco was no more than five years old at this time, and we cannot assume he took detailed measurements of it. Of course, Velasco could have used papers left by Jacopo Torni at the time of his death, but there is no evidence that Velasco inherited books or documents from his father. Pizarro and Mogollón (1999, p. 25) assume that at least Vitruvius' treatise reached Velasco by this way, taking into account an early essay by Bonet Correa (1966 [1993], pp. 31-34). This work discusses a quite singular Ionic doorway in the ante-sacristy of Murcia cathedral, with feminine heads in place of capitals. Bonet ascribes the doorway to Torni and identifies Fra Giocondo's edition of Vitruvius as its source, taking into account that Velasco quotes this edition. However, the ascription of the doorway to Torni was challenged when Belda (1971, pp. 222-223) found a document which proves that the chapter approved the erection of this doorway in 1531, five years after Torni's death, and was discarded when a survey by Vera (1993, pp. 51-58) proved that the wall in which the doorway opens was erected in the decade of 1530 or possibly later. Furthermore, even if we accept, for the sake of argument, that Velasco could inherit some papers from his father about his work in Murcia cathedral, it is difficult to assume this papers included detailed, measured plans for a crane, and even a full explanation of the operation of the machine, since we know no documents of that kind for the Spanish Renaissance.

Thus, we must look in another direction. As far as we know, Velasco spent all his adult life in Granada. Moreover, he was linked to the cathedral of Granada since 1550 as choir-book illuminator and, later on, as a calligraphist and chapter member. Around 1565, in the central years of the preparation of Velasco's manuscript, the rotunda of Granada cathedral had risen to its present height. Although no direct evidence exists, we can confidently assume that some fairly big cranes would have been used in the cathedral works, and even that a fair number of “suelos de bobeda”, that is, scaffolds under the ambulatory and rotunda vaults, would have been set. Also, that Velasco could have seen a number of hoists in them. Thus, there are two possible sources for Velasco’s big crane, but neither of them is conclusive. The *ingenio* in Murcia cathedral is well-documented, but Velasco was no more that five years old when his father died and he returned to Granada. On the other hand, there is no direct evidence for such a big crane in Granada cathedral, but some hoisting devices must have been employed in the construction of the rotunda and the walls of the nave, and Velasco must have known these.

Another possible source of influence are the earlier cranes in the Escorial complex. The well-known cranes on the basilica or main church are not suitable candidates, since they were designed and set between 1575 and 1577, when Velasco’s translation was quite probably finished. Besides, the lower frames in the basilica cranes, as depicted in the Hatfield house drawing, are prismatic and not pyramidal as those in Velasco’s description (Íñiguez 1963, p. 210; Bustamante 1994, pp. 411, 419, 481; Lorda 1997, pp. 89-90). However, Lorda’s reconstruction of the earlier Escorial cranes (1997, pp. 87-89), used by Juan Bautista de Toledo, Lucas de Escalante and Pedro de Tolosa in the friars’ quarters, includes a pyramidal lower frame. Lorda does not quote his source in that instance, but he includes a drawing of a crane with a pyramidal frame from *Los veinticuatro libros de los ingenios y las máquinas*, a manuscript by Juanelo Turriano or Pedro Juan de Lastanosa.

There are also other connections between Velasco’s hoisting devices and the Escorial building practice. Apart from Velasco's *cabrita*, an antecedent of the Escorial *cabrilla*, it should be noted that a manuscript by Juan de Herrera, known rightly or wrongly as *Architectura y machinas*, deals with the operation of a big wheel with an attached windlass, such as the one described by Velasco. What is more remarkable is that the manuscript, written at Philip II's suggestion, explains the multiplication of the machine's lifting power on the basis of the lever principle, and does so quoting Archimedes. All this can hardly account for Velasco wide knowledge of cranes, since he was never connected with the Escorial, as far as I know. Quite to the contrary, all these similarities suggest that both Velasco and Herrera read Vitruvius and other classical texts not only as stylistical guides, with beneficial effect, as the later works in the Escorial or San Jerónimo's altarpiece show, but also as technical manuals.

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