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The Machines That Milled the Sugar-Canes:
The Horizontal Double Roller Mills in the First Sugar Plantations of the Americas

Bogota, New Jersey
January 2013

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Foreword

This essay intends to demonstrate in a more or less definitive manner that the horizontal double rollers were the mechanism used to crush the sugar-canes and to squeeze out their juice in the first sugar farms or plantations of the colonial Americas, those that were first established in the early sixteenth-century in *La Española* or Hispaniola, itself the first permanent European colonial settlement in the continent in modern times. It does so by combining a comprehensive review and assessment of the scholarship and published documents on the century-long colonial Iberian Atlantic sugar-making enterprise with an analysis of archival sources on sixteenth-century *La Española*.

In the author's effort to make the study as encompassing as possible, the text ended up being too long for a regular academic journal (provided it would have been approved by a peer-review editorial board) and too short to qualify as a monograph to be editorially considered for any of the existing commercial book series. After a lot of hesitation, finding it too unpalatable to shorten the text after so many dozens of hours of research invested, and watching years go by without any certainty as to the possibility of integrating the piece into a thematically broader text, the author has decided to publish it independently online.

At this point, the predominant motivation and hope guiding this publication is that, as an introductory overview on the matter, it will save considerable research or study time to those delving for the first time into the study of the beginnings of cane-sugar production in the Americas, and more particularly the study of the milling equipment that was used in the manufacturing of the sugar. For the more seasoned specialists on the early colonial Caribbean, the author hopes it clarifies past obscurities as to what type of roller mills were used to crush the canes since standard sugar began to be made there during the second decade of the sixteenth-century.

An earlier, shorter version of this essay was originally published in Spanish as 'El Uso del Molino de Rodillos Horizontales Dobles en las Haciendas Azucareras de la Isla Española en el Siglo XVI: Viejas y Nuevas Evidencias,' in *O Açúcar Antes e Depois de Colombo. Seminário Internacional de História do* Açúcar, Funchal, Centro de Estudos de História do Atlântico, Funchal, Madeira: 2009, p. 70-126. The essay is part of a broader research project by the author on cane-sugar farms or plantations in the regions of Azua and San Juan de la Maguana, in the southern-central area of the island of La Española during the second and third quarters of the sixteenth-century. Another section of said research has been the basis for the author's Master's Degree Thesis presented at The City College of New York in December of 2005. The bulk of the essay was finished as is in the spring of 2011. A minor updating of the content was done in November of 2012.

The author wants to express here his thanks to the staff of the Cohen Library of The City College of New York, and especially its Inter-Library Loan Office, as well as to the New York Public Library's Research Library for facilitating access to the rather scattered published sources on this topic. Equally thankful appreciation goes to the General Archives of the Indies of Seville, Spain, for the access to the precious primary sources held there that the author has used throughout the years. Finally, as it is so often the case, the author thanks Maria Pilar Sáez, wife and companion, for consenting to and understanding so many hours devoted to the imagining and talking about ancient tools that, due to the perishable nature of their wooden construction, have left no trace in the archaeology but in the archives.

Bogota, New Jersey, January of 2013.

The Island of La Española, today the Dominican Republic and the Republic of Haiti, was the scenario of the birth of the cane-sugar industry in the Americas. We know that the production and commercial exporting of cane sugar became one of the bases of the colonial economy of La Española during at least five decades of the sixteenth century and that this was the colony in the Americas that in fact exported more sugar to Spain during said century. But the information we have in this regard, or at least what has been published so far, is still extremely broad and fragmentary in its coverage. We know very little yet on many key aspects necessary to construct a minimally valid view of the men and women who implemented the launching and survival of sugar manufacturing while it lasted as an economically viable activity in La Española at the time. There are some data on the global volume of the official sugar trade, that is to say, the one supervised by the imperial authorities on both shores of the Atlantic, offered by historians like Pierre and Huguette Chaunu (1955-1959) and Eufemio Lorenzo Sanz (1979). But it is well known that there was a huge smuggling from the western coasts of the Island for which we have practically no indicators yet.

Also we know relatively little about who were exactly those protagonists of the early-modern sugar of La Española, be it the plantation owners, their slaves, the exporter-merchants that shipped it out of the island, and the merchants that in fact received and distributed the Dominican sugar in Europe. We know practically nothing about what happened exactly to Dominican sugar once it arrived at Spain's transatlantic ports in the sixteenth century, the

regions and cities of early-modern Europe that it finally reached, and who were its final consumers. Another aspect of La Española's sugar industry of this period on which until now we knew considerably little is the milling technology that was used in the 'ingenios' or mills of the sugar plantations or farms of the colony at the time. This essay attempts to provide new data and a comprehensive interpretation on the matter.

The prevailing interpretations in the existing scholarship on La Española's sixteenth-century sugar mills

What exact kind of equipment was used to crush the sugar cane wherever cane-sugar production took place in modern times is a question historians of sugar have asked because it has implications in terms of construction costs (which in turn implies the social affordability of the activity itself), productivity, potential volumes of production, types of energy, and types of labor used. In the case of the sugar estates of early colonial La Española, a number of notions have been conveyed by historians on how the equipment used in the early *ingenios* there probably looked like. Most have proposed that some type of roller-mills (a set of parallel adjacent cylinders, similar to those in the old clothes-wringers) were used, but often –in our opinion-- those interpretations have been based on not fully-demonstrated assumptions. A revision of the existing interpretations, themselves looked at in the historical sequence in which they were generated or at least published, on the one hand, and of new data recently made available by some scholars, allows us now -- we want to submit-- to construct a more complete description and explanation of `the use and functioning of this milling technology in La Española, and to

draw a clearer sketch of its components. Sharpening that description and explanation in a manner more accessible to the general public is the main purpose of this essay. A secondary goal is to contribute to the dissemination of certain theories on the matter that, in our judgment, have been little considered at least in the scholarship published in Spanish on the topic.

But before proceeding with such an overview it is probably convenient in this regard to mention the two most influential theories on the history of sugar milling technology of modern times that seem to have prevailed among historians during the twentieth century and all the way into our own time. Both center around the application of the roller-mills (called *eixos* in Portuguese and *exes* in Spanish) that, at different times depending on which author we consult, replaced the old European round milling-stones or *edge runners* (called *muelas, rulos, rulas or piedras molares* in the Spanish linguistic tradition) that –after being used for centuries in the Mediterranean wheat and olive-milling traditions—were actually applied to sugar-cane milling when the crop was first brought over to southern Europe and the Iberian Peninsula. (See Figs. 1-7) One was the interpretation by Edmund von Lippmann in the 1890s (originally published in German and later disseminated in Portuguese in the 1940s) and by Noel Deerr in the 1920s and 1950s, both of whom traced the sugar roller-mill back to Sicily in the Late Middle Ages. The other one is the revisionist critique of Lippmann-Deerr initiated by Brazilian scholars Gil Methodio de Maranhão and Moacyr Soares Pereira in the early 1950s that essentially denied the pioneering Sicilian application of the roller mill to sugar-cane crushing.[1]

[1]Moacyr Soares Pereira's study had been commissioned by the Instituto do Açucar e do Alocohol of Brazil, where the questioning of Lippmann's thesis seems to have been incited at least by Gil Methodio Maranhão in as early a date as the year 1952. Methodio seems to have been who in fact proposed that Soares Pereira be commissioned , taking advantage of a trip to Italy that the latter was about to embark in to participate there in an international conference on a different matter. Soares Pereira himself, in the Introduction to his study published in 1955, refers

This paper is conceived departing from the second theory, which gears the search for the origins of the 'Western' sugar roller-mill towards other geographical latitudes. As Maranhão especially indicated, said theory, in tracing the presence of the term 'eixos' as equivalent of 'cylinders' in certain Brasilian documents of the last quarter of the sixteenth century, relocated the probable origins of the sugar roller-mill to a period and a place subsequent to those proposed by Lippmann-Deerr: the beginnings of the colonial Americas.[2] As will be seen, both these

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to 'la polémica iniciada por el Dr. Gil de Methodio Maranhão' […] 'no que tange a la veracidade da afirmação de Lippmann e Deerr' (Soares Pereira, 1955: 16). In 1953 Methodio Maranhão had published an article announcing Soares Pereira's discovery. The same article was later used as prologue to the short book of 1955 in which Soares' study was published in full. In his short article Methodio Maranhão, among other things, is the first scholar to refer to the term 'eixos' as the one used to designate the sugar milling cylinders ('cilindros açucareiros') in the new 'Western mills' (engenhos ocidentais)' (Methodio Maranhão 1953: 60). In the 1955 publication, in his prologue to the work by Soares, Maranhão posed the following:

> […]'Os dados disponíveis parecen vir ao encontro dessas probabilidades quanto à precedência no uso dos cilindros açucareiros./
> As mais antigas referências autênticas de que se dispõe sobre o seu aparecimiento nos engenhos ocidentais, sob a denominação de 'eixos' e aquí, agora, pela primeira vez assinaladas, aparecem em documentos relativos a engenhos brasileiros de começos do último cuartel do séculoXVI.' […] (Soares Pereira 1955: 10, *Prefacio*)

Methodio Maranhão called as well the attention upon the technical and production advantages, when it came to milling canes, of the roller mil vis a vis the traditional mil of stone wheels, which required the use of additional labor to chop the canes before they were placed in between the milling stones or *rulos* or *muelas*:

> […] 'trituradoras, de pouca eficiencia, sujeitas ao trabalho preliminary de redução da cana, com o emprêago da faca manual, a pequeño pedazos, que transportados em cestos se despejavam nas moegas, á semelhança dos grãos de trigo.
> A cana era agora exprimida, em vez de meramente desfibrada, dispensando qualquer trabalho preparatório' […] (Maranhão 1953: 61; Soares Pereira 1955: 11).

[2] In his texts of 1953 and 1955, Gil Methodio Maranhão does not say how he arrived at identifying the word 'eixos' as equivalent of 'rollers' or 'cylinders,' but we know that –different than what happened in the documentation related to sugar that survived in the Spanish speaking world—in the Portuguese document tradition, and especially in the colonial chronicles, explicit as well as implicit references to the technical meaning of the word 'eixos' as synonym of

theories survived parallel in the scholarships printed in the respective languages they were originally published in. And both theories have influenced the scholarship on sugar making in early colonial La Española, with a more recent prevalence of the Americas-centered interpretation of the application of the roller-mill to cane-sugar.[3]

'rollers' did survive, and it is more than likely that a specialist like Methodio Maranhão had known them. References of that sort are found at least in sources like the *Diálogos das Grandezas do Brasil,* of 1618, in the *Relação da Provincia do Brasil* by Jácome Monteiro of 1610, both cited by Antonio Barros de Castro (1980: 682, note 7, and 683, note 8), and especially in André João Antonil's *Cultura e Opulencia do Brasil* of 1711 (Antonil 1982). Antonil's text has been broadly disseminated at least since the 1990s onwards by the Centro de Estudos de História do Atlântico of Funchal, Madeira, including a digital on-line version in its website. Antonil's chronicle includes what seems to us the most specific written description of the 'eixos' or cylinders of a colonial roller mill that exists amongst the colonial sources published in Portuguese language, included by Antonil as he described a triple vertical roller mill of Brazil at the beginning of the eighteenth century:

> […] 'Os três eixos da moenda são três paus redondos de corpo esférico, alto nos menores iguais cinco palmos e meio, e no maior, que é o do meio, alto seis palmos e também de esfera maior que os outros, e por eleição o melhor, porque, jogando como os dous, que nas ilhargas continuamente o apertam, gasta-se mais que os outros,' […] 'e, por isso, por boa regra, os menores' […] (Antonil 1982: 109)

In fact, in his chronicle Antonil seems to use the Word 'eixo' to refer both to the rollers or cylinders that crush the canes (in the restricted, specialized, sense of the sugar-making jargon of colonial times) as well as to the axles (in our contemporary sense of the word) or thick studs around which the water wheel swirls or moves. In a paragraph immediately before the one cited above, while describing the gear of the main water wheel, Antonil wrote:

> […] 'Entrando, pois, na casa interior, o modo com que se comunica o moto por suas partes à moenda é o seguinte. O eixo da roda grande que, como temos ditto, pela parte de fora se mete dentro da casa do engenho, tem no seu remate interior, chegado aonde assenta o aguilhão sobre o brinquete e esteios, um rodete fixo e armado de dentes' […] (Antonil 1982: 109)

In general, the section most dense in data about the physical structure and the mechanics of a sugar mill in Antonil's chronicle, including details on several of the parts of the milling mechanism itself, is the one comprised by chapters V,VI, and VII of Libro II of his *Cultura e opulencia* (Antonil 1982:107-114).

[3] Several authors estimate that Soares Pereira's critique demonstrated once and for all the mistake of the Lippman-Deerr thesis about the Sicilian origins of the application of the roller mill to the squeezing of the sugar canes (Barros de Castro 1980: 685, note 9; Daniels and

As with so many other aspects of early cane-sugar production in La Española, probably the first scholar to comment on which type of milling devices were used in the first sugar mills built in the island was probably Mervyn Ratekin, first in his little known master's thesis of 1952 and then in his very visited 1954 study. Apparently not finding any primary sources with specific descriptive data on the actual make up of the milling machines of the sixteenth century, it seems Ratekin just decided to, so to speak, go by the existing authorities at the time, and follow, therefore, Lippmann, Deerr, and Fernando B. Sandoval. He also used the 18the century treatise by Labat.

All indications are that, in terms of primary sources pertaining to La Española's early sugar estates, Ratekin only had access to the document abstracts published previously by Irene Wright (which he used rather thoroughly, otherwise) and these do not seem to include any specifics about the milling machinery used by La Española's sugar producers. On the other

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Daniels, 1988: 501-503). Daniels and Daniels –as we will see further ahead in this study—seem convincing when they argue that the lack of knowledge of the work of Soares Pereira and Gil Methodio Maranhão amongst English speaking scholars is probably one of the reasons why the Lippmann-Deerr thesis is still followed by some authors (Daniels and Daniels 1988: 513, note 72). That same ignorance by a number of English language scholars has probably affected also the work of Antonio Barros de Castro. Nevertheless we can add that the dissemination of the Portuguese scholars has not been that great either in the Spanish speaking world until very recently. Cuban scholar Fernando Ortiz, as it has been already pointed out, mentioned in 1961 and 1962 the work of Methodio Maranhão and Soares Pereira, but only in passing, and it seems that nobody else after Ortiz, in the scholarship written in Spanish, tried to explore Soares' study's contents. In the following decades, authors like Justo del Río Moreno, Lorenzo López y Sebastián, and Genaro Rodríguez Morel, among others, while embarking in studies of the early cane-milling technology of La Española during the sixteenth century, have cited Ortiz's interpretation, but without referring explicitly to the critique of the Lippmann-Deerr interpretation raised in their day by Methodio Maranhão and Soares. Both a linguistic barrier as well as an insufficient scholarly or academic communication between the Luso-phone and Hispano-phone worlds in general, and more specifically between historians on both side, may have played a role in the matter.

hand, he seems not to have been aware, at the time of his writing, of the pioneering study on early cane-sugar manufacturing in the Canary Islands in the sixteenth-century published just two years earlier (in 1952) by María Fabrellas, nor of the 1952-1955 work by Gil Methodio Maranhão and Moacyr Soares Pereira, which, as we will see, if read together with Fabrellas' study (and the short selection of primary sources her study includes)[4] might have led Ratekin to another interpretation (Ratekin, 1955: 4-5, 7, including footnotes 14, and 29 and 32, respectively). Whatever the case, in the 1970s and 1980s Ratekin's interpretation itself would still be closely followed by historians studying early sugar production in Mexico (Barrett: 53-54) as well as La Española itself (Haskett: 62).[5]

[4] In her 1952 short study on scane-sugar production in sixteenth-century in island of Tenerife (Canary Islands), Fabrellas already identifies the process of sugar-making practiced there as a two-step sequence, and she also includes some brief summaries of documents that describe the parts of components of some of the *ingenios* or mills, one of 1506 and another one of 1527 at least. The milling device or *ejes* is clearly mentioned there as something different from the *prensa* or press. (Fabrellas, 1952: 468 y 470, nota 27)

[5] Robert Haskett, then Ph.D student at the University of California-Los Angeles, holds the merit of having engaged in the first detailed study that we know of on the Santiago de La Paz sugar mill of Azua, based on data from the December 1547 inventory gleaned from a transcription of the inventory made by Roland Hussey and kept at the time amongst the Roland Hussey Papers of the University Research Library at the University of California-Los Angeles (Haskett: 51 and 74, note 1). Haskett, who seems not to have used the transcription of the inventory published by Juan Marino Incháustegui, adhered to Ratekin's on the use of the roller mills in La Española's sugar mills at the time (62) but he seems to have confused, to a certain degree, the concepts of *molino* and *prensa*, attributing by mistake to the term 'caxas' (which refers to the parts of the press in which previously chopped canes were placed) the meaning of rollers and at the same time skipping the mentioning of the '*exes*' or rollers in the translation of the inventory that he included as appendix to his article (77). Haskett also followed very closely the description of Mexican sixteenth century mills provided by Ward Barrett. As to the 'caxas' or boxes being parts of the presses used in the mills, we may find it, for instance, in the inventory and accounting presented by Damián Peralta in La Española in 1533 of the assets left by his late uncle Alonso de Peralta, which included a mill, where 'a box for the press' ('una caxa para la prensa') and 'a box of two chains for the presses' ('una caxa de dos cadenas para las prensas') are mentioned. Vid. Archivo General de Indias, Sección Justicia, Legajo 12, No. 2, Ramo 24, 'Diligencias del oidor Lic. Vadillo, oidor, con Damián Peralta.' (We do not provide here page numbers for this source because at the time we used it for this study no pagination had been done by the archivists.)

More specifically Ratekin understood that the first machinery actually used in the earliest sugar-making attempts in the area of La Vega in central La Española at the end of the first decade of the sixteenth-century followed the 'inefficient' ancient technology of the edge-runner, and that this inefficiency had been one of the reasons for the failure of this initial attempt (Ratekin 1954: 4-5, and 5, note 14). In this regard the author cites Noel Deerr [6] and eighteenth-century writer J.B. Labat,[7] as well as Henry Roth Ling.[8] He also cites Fernando Sandoval. [9]

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[6] Noel Deerr, *History of Sugar*, London: 1949, 2 vols, I, p.79.

[7] Labat, J.-B., *Nouveau voyages aux isles de l'Amerique*, La Haye: 1724, 2 vols., I, 260.

[8] Roth Ling, Henry, *A guide to the literature of sugar*, London: 1890, p. 42.

[9] Sandoval's 1951 book, *La industria del azúcar en Nueva España*, is possibly the first monograph by a Spanish American author exclusively dedicated to the history of sugar in a particular nation, México in this case. Yet we do not see very clearly what may have been the data Ratekin found in Sandoval applicable to the understanding of Hispaniola's case. In a preliminary chapter about the beginnings of cane-sugar in the Antilles, Sandoval refers to the mills used in Hispaniola as being like the same two models reportedly used already in Spain: *ingenios* powered with water and *trapiches* by animals (19). As to the grinding mechanism used in either type of mill, the only comment made by Sandoval was rather simple: 'The truth is that as the sugar manufacturing technique was introduced in the Antilles, as we have seen in Chapter I, presses were brought over to grind the canes that were powered by a hydraulic wheel and that the first *ingenios* that Mexico had were of this type, with the most advanced machinery of its time' (Sandoval 1951:156). Rather than an impression of inefficiency conveyed by Ratekin, therefore, there seems to be here a notion of cutting-edge technology associated to this type of mill. When discussing sugar estates in Mexico per se, the oldest archival data Sandoval explicitly cited are about the Tuxtla estate, on the coast of Veracruz, in 1566, when the milling house of the estate had 'two presses and axis, wheel and two houses' ('*dos prença*s *y eje, rueda, y dos casas*') (34). In my view, Sandoval seems to have confused presses and rollers because he seems to have understood the word '*ejes*' as 'axes' rather than 'rollers'. He repeated the notion when, referring to the *ingenios* in particular, he wrote: 'They were different than trapiches in that they moved their presses by means of a water wheel' ('Se distinguían de los trapiches en que movían sus prensas por medio de una rueda hidráulica') (158). The 1566 data were not the earliest ones provided by Sandoval in his book, though. As Horacio Crespo (1988, I :417) has noticed and we will see further ahead, Sandoval had included in the appendix of his book a document from 1534 that showed the presence of rollers already at that time. An inventory of that year mentioned already 'the roller of the mill' ('*el eje del ingenio*') in that sugar estate as

Subsequently, according to Ratekin, a transition towards the roller-mill technology took place (initiated by physician-entrepreneur Gonzalo de Velosa or Vellosa) in the 1510s, presumably when Canarian technicians were also brought in (Ratekin, 1954: 6-7, and 7, note 32), and these initiatives allowed for the first commercially viable cane-sugars of La Española.[10]

In 1961 historian Guillermo Camacho y Pérez Galdós, writing on sugar manufacturing in the island of Gran Canaria in the early sixteenth-century, based on archival sources of the time (specifically notarial records), sustained the thesis that the mills used there and then were

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well as 'verdugos' or bars adhered to one of the mill's rollers (211). Yet it is the data of 1566 the ones Sandoval quotes in his description, as if not noticing the meaning of the 1534 text, further evidence, in our view, that he did not find any specialsignificance in the presence of the word '*ejes*.'

[10]In his master's thesis of 1952, presumably affording more writing space that in his 1954 article, Ratekin in fact posed the possibility that at least 'three types of sugar mills' may have been 'in common use in Española in the early days', these being the old edge runner mill, traditional in the Mediterranean area and 'of relative inefficiency' (Ratekin 1952: 55, note 35), and the two versions of 'the more efficient type of mill' described as 'using two vertical cylinders of wood working': the *trapiche*, described by Ratekin as propelled by horses harnessed to a beam that 'angled upwards and was mortised into a vertical axis at the lower end of which was one roller of the wringer,' and the *ingenio*, 'run by water-power' and with its rollers 'geared to a great flying hoop rotating horizontally overhead, which in turn was geared to the shaft of the water wheel' (56, note 35 continued). It seems obvious that the switch from an envisioning of three types of mills in the 1952 thesis to two types of mill in the 1954 article is simply a consequence of consolidating, in the 1954 article, *ingenios* and *trapiches* as two versions of the same type of mill based on rollers. As to the milling mechanism itself, see Ratekin 1952: 37, paragraph 1 and note 43. More details are offered on page 55, main text, in pages 55-56, on pages 56-57, note 36, and on page 115. To present his interpretation more concretely, Ratekin in fact included two drawings in his master's thesis of 1952 that were not included in the 1954 article in the Hispanic American Historical Review: a drawing of an edge-runner type of mill and a screw press operated manually (page 37-a) and a drawing of a roller mill (page 116-a). Said illustrations are reproduced in Figures 5 and 8 included in this essay.

In his 1954 article, Ratekin seems to envision a quick transition in La Española's early attempts at cane-sugar production, around 1515, from the old medieval edge-runner to the late medieval roller mill, with its two variants in the form of the *trapiche* and the *ingenio*, rather than a vaguely defined coexistence of the three as pointed in the 1952 thesis.

possibly similar to the 'traditional' pre-industrial-revolution type still used or existing in the Canaries at the time of Camacho's writing, specifically triple cylinder mills, the milling device itself formed by one main cylinder moved by a water wheel and two other cylinders moved by the main one, parallel and adjacent to it (Camacho y Pérez Galdós 1961: 28-29). This interpretation implied that such a devise, usually thought of as appearing for the first time in the Americas in the early seventeenth century, had indeed a much earlier precedent in the Canary Islands. But the argument, for whatever reason, seems to have gone for the most part unnoticed by most of the historians that, in the ensuing two decades after Camacho, have given any attention to the beginnings of the use of the roller mill in the Americas, with the exception, and even then in passing, as we will see, of Stuart Schwartz in his 1985 monograph on the early colonial Brazilian sugar production.[11]

Camacho may have based his thesis on a 1517 document, a contract for the logging and transportation of a number of pieces of timber for the construction or repair of a sugar mill, among them 'three mill axes, one large and two small,' besides the timber for 'a wheel with its gear' (Camacho y Pérez Galdós 1961: 29). But we do not know exactly if he did it guided by the mentioning of *three* 'exes' or rollers of the different sizes he mentions, or because the traditional mills still existing in his lifetime also used three roller, or maybe because in the local traditional sugar-making jargon, still at the time the author was writing, the term 'eje' might have been still

[11] One possible reason, we may speculate, for this seemingly little awareness, among historians on the western side of the Atlantic in the 1950s and early 1960s, about the efforts done by historians in the Canary Islands in studying the history of early sugar production there, might have to do with little circulation, in the rest of the world, of the publications made in the Canaries, a province of Spain, maybe as part of a general situation of political international isolation that the Spanish regime had gone through under the first decades of Francisco Franco's dictatorship.

in use to refer to the milling rollers. Nevertheless it must be said that the fact that in his article Camacho, apparently, did not present complete and direct quotations from the documents he used as sources, but rather what seems to be a paraphrase of the original data contained in them, leaves space for our doubts and uncertainty as readers as to the validity of the conclusions he arrives at, especially considering that in this matter the exact terminology used on the documents is decisive for the specific interpretation we may construct.)[12]

Camacho used the same type of retroactive argument –comparing surviving artifacts of his time with those mentioned or described in the sixteenth-century documents – as he tried also to visualize another key piece or tool of the cane-sugar milling premises of that the time: the *prensas* or presses used to further squeeze the juice out of the canes once they had been crushed or squeezed at least once in the *molinos* or mills. (Camacho y Pérez Galdós 1961: 30-31). Apparently referring to a document of 1528 and noticing similarities between the vocabulary used in the sources describing the parts of the sugar-cane press used in a sixteenth-century mill and the one still used in the presses of 'primitive' grape mills or *lagares* at the time of his writing, Camacho concluded that the structure of both 'could have been' similar. The essential mechanism of these presses consisted of a large vertical, column-like wooden screw ('husillo') erected in the center of a thick horizontal circular stone or stone-wheel fixed on the ground. The vertical screw also traversed vertically, at a higher level, a set of huge, heavy horizontal wooden logs which could be moved down (literally screwed downwards) until crushing the cane stalks

[12] The three 'exes' or cylinders mentioned may well have been destined to one single triple roller mill, but we can also construe the data as referring to one large cylinder and a small cylinder for *one* double (not triple) roller mill plus a *spare* small roller, and even all of them being spare parts for *more than one* mill. What seems clear (and most significant to us for the purpose of this essay) in the source referred to and cited by Camacho is that there were '*exes*' or cylinders being used for the milling of sugar canes.

against the lower wheel and then moved back up to allow the crushed remains to be taken out. (Camacho, 1961:31) As with the notion of the milling apparatus itself, this notion about the cane press seems to have gone equally unnoticed for many years in the ensuing scholarship.[13]

In two articles in 1961and 1962 articles, Fernando Ortiz commented on the milling mechanisms used specifically in La Española's sugar estates of the early sixteenth-century. In 1961 Ortiz argued that, at the time of his writing, the exact sugar-cane pressing or squeezing mechanism used in La Española before the first actual mill was built was not known yet. (Ortiz, 1961: 12) Still the renowned Cuban scholar, citing from sixteenth century cleric and chronicler

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[13] Still in 1991, for example, historian Benedicta Rivero Suárez, in her monograph *El azúcar en Tenerife (1496-1550)* identificaba la 'mola olearia' or edge-runner as the type of milling instrument used in Tenerife during the first half of the sixteenth century (Rivero Suárez 1991:116). According to this scholar, in Tenerife also the lexical duality of *ingenio* and *trapiche* was used to refer to the water-propelled mill as opposed to the mill moved by animal power, the *ingenio* being the prevalent type.

As in the case of other scholars who have studied other sugar producing locations, Rivero Suárez found in sixteenth century Tenerife the practice of the double sequence of grinding and pressing of the canes as a procedure to maximize the cane's juice extraction. But when describing the type of presses used, Rivero seems to identify both the *husillos* and the *ejes* as part of the presses rather than parts belonging to different devices (press and mill, respectively) (Rivero Suárez 1991: 17). Rivero bases her interpretation on a document from Tenerife of an unspecified date where, according to the author, a contract was laid out for a repair job to be performed on 'the screw and the small cylinder of the press' ('el husillo y el eje pequeño de la prensa') (Rivero Suárez 1991: 117, note 11). If this expression was a textual quotation from the source used, then we would have to consider the possibility that at a given time in Tenerife the terms *ingenio* and *prensa* may have been used as similar; but know of no precedent so far. One of the few, if not the only, studies on the functioning of the early modern type of agro-industrial presses consisting of a huge horizontal beam that squeezes by exerting pressure downwards as if a gigantic hand stapler, is José Ignacio Rojas Sola's *Estudio historico-tecnológico de molinos y prensas para la fabricación de aceite de oliva* , especially the graphics and photos contained in pages 45, 63, 67, 125, 128, and 132-35. Equally useful are the text and illustrations included in the extensive overview by medievalist Ricardo Córdoba de La Llave, 'Las técnicas industriales,' in Luis García Ballester, coord., *Historia de la ciencia y de la técnica en la corona de Castilla, Vol. 2 (Edad Media 2)*, pages 223-432, especially pages 328-329.

Bartolomé de las Casas' rather vague description of the initial tools used in La Española to squeeze the canes, considered that, before 1515, 'the Indian *cunyaya* was the only cane-milling machine here,' meaning in La Española.[14] Further citing Las Casas' Ortiz mentions the lack of a 'good assembly' in the industry of the colony in its early beginnings, until sugar-mill pioneer Gonzalo de Vellosa subsequently achieved 'certain more convenient instruments' shortly before building the first *trapiche* or muscle-propelled mill. (Ortiz, 1961: 12, 13 and Ortiz 1962: 45).

In his 1962 article Ortiz concluded that he could not reach at the time any firm conclusion as to the milling technology used in the first sugar mills in La Española, but (noticing the use of the word '*ejes*' by Fernández de Oviedo when describing La Española's sugar mills in the 1530s and 1540s in his *General and Natural History of the Indies*) Ortiz defends the theory that wooden double cylinders were used in the very first sugar mills constructed by the Spaniards in the colony, at least as early as 1516. (Ortiz, 1962: 59) Implicitly, he seemed to be using the same lexical argument –in terms of the meaning of the word '*exe*' as equivalent of 'rollers' in the context of the early Atlantic cane-sugar manufacture—as Brazilian scholar Gil Methodio Maranhão , whose work Ortiz actually mentions elsewhere, though no explicit reference is made by Ortiz to the lexicological issue per se.

On the other hand, noticing a comment made by emperor Charles V of Spain in a royal order of 1518 directed to the king's officials and bureaucrats in La Española, indicating that the

[14] Besides the *cunyaya*, reference has been made as well by Dominican historian Ramiro Matos González to another traditional hand-operated pressing device made of wood in the rural South of the Dominican Republic, the *machaque*, that could squeeze sugar canes between a fixed base and an articulated arm or lever with anh up and down movement (Matos González 1995: 164-166, 167).

same sugar producer Gonzalo de Vellosa had 'invented' a cane-sugar mill in the island, Ortiz (1962: 49) further theorized that such a mill, again conceived as a double cylinder mill, could indeed possibly be a local invention by Vellosa, a Spanish settler in La Española, rather than one by Portuguese settlers in Brazil during the last quarter of the sixteenth century, as studies by Brazilian historian Methodio Maranhão --according to Ortiz-- suggested.(52) As to the supposed invention, the Cuban author further inferred that 'it was not the simple transplant of a machinery already known and used in the Old World.' Since the first colonial economic activity in La Española was gold mining, Ortiz argued that in La Española coexisted very closely those 'interested in mining' and the promoters of the sugar industry.' (54). And since a type of cylindrical laminator for metals had already been in use in European mining since the fifteen-century, it was 'believable that the cylindrical mills, already in the xvth century and in the first part of the xvith in Europe, were the inspirers of Velosa's invention.' (54) The scholar supposed as well that the discovery by Gonzalo de Velosa must have been something 'sensational' and 'revolutionary.' (52)

'It does not seem, therefore, unbelievable' concluded Ortiz, 'that the great achievement of Velosa had been based on having made with the timber from the land a mill of *ejes, masas or tambores* [which given its larger potentil had to be moved by hydraulic force, as it was the style already in the Old World,' thought Ortiz in 1962 (58).[15] Together with *rodillos*, the words *ejes*,

[15] In his classic study about the history of sugar and tobacco in Cuba *Contrapunteo cubano del tabaco y del azúcar*, published in the 1940s, Ortiz had already commented, in two of its chapters, on the beginnings of the cane-sugar industry in La Española, using data taken from Gonzalo Fernández de Oviedo and Bartolomé de Las Casas. Yet on that occasion the scholar did not include any analysis on the topic of the specific milling instruments used by the early sugar manufacturers of La Española. The most immediate way of explaining this silence would be that, as it has been indicated before, it was probably after reading the Brazilian historians already mentioned that Ortiz began to give attention to the sugar-making lexicon, and in particular to the

Spanish term 'exe,' as an indication of the type of milling mechanism employed. Since Methodio Maranhão published his interpretation for the first time in 1953 and 1955, it was rather improbable that Ortiz would have known about it in the 1940s, except through some potential personal contact with the Brazilian historian at the time of wich we simply have never seen any proof.

In our view, Fernando Ortiz' theory seems basically reasonable, but in our judgment] does not raise clearly enough its main linguistic (more specifically terminological, lexical) nature, centered around the use of the word 'eje' by Fernández de Oviedo in his chronicle. The equivalent Portuguese word 'eixo,' which apparently survived very much in use in the Portuguese-Brazilian cane-sugar manufacturing jargon throughout the centuries, was at the center of Gil Methodio Maranhão's 1953-1955 theory, and this author's work was explicitly cited by Ortiz. On the other hand Ortiz' argument has been picked up in the 1990s by more recent authors like Rodríguez Morel and Del Río Moreno, but –like it happened to Ortiz—in an implicit way, without fully presenting the lexical argument.

As we indicate elsewhere in this essay, the word 'exe' also appears in somewhat earlier documents related to sugar making in the Canary Islands, indicating –if we use the same linguistic argument—that cylinders were probably used at least in some of the sugar mills in the Canaries already in the early 16th century, which then leads to the question of whether the technology had been actually imported from the Madeira Islands, which is from where the whole sugar complex model –as it was established in the Canary Islands—was admittedly brought into in the late fifteenth century. Furthermore we now know that the word also appear in much earlier documents related to cane-sugar production in the Portuguese colony of Madeira in the early 1470s (Gouveia, 1985: 269,272; Vieira, 2000:18-19). On the other hand, the Andalusian sugar industry that existed at the time, mostly in the coastal area of what used to be the Kingdom of Granada, has not been related by the scholarship –to the extent this student is aware—with that of the Canary Islands. The latter, again, has been explained more as a result of Portuguese influence via Madeira, with which the colonized Canary Islands sustained an active maritime trade.

Another issue has to do with the seeming interpretation by Ortiz of the word 'huso' as synonym of 'eje' or cylinder (Ortiz, 1962: 54, 56) in the sugar-making jargon of the early sixteenth-century, apparently as a result of reading the sources too quickly. No argument is given by Ortiz for this interpretation, though he cites expressions where the word 'huso' and the word 'eje' appear in sequence, apparently interpreting this concatenation or seriality in the listing of the basic parts of the mill as indication of synonymity.

According to the Real Academia Española's *Diccionario de Autoridades*, the word eje was used to refer to 'One of the fundamental machines of machinery, which consists of a cylinder or round column (also called 'Tympano') which may be capable of spinning on the notches of the timbers that serve as its legs, and a wheel well united to the axis. It is used for sustaining or easing the lifting of a weight.' (*Diccionario de Autoridades*, v. 2, Ed. Facsímil, Madrid 1963, p. 676) and Amado Alonso, *Enciclopedia del Idioma*. The words 'huso' and 'husillo' seem to have been used during the 15th and 16th centuries in Spain sometimes to refer to the 'exes' or axes of cart wheels, but it seems its most prevalent use was for the large wooden screws that acted as main support for the vertical presses that were used to smash the grapes in the process of wine-

masas, *tambores* and *cilindros* are the terms by which the milling rollers or cylinders have been historically called in the sugar-making jargon in Spanish. As we will see, in the 1990s other scholars would follow the distinguished Cuban social scientist's theories—though, in our view, without the same degree of explicit caution as Ortiz's.

In general, in his 1962 article Ortiz concluded that it was not possible for him at the time to reach a firm conclusion about the milling technology used in the early sugar mills of La Española,[16] but (again, noticing the use of the Spanish word 'exes'—the equivalent of the Portuguese term 'eixos'—by Fernández de Oviedo in his *Historia General y Natural de las Indias* while describing the sugar mills of La Española of the first half of the sixteenth-century) it is clear that Ortiz defended the theory that, in the first sugar mills built by the Spaniards in La Española, double wooden cylinders were used at least already in 1516 (Ortiz 1962: 59).[17] In a

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making. Vid. Amado Alonso, *Enciclopedia del Idioma*, and Real Academia Española, *Diccionario de Autoridades*. Also as we indicated in note 64 of this study, nowhere in the sources related to the wheat and olive milling industry of Souther Spain at the time is the word 'eje' used, while the word 'huso' is documented as having a very different meaning there.

In his 1961article Ortiz also called our attention to another aspect: the need for studying the Canarian technicians who actually did the construction of Velosa's first and second mills, a trapiche and an ingenio respectively. Not consulting the bibliography on Canarian sugar published in the late 1950s[15] seems to have prevented Ortiz from theorizing the arrival of the horizontal cylinder mills as a transfer from the Canaries into a new American colony like La Española, where apparently nobody seems to have been really acquainted with cane-sugar production in terms of its latest techniques at the time. (After all, why then would the settlers of the 1510s in La Española take the trouble to embark in importing technicians all the way from the Canary Islands if it had been otherwise?)

[16] 'In conclusion –wrote Ortiz at the very end of his 1962 article—'we know who, when and where built the *first ingenio of the Americas*, but in terms of how its mechanical structure looked like, it is still not known. The introduction and origins of the roller sugar mill are still to be confirmed' (Ortiz 1962:59).

[17] Though Fernando Ortiz, in his 1962 essay, did not leave an exact reference to the passage by Gonzalo Fernández de Oviedo from which the quotation was gleaned, it is not too difficult to

locate the passage through a thematic search in the content indexes of the 1535 edition of *Historia general y natural de las Indias* and looking for the theme of the passage: the timber trees of the island of La Española and the Indies. The quote used by Ortizis if found exactly on Chapter IX of Book IX. Not only that: we found another comment by Fernández de Oviedo very similar in Chapter VIII of the same Book IX. In the first edition of the *Historia general y natural* of 1535, a copy of which we have consulted at the Rare Books Division of the Humanities Research Library of the New York Public Library, the two passages, transcribed here with their original spelling but with the abbreviations spelled out in between brackets and with the text lines separated by bars, say as follows:

> […] 'fo. Lxxxviii [v.] , Book Nine, Chapter VIII, about the oak of this Española island. In this Española island there are very large natural [robles] like those of Spain and of very sturdy wood, and the leave is like that of the [robles] of Castille. Of these and of other tree that I will mention in the next chapter fo. Lxxxix [ro.] the screws and rollers and wheels of the sugar *ingenios* are made in this island and the beams for the presses which are very long and thick, and chiseled at their four corners, of seventy and eighty feet in length and of sixteen *palmos* and more in square and in circle or waist after the beam is carved, which is a very great thing and are very beautiful pieces to see for their large size and thickness, and as I have said is a very sturdy and good timber' […]
>
> […] [fo. Lxxxix ro.] 'Chapter. IX. About the tree called Caoban of this Española island' […] 'which timber is rather redish and of it are made very good doors and tables and boxes and wood for whatever they want and very beautiful beam and so thick and long as they want and everywhere in the world this timber would be appreciated and it is very strong and of this Caoban are made very beautiful and large beams for the presses of the sugar ingenios as it was said in the prior chapter about the oak: and the rollers and screws and wheels and everything else they may want to make out of this timber: and for the wooden parts of the buildings of the houses in this city and other parts of this island it is the best, for besides being strong it is beautiful and of a gracious color.' […]

Fernández de Oviedo's testimony is significant for the historical scholarship at least for two reasons: 1) it confirms that indeed the 'exes' or rollers and the 'vigas' or presses were used in La Española's *ingenious*, and 2) it confirms a chronological frame for this practice that goes from at least 1535, year of the printing of the first edition of the *Historia natural y general*, until 1547, year of the writing of the second edition of the work, or at least year of the second writing of the chapters devoted by the chronicler to sugar production in La Española. (As it is well known, the second edition of Fernández de Oviedo's *Historia*, 'corrected' and 'expanded' according to the words of the author, came out of the press in 1557 in Spain very shortly after the passing of Fernández in Santo Domingo.)

Another detail that seems interesting, in relation to Fernández de Oviedo's testimony published in 1535 about the use of the roller mills in La Española, is the fact that the chronicler himself, who seems to have been so conscious as to the language and the terms he used while writing about the Indies and their inhabitants and landscapes, in fact used terms of the sugar-making jargon like 'exes,' 'husos,' and 'vigas' apparently without feeling the need to add any specification nor comment about their meanings so they were more clearly understandable for his readers. This is turn would seem to indicated that the author himself was implicitly

semi-implicit way therefore Ortiz seemed to be using the same lexicological argument –on the meaning of the word 'exe' as synonym of 'rollers' within the context of the beginnings of the Atlantic sugar manufacturing—as Brazilian scholar Gil de Methodio Maranhão, whose work, as we have shown before, Ortiz explicitly mentions in his essay, though without making any explicit reference to the lexicological issue per se.[18] The furthest Ortiz went in writing a more

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convinced that the meanings of these sugar-manufacturing terms were by then known not only by those potential readers that knew directly the sugar production settings but by the reader public in general at the time. In passing, when mentioning these pieces precisely in the chapters and passages devoted to timber trees, the author is confirming for us also that all these were carpentry pieces. Finally, let us say that the description provided by Fernández de Oviedo seems to correspond to the traditional presses 'de viga y quintal' portrayed and studied in the work of José Ignacio Rojas Sola already referred to in endnote 13 of this essay.

[18] Fernando Ortiz, therefore, bears the merit of being the first Spanish language scholar that, in 1961-1962, and –according to all indications—following the lexicological analysis and reasoning applied by Gil Methodio Maranhão a decade earlier to the case of the first Luso-Brazilian colonial mill, looked into the jargon of the Spanish sugar manufacturing of the sixteenth century and considered it as a tool and indicator to trace the type of milling instruments that were used in the beginnings of the Spanish colonial sugar-making in the Americas. Before Ortiz in the early 1960s, in so far as we know, no other Spanish language scholar had looked at the comments contained in Fernández de Oviedo's chronicle from this perspective. It is obvious, in this sense, for instance, that the Canarian researchers that studied for the first time the beginnings of the Canarian cane-sugar manufacturing a decade earlier, did not give consideration to this lexical element, which undoubtedly might have given them a rather effective analytical when it comes to clarify the type of machinery utilized in those late-medieval or early-modern mills. The fact that Ortiz had presented his comments at the time he did, almost two decades after the first editions of his *Counterpoint*, makes more believable –as we indicated before—the possibility that it was after reading the Brazilian historians of the early 1950s when Ortiz made the necessary analytical connection to adopt the lexicological theory.

On the other hand, and curiously, the application to the case of La Española, by Ortiz, of the lexicological analysis contributed by the Brazilian scholars led him to question one of the historical conclusions on the antiquity of the Brazilian colonial roller mills that these Brazilian historians themselves arrived based on their own theories of 1953-1955. Methodio Maranhão had established in his essay that the sugar roller mill *could not* have been introduced in the Americas by the Spanish colonists of La Española and that instead it was much more probable that it had been introduced by the Portuguese colonists of Brazil at least as early as 1570, date for which Methodio had already identified a document-based evidence of the presence of the word 'eixos,' as it was indicated before (Methodio Maranhão 1953: 60). Ortiz, on his part, observing in 1961-1962 the use of the term 'exes' by Fernández de Oviedo already in 1535 in his comments about the sugar mills of La Española provided in his *Historia general y natural*, was

meticulous analysis on the subject, was when he affirmed: 'The Brazilian hypothesis of the introduction of the sugar-industry's use of the word *eixos* (or ejes) in the year 1577, appears contradicted, since already before then it was commonplace in the Antilles' (57). Which does not mean that Ortiz's statement may not have as much implicit conceptual force, at least, as that of the Brazilian scholar. As we will try to show further ahead in this essay, in fact the reference to and raising—even when partial, in our view— of the subject done by Ortiz ended up being fundamental for the study of the milling technologies initially used in the Spanish speaking colonies of the Americas. [19]

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able to immediately pose a solid questioning –still valid today-- of the notion of a Brazilian historical primacy in regards to the use of the roller mills (Ortiz 1962: 57-58). After Ortiz other Brazilian historians like Antonio Barros de Castro have found earlier data (of the 1540s) on the use of the roller mills in Brazil than those detected by Methodio Maranhão, but their date is still later than that of Fernández de Oviedo's testimony on La Española's mills given in his *Historia* (1535).

[19] The *Diccionario de Autoridades* of the Royal Spanish Academy, published for the first time in 1732, provides the following as its first definition of the meaning of the word 'eje': 'EXE. 1.m. One of the fundamental machines of the machinery [sic], which is formed by a cylinder or round column (also called *Tympano*) that may swirl on the sockets of the studs that serve as its feet, and a wheel well united to the *exe*. It is used to sustain or facilitate the raising of any wheight. This machine is also called *Torno*' (Vol. 2, (D-Ñ): 676). This same meaning is collected in Martín Alonso, *Enciclopedia del Idioma* (II, D-M: 1631, description No. 4) and in Real Academia Española, *Diccionario de la lengua española* (2001: 587, description No. 12). The term does not appear in the vocabulary included by Cuban historian Manuel Moreno Fraginals in his well known treatise *El Ingenio*, and it could be speculated whether this is because in the documents of the period studied by this scholar in his multi-volume book the term had already disappeared from the Cuban oral sugar jargon. The terms *huso* and *husillo* (screw, in English) seem to have been used during the centuries of the Late Middle Ages in Spain to refer to the axles of wheeled carts, but it seems that the most generalized usage was the one that signified the big wooden screws that functioned as main support of the horizontal presses used to smash the grapes in the wine-making process. See Martín Alonso, *Enciclopedia del Idioma*, and Real Academia Española, *Diccionario de Autoridades*. Likewise, in none of the sources that we have used that dealt with the wheat and olive milling industries in Southern Spain at the beginning of the Modern period have we found the word *exe*, while the term *huso* does appear documented with a very specific meaning. See for instancethe 1992 monograph by Isabel Montes Romero-Camacho on agriculture in Western Andalucia in the Late Middle Ages, in which several references to the terms *viga* and *huso* do appear.

One of the now classic studies on Latin American early colonial sugar manufacturing , Ward Barrett's *The Sugar Hacienda of the Marqueses del Valle*, published in 1970, touched briefly on the beginnings of the roller mill in the colonial sugar plantations of the region. Yet Barrett seems to have had access only to descriptions of the colonial mills contained in French and English chronicles of the seventeenth and eighteenth centuries. The bibliography in his book does not cite any of the sources that, as we know today in hindsight, may have led him to establish the connection between the term '*exes*,' as it appears in the earliest primary sources on Mexico's first colonial sugar mills, and the use of milling rollers in those same mills. And though Barrett used Fernando Sandoval's book and had access to the sixteenth century documents it contains, it seems fair to assume he could not have interpreted effectively the presence of the word '*exes*' in them anyhow. Possibly more revealing even, the Glossary section in his book does not include the word 'exe' at all. Furthermore his bibliography does not mention either of the Mexican colonial chronicles by Francisco Hernández de Toledo nor Francisco Ximénez that have been later identified in the scholarship as important descriptive sources on the early roller mills of colonial Mexico.[20] Yet the author seems to have clearly suspected the lexicological issue at hand when he explicitly warned the reader : 'The inventories, unfortunately, contain many words not found in modern dictionaries or now given meanings different from those they had in colonial times' (53). In this context of the late 1960s, it is understandable then that Barrett suggested the relying on the illustrations in the seventeenth and eighteenth centuries' chronicles as the only tool then available to imagine the structure of the sixteenth century milling equipment. And it is no surprise that Barrett theorized that the sixteenth

[20] On the chronicles by Hernández de Toledo and Ximénez, see comments on the work of Mexican historian Horacio Crespo further ahead in this essay.

century Mexican mills could have been similar to the vertical roller mills of the ensuing centuries, except for the change introduced with the enveloping of one of the rollers with the metal sheaths.

Almost two decades later, in 1980, Brazilian scholar Antonio Barros de Castro made an additional contribution to the study of the initial application of the roller mill in the sugar manufacture of the beginnings of colonial times in the Americas, but circumscribing himself only to the Brazilian case. Barros, using as conceptual footing the work by Gil de Methodio Maranhão and Moacyr Soares Pereira of the 1950s, found document references to the use of the word *eixos* in Brazilian sugar mills of 1548 and, understandably, concluded that roller mills were already in use at that moment in Brazil (Barros 1980: 684 and 685, note 10). Nevertheless, when referring to the use of this technology in Spanish America, the only case he referred to is that of México, dating it 'possibly' in 1615 (686, note 14). In his study, though Fernando Ortiz's *Contrapunteo* is cited to refer to the best known chapter of Fernández de Oviedo about the *ingenios* of La Española, no mention is made of Ortiz's essays of 1961-1962, nor of the other passages of Fernández de Oviedo himself about the use of the *ejes* or rollers cited by Ortiz in those latter studies (1980: 689, note 19). Yet Barros included in his article a very useful summary of the characteristics of the early modern times mills, both those with stone milling wheels as well as those with rollers, indicating the limitations of each type's capacities. Equally useful are the schematic drawings of the instruments of the sugar milling included by the author in his piece, the horizontal roller mills amongst them, several of which –due to their informational value—are reproduced in this essay. (Figs. 9 and 11) In any event, as we will see further ahead in this essay, some of the details of the description provided by Barros of the first

colonial roller mills of Brazil also have implications for the study of the use of the same type of equipment in other colonies in dates that were fact earlier, like those in La Española.[21]

In 1985, in his well known and heavily archival study of Brazilian colonial sugar plantations, historian Stuart Schwartz was the first Anglo scholar to explicitly state the precedence of the use of the roller mills in the Portuguese and Spanish Eastern Atlantic islands before the industry arrived in the Americas. Though he seems to have attributed the notion of a Brazilian historical primacy in this regard to Moacyr Soares Pereira instead of Gil Methodio Maranhão, Schwartz clearly saw the importance of the data provided by Camacho in 1961 and alluded to the evidence they contain on the existence and use of the roller mill in Canarian sugar estates well before the cane-sugar industry was launched in the Americas (Schwartz, 1985: 4, 8 and 11, and 504, notes 4 and 5). He also criticized the historical inaccuracy of Theodor de Bry's famous 1595 engraving reportedly depicting a sugar estate in sixteenth century Hispaniola, where an edge runner is the only type of milling machinery shown.[22] Yet at the time Schwartz did not analyze the evidence about roller mills themselves in any detail and skipped discussing

[21] In 1980 Barros de Castro proposed the year 1548 as the earliest date for which there is documented evidence of the presence of a roller mill in Brazil (684). At the time when his essay was published, the author considered that the exact historical origins of the application of the rollers to the milling of sugar canes were ultimately yet unknown. According to Barros, on the other hand, in Brazil the roller mill went through a 'slow' and 'limited' diffusion process, to the point that on a date like 1570 there were still cases in which the rollers had not been incorporated into the milling (686). The Brazilian historian used as well a testimony by Giuli Landi from 1574 in which, says Barros, it is mentioned that in 'the Atlantic islands' (apparently referring to the Portuguese colonies in the Eastern Atlantic) sugar canes were by then milled both procedures: either the rollers or the stone wheels or *muelas*. (The original reference to Landi used by Barros in his essay is taken from the 1965 work by Vitorino Magalhaes Godino, *Os Descobrimentos e a Economia Mundial*, but at the time of completing this essay, we have not been able to revise in Landi's original whatever he wrote on the subject.)

[22] In a caption accompanying a reproduction of De Bry's engraving Schwartz says: 'This view, although based on reports from the Caribbean, probably represents Mediterranean practices. Note the use of a millstone rather than a roller press' (Schwartz 1985: 7, Figure 1-1).

the implications of the presence of the term *exes* in the archival sources, essentially referring the reader to the works by Camacho, Fabrellas, and Barros de Castro. The issue of the cane-sugar roller mill in the Spanish-speaking territories, therefore, remained not spelled-out. [23]

Also in 1985 the leading Caribbeanist anthropologist and historian Sidney Mintz referred to the early colonial cane-milling technology of the Americas as well, and more specifically to that of Hispaniola. Mintz credits Hispaniola's early sugar entrepreneur Gonzalo de Vellosa as the one who 'took the first step towards creating an authentic sugar industry in the Caribbean' when he imported Canarian technicians to construct what Mintz describes as 'a mill with two vertical rollers' (34). Like Schwartz that same year, Mintz, whose notion about the mill seems to come from Ratekin's work, explicitly questioned Theodor de Bry's engraving representing a cane-sugar estate in Hispaniola, indicating about the edge-runner type of mill included by de Bry in his image, that its 'use is not documented for the New World.'[24] Still, no mentioning was made by Mintz either of the lexicological thread of evidence about the roller mills.

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[23] In his 2004 work, Schwartz commented that in sixteenth-century Brazil both edge runners as well as, 'more commonly, horizontally arranged rollers' were used in Brazilian sugar estates, but no additional evidence was presented by the author. (Schwartz 2004: 163).

[24] Understandably, Mintz saw a long term continuity between the reportedly vertical rollers of the early colonial mills and those in a few traditional *trapiches* that had survived in rural areas of the Dominican Republic. Included amongst the images in the book is a unique photograph of *trapiche*, described as 'a contemporary sugar mill in the Dominican Republic' […] 'closely resembling their predecessors going back several centuries.' The images in the 1986 edition of Mintz's book are staggered between pages 78 and 79 with no pagination. If we were to number these pages with the number 78 followed by alphabetically sequenced letters, the one showing the Dominican *trapiche* would be 78e.

In 1986 an inventory of the Cuban sugar mill *Nuestra Señora del Rosario* near Havanna in 1603 was published with an introduction by archivist Norma Roura, author of the paleographical transcription of the original document, and historical comments on the mill's machinery and components by noted Cuban historian of sugar Manuel Moreno Fraginals. Both the data in the inventory and the companion comments are pertinent to our discussion. [25] The inventory offers what we consider the first documented use of the word *massas* to designate a mill's rollers; a term–sometimes spelled as *masas* or *mazas* as well-- that would survive in the Cuban sugar-making jargon throughout the centuries of the colonial period.[26] More specifically, the said inventory mentions 'two *massas* of the said *yngenio*, one large and another one small' (Roura and Moreno, 1986: 16), which seems to clearly allude to the same *horizontal double rollers* used since three quarters of a century earlier in La Española. The accompanying interpretive comments by Moreno Fraginals on this mill as described in the cited document, though, may sound somewhat ambiguous and potentially confusing for the early history of the cane milling technology in the Spanish Caribbean.

Moreno Fraginals' reading of the 1603 inventory led him to conclude that this mill was 'a transition *ingenio*, that has developed the possibilities of the most ancient technique for

[25] The historical comments by Moreno Fraginals themselves that accompany the document, though, are clearly dated 'July 7/1984' by the author, so it must be understood that their writing has to be dated at least before this date, much earlier than the date of publication in the *Boletín del Archivo Nacional*. Our warm thanks should be expressed here to prominent Cuban historian Dr. Alejandro de La Fuente García for alerting us in April of 2010 to the existence of Moreno Fraginals' article and providing us the bibliographical reference to it.

[26] In the glossary included in Moreno Fraginals' famous treatise *El Ingenio*, the term 'maza' is defined as with a single meaning: 'each of the cylinders of the *trapiche* [see] which squeeze the canes to extract the juice' (Moreno Fraginals 1978: 144). The term is not defined in the brief glossary accompanying Moreno's 1986 essay.

extracting the juice of the cane by means of a mill constituted by two large *mazas*: a horizontal one, on top of which spins another *maza*, placed in a vertical sense. The motion force is animal (horses), applied directly to a large flying wheel that engages the wheel of the *molienda* through a lantern' (Roura y Moreno, 1986: 30). At first glance at least, the reference to a 'horizontal' element and another one placed in a 'vertical sense' easily induces us to understand that Moreno took this 1603 Cuban mill to be the traditional Mediterranean *edge runner* used in the olive oil making industry, with one round milling stone spinning and running vertically on top of another, horizontally laid, circular stone, and describing in its movement a circular path on the face of the latter. And in another passage of the same comments, while comparing this mill to the structure of the *triple vertical roller*s that would appear in Cuba around a decade and a half later, Moreno describes the 1603 mill as one of 'the ancient mills of two *mazas* and their complex presses' (31). At no point whatsoever the mill of double horizontal rollers is mentioned, as if, in a way, there had been –at least in Cuba-- simply a transition from the early medieval type of edge runners to 'the vertical three roller mills, placed tangentially, in a straight line.' We would argue, conversely, that everything in the 1603 inventory indicates the presence of a double horizontal roller mill as we know this type of mill from earlier sixteenth-century descriptions.

Besides the horizontal *massas* or rollers themselves, the 1603 Cuban inventory also contributes a rather clarifying mentioning of other parts of the roller mills that had been typical since early on in the sixteenth-century. It happens to provide, for instance, the most illuminating description, amongst all the documents in Spanish known to us about the early sugar mills of the Americas, of two particular elements: the *verdugos* [27] –the iron bars affixed alongside and

[27] We must indicate, though, that the definition of 'berdugos' provided in the glossary that accompanies the 1603 published inventory, presumably the work of Moreno Fraginals, identifies

around the upper roller to function as longitudinal protrusions or teeth to crack or crunch the canes--, and the *chapas* or iron sheaths mounted around the lower roller of the mill to further squeeze the canes. The other components cited are the *guijos* (the longitudinal metal axes on each side of the rollers or *masas*, on which the rollers themselves spined), the *chumaceras* (the metal pieces with a hole where the *guijos* rested), and the *sortijas* (the rings that reinforced the outside of the rollers).[28] It also includes a number of details about the other almost constant companion machinery of these mills, the presses: 'two presses [made] of *hácana*, large, thick and very good with their boxes on top of the wooden ones and filled with stones so they may have more wheight' (Roura and Moreno:17).[29]

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them as basically a piece associated to the axle of carts ('a piece of timber that, in carts, is laid between the axle and the board's jamb post'), not even to the mills themselves (Roura and Moreno, 1986: 28). And even if it was the case that this was the meaning of the word that survived in Cuba in the long run, we need to remember that in the 1603 inventory the word is clearly spelled out while describing the milling or crunching machinery of the *ingenio* or mill itself (Roura and Moreno, 1986: 28). The description included in Moreno's glossary in 1986 does not fit the configuration of the 1603 Cuban mill at hand, nor that which appears in inventories of La Española's sixteenth-century roller mills that we may assume were its predecessors, nor in the Brazilian sugar-making terminology. As we will see, Antonio Barros de Castro has provided what seems to be a more coherent description of the *verdugos* as the pieces that were added to the rollers to increase their smashing power. Also, in Moreno's glossary, the word is spelled as 'verdugo.'

[28] The Spanish transcription of the passage by Roura is the following: 'Dos massas del dicho yngenio, una grande y otra pequeña, la / molienda dellas herrada, la grande con berdugos de hierro de dos / dedos de ancho y uno de grueso y la de auajo de chapas de hierro/ anchas, todas con tres sortijas encaxados'/ [sic] ('two rollers of the said mill, one large and another one small, their assembly reinforced with iron, the large one with bars of iron two fingers wide and one [finger] thick and the lower one with wide sheaths of iron, all incased with three rings' (Roura and Moreno, 1986: 16).

[29] The original text in Spanish says 'dos prenssas de hácana grandes, gruessas y muy buenas con sus caxas ensima de las de Madera y llenas de piedra para que tengan mayor pesos' (Roura and Moreno, 1986: 17).

Finally, a warning may be due on Moreno Fraginals' treatment of the terms *ingenio* and *trapiche* used to identify different types of sugar mills in the early Spanish colonial period. Narrowly adhering to --and implicitly generalizing from-- the Cuban case, where the colonial sugar industry as such began three quarters of a century later than in Hispaniola and Puerto Rico, Moreno poses that *ingenio* was the term used to designate sugar mills since they began to appear in the Americas, while *trapiche*, according to the Cuban historian, was a term introduced at the end of the sixteenth-century (Roura and Moreno: 31). Yet, as explained somewhere else in this essay, around the time Moreno published these comments, the scholarship was already clarifying the presence and use, since at least the first third of the sixteenth century, of the *ingenio*/*trapiche* terminological and typological duality in Hispaniola. [30]

In 1988 John and Christian Daniels published a fundamental overview or update on the issue of sixteenth-century sugar milling technology in the Atlantic world. In an now famous article on the origins of the sugarcane roller mill published in the journal *Technology and Culture* that year, the Daniels presented the most thorough review up to then of the existing literature and concluded that there was evidence that *roller mills* (not just the old type of European *edge-runner mills*) had been in use in the Americas in the first half of the sixteenth-century, either resulting from an adaptation by Europeans, somewhere in the Atlantic world, of so-far little disseminated metal-milling rollers technology to sugar-cane crushing, or from an early Portuguese borrowing of Asian roller-mill technologies found after their first direct trips to

[30] It is particularly intriguing, for instance, that Moreno Fraginals did not refer in these comments of 1986 to the sixteenth-century chronicle of Gonzalo Fernández de Oviedo, where *trapiches* and *ingenios* are mentioned.

India via the Eastern Atlantic, or maybe even as a result of an independent, parallel development taking place in the Americas (Daniels and Daniels 1988: 512-517).

The basis of the Daniels' interpretation was a new assessment of the existing descriptions of the mills of the Americas, and more exactly a re-interpretation of the semantics of the words *exe* or *eje* (Spanish) and *eixo* (Portuguese) that appear in some inventories of mills from both the Spanish and Portuguese early colonies in the Americas, respectively, though only one case in Mexico in 1534 and one in Brasil 1572 are mentioned by the authors. This reassessment was combined with a new dating of a testimony on the use of the word *exe* in sugar mills made by Spanish cleric Francisco Hernández, which so far had been thought to be from the early 1610s but was re-dated by the Daniels as actually being quite earlier, from 1570 exactly. Using the works of Gil Methodio Maranhão and of Antonio Barros de Castro on the meaning of the Portuguese word *eixo* in the sugar-producing milieu, the Daniels reached the conclusion that wherever this word appeared in descriptions of mills in the sixteenth century Atlantic, it is actually referring to roller-mills (that is, mills using parallel adjacent cylinders to crush the canes) rather than to its other –more contemporary-- meaning of 'axis' (that is, a bar or point around which another piece spins or swirls in a circular motion) (Daniels and Daniels 1988: 513). This reassessment was combined with a new chronology or dating by the Daniels of a testimony on the use of the word *exe* applied to sugar mills in México written by Spanish cleric Francisco Hernández de Toledo in 1577 in his manuscript *Rerum Medicarum Novae Hispaniae Thesaurus*, which until then had been dated by scholars around 1615, and on accasion even attributed to its translator into Spanish at the time, Francisco Ximenes. Since Hernández did, in his 1577 original, a description of a horizontal roller mill of 1570, the Daniels considered his

work as the first description done in the Americas of this type of rollers.

It must be added, yet, that for whatever the reason and despite the great bibliographical coverage of their review of the studies on the cane milling technologies of the modern period, there were three studies the Daniels do not seem to have consulted and which –had they examined them— would have possibly allowed these historians to construct an even more comprehensive and solid view of the issue. The studies in case are María Fabrellas' 1952 article on the beginnings of sugar in Tenerife and the two 1961-1962 essays by Fernando Ortiz mentioned above on the origins of sugar production in the Americas.[31] The article by Fabrellas, pioneer in the studies on modern Atlantic cane-sugar, does not analyze per se the theme of the milling technology used in the island of Tenerife during the period it covers, but it contributes document excerpts that, perhaps unnoticed in their meaning for the author herself at the time of writing her study, happen to constitute now for us a fundamental data –as we will see further ahead in this essay—to achieve a more illuminating clarification on the matter. [32] As to the

[31] As it occurred with Antonio Barros de Castro, whose work is used openly by the Daniels as one of their paramount sources, these authors consulted Fernando Ortiz via his citing of Fernández de Oviedo's chapter on the sugar mills of La Española, but do not seem to have consulted Ortiz's interesting essays of 1961-1962 that analyze the word *ejes* applied by the chronicler to the milling machines of the sugar estates of La Española (Daniels and Daniels 1988: 515, note 80).

[32] Reading Fabrellas' 1952 study, for instance, and more specifically the document excerpts included in it, Daniels and Daniels would have found that already in 1506 in Tenerife the term *eje* was being applied to a part of the mills that, according to the logic of their own lexicological argument, could not have been other than the milling cylinders or *rollers*. This in itself signalled the origins of the term, and probably of the rollers themselves, as a cane-sugar milling device, in the Eastern Atlantic. More yet. In the documents about *ingenios* cited by Fabrellas there is mentioning as well of the presence of *cinchos para los ejes* (iron 'fasteners for the cylinders'), which further strengthens the theory that the *ejes* were indeed cylinders or rollers made of pieces of wood and reinforced or held together by the iron strips, belts or fasteners that the *cinchos* were. We discuss this detail also later in this section when we comment on the narrative written by Italian merchant Galeotto Cei during the second half of the sixteenth-century in which the

articles by Ortiz, we have summarized already their content before, and their pioneering implications, within the scope of the scholarship written in Spanish, about the origins of the use of roller mills in the Americas. Ultimately, the studies of the Canarian and the Cuban scholars happen to point into the same direction in showing or proposing an early presence of the roller mill in the sugar estates of the territories of, let us say the Iberian Atlantic, and had their work been considered by the Daniels, it would have definitely consolidated the bases of some of the theories reviewed by these scholars in their review.

In any event, the survey drawn by the Daniels on the topic, despite hinting at the possibility –as one amongst four different theories—that the first roller mills of the Americas had been constructed in La Española and yet providing practically no single data about this colony on which to sustain said interpretation, had the importance of helping to considerably clarify the lexicological argument about the *exes* or cylinders that had been used implicitly by Fernando Ortiz himself in 1961-62 and was picked up from the 1990s onwards, as we will see, by the authors of the most recent scholarship on La Española's early sugar manufacturing.

Another contribution to the history of the cane-sugar milling devices also published in 1988 has implications as well for the study of the sugar estates of La Española in the sixteenth-century. It is the *Historia del azúcar en México*, a two-volume general survey on the history of cane-sugar in Mexico, produced by a team of Mexican historians led by Horacio Crespo, in which some considerations are provided on the origins of cane-sugar in the Americas. In terms of the milling equipment, Crespo et al. defined the earliest Mexican mills as *trapiches* and (citing

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author provides an extremely rare testimony about the make-up of sugar-mills in La Española in the 1540s, time when he visited the island.

Deerr) identified them as *vertical triple-roller* mills, still attributing to them a Sicilian historical background beginning in the 15th century along the lines of the Lippmann-Deerr theory (415). Concomitantly, following priest Francisco Ximénez's 1615 translation of clergyman Francisco Hernández de Toledo's 1570 chronicle and its description of sugar mills as a source, Crespo concluded that there were also *horizontal double-roller* mills being used in sixteenth-century Mexico, identifying them as 'a model prior to Speciale's vertical one,' (Crespo 1988, I: 415, footnote 145), while still adhering to Deerr in understanding that this model existed prior to the reported Sicilian type of the 15th century and that 'its presence in Mexico has the direct precedent of its use in Spain still in the xviith century' (415, footnote 146, and 456-457).[33] On the other hand, when dealing more specifically with the issue of the type of milling mechanism of these early Mexican mills, Crespo applied to the Mexican case the 1950s' argument by Gil Methodio Maranhão on the use of the Portuguese term *eixos* in Brazil in 1572 and 1577 to refer to roller mills, and concluded that the presence of the word e*xes* (the Spanish equivalent of the Portuguese term *eixo*) in Mexican colonial documents from 1534 about a mill in Tuxtla at the time is proof that it was in México where the *vertical* rollers were first used in the manufacturing of cane-sugar in the Americas (vol. I: 420).[34]

[33] In note 145 of page 415, volume I, of Crespo's book, a reference is made to page 92 lf Ximénez work, while Crespo's note 146 is an internal reference to page 457 of the same volume where Crespo reiterates the Italian origins of the vertical roller mill and points out its advantages when compared to the horizontall roller mills. It seems obvious that Crespo's explanation ignored the analysis published by Daniels and Daniels the same year of his publication, 1988, in which, as we have seen, both the theory of Lippmann-Deerr and the text attributed to cleric Ximénez were commented and critiqued upon in detail. As the Daniels indicated, it is important to remember that Ximénez had translated the data on Mexican mills from the chronicle written much earlier by priest Francisco Hernández, who mentioned in his text that this type of mills existed already in the decade of 1570. Since Crespo takes Ximénez for the author of the chronicle, it is understandable that he and his team do not refer to Hernández in their work.

[34] Possibly due to a confusion between Soares as author of the study on the Sicilian mills and Methodio Maranhão as author of the prologue where the theory was spelled out, Crespo and his

In the inventory of the Mexican sugar mill of Tuxla of 1534 the authors of the *Historia del azúcar en México* found as well mentions of three other terms from the early colonial sugar-making jargon that, according to these scholars' interpretation, would underscore the historical primacy of the Mexican colonial sugar industry in the Americas: 1) the term *trapiche*, whose use in Tuxtla in 1534 was reportedly the first ever in the Spanish language to describe a sugar mill, a year before the word appeared published in Gonzalo Fernández de Oviedo's *Historia General y Natural* in what Spanish linguist Joan Corominas had considered the first documented appearance of the word ever (Crespo 1988, vol. I: 419, and 419 note 155); 2) the term *prensa* to refer to the instrument in which the second step of the squeezing of the sugar canes took place (418), and 3) the term *cincho* that designated the iron fasteners or belts used to reinforce or hold together from the outside the *ejes* or rollers of the mills (419). Finally, the Mexican historians thought to have found as well in México the first documented reference to the use of a draw-wheel applied to an *ingenio*, concretely in documentation pertaining to a sugar estate in Tlaltenango 'in the decade of 1530' (421).

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team attributed the theory of the synonymity of the Portuguese word *eixos* and the word *rollers* to Moacyr Soares Pereira but –as we have seen—in reality it was the work of Gil Methodio Maranhão, presented for the first time two years earlier in a short essay, and published again in 1955 as part of Maranhão's prologue to the book by Soares Pereira.

Why exactly Crespo and his team followed the description about the use of *eixos* or rollers in Brazilian mills as spelled out in Maranhão's texts in Soares Pereira's book and still adhered –as we have already seen-- to the old Lippmann-Deerr theory on the Sicilian origin of the sugar roller mills precisely debunked in Soares' book, is something we have not been able to understand, unless it was only the prologue of Soares' book what the Mexican researchers read at the time.

Crespo and his team contributed also a useful description of other vocabulary that had survived in the Mexican sugar-making lexicon from colonial times and which designated a number of the parts of the vertical doble roller mills that existed in México until recent times: 1) *guijos*, which were the pivots in form of rods or spikes that protruded from the center of each round side of the rollers; 2) *chumaceras*, which were each of the pieces with a hole or notch where the *guijos* would rest vertically in, and which were drilled into 3) the *banco* or base of the entire milling mechanism, base that in turn was laid on the floor and was made of either wood or stone (vol. I: 417).

Another statement by Crespo et alii on an additional piece of the sugar-cane milling equipment has implications for the study of the early sugar manufacture of La Española and is probably worth a quick comment here. The authors maintain that it was at the end of the 17th century when 'an important innovation' occurred as the rollers began to be covered with 'planks of melted iron,' called *verdugos* according to the authors, whose function was that of prolonging the life of the rollers and augmenting the efficacy of the squeezing pressure. These pieces were reportedly also made, subsequently, of copper or bronze and the authors considered them essentially a technological borrowing taken from the British industry of the mid seventeenth-century (Crespo 1988, I: 417). Two critical clarifications seem in order on the matter. One is that there is now clear evidence that these metal sheaths had been in use much earlier, in the Canary Islands since at least 1503-1504 (Gambín García, II: 16 and 18),[35] and in La Española at least since 1523 (Del Río 1991: 370).[36] The second has to do with the meaning of the term itself.

[35] See endnote 35 further ahead in this essay with more details about the 2008 monograph by Mariano Gambín García on an early sixteenth-century Canarian sugar mill.

[36] Del Río mentions the sheaths, referred to in the documents as 'chapazón' (meaning the set of

The description of the mechanical function of the *verdugos* presented by Crespo et alii, when compared against the inventories of sixteenth-century mills of La Española, and especially against the Cuban inventory of 1603 referred to above, seems to fit more that of *chapas* and *chapazón* as they appear mentioned in those inventories, and where the *verdugos* seem to be the same as the homonymous parts of early colonial Brazilian mills, also mounted on the *eixos* or rollers, and which Barros de Castro has described as 'the teeth that cut the cane' (1980: 633).[37]

In his well-known survey on the global history of sugar appeared in 1989, probably the most prevalent overview of sugar-making from a world level perspective in recent decades, John Galloway allocated almost seven pages to the early history of sugar in Hispaniola, but included very little comment on the technologies used in the colony to mill the canes, and none on the issue of the milling rollers or cylinders. Just defining Hispaniola's sixteenth-century mills as 'Old World technology' (Galloway 1989: 67) or 'Mediterranean milling technology' 'unsuited to

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'chapas' used) amongst the expenses incurred at the *Sanctiespiritus* in chapter 9, part 2, 'La contabilidad de dos modelos distintos de plantación,' of his book, and cites as the source the 'Relación de las cuentas de Juan Villoria,' Archivo General de Indias, Sección Justicia, Número 2. This mill, according to the author, began milling on May 15th, 1523. Furthermore, the 'chapazón y verdugos' appear clearly mentioned in an inventory of 1533 as different items made by the ironsmiths for the *ingenio* of cleric Alonso de Peralta in Azua, possibly on the same river and nearby the mill of Alonso Hernández de las Varas. See 'Diligencias del oidor Lic. Vadillo, oidor, con Damian Peralta,' Archivo General de Indias, Sección Justicia, Legajo 12, No. 2, R.4, also cited by Del Río (1991: 374) but only in regards to the mill's accounting. The difference between these two components of the mill is clearly spelled out as well in the unique written description left by Galeotto Cei, where he refers to the 'spranghe di ferro' adhered to the larger upper roller and the 'foglia di ferro' placed on the smaller lower roller (Cey, *Viaggio*, 1992: 24-25). See complete quote of Cei's description on footnote 55 of this essay.

[37] The term *verdugo*, though it appears in the glossary published with Moreno's 1986 comments on the Nuestra Señora del Rosario's Cuban mill of 1603, does not appear cited neither in the glossary of his *El Ingenio* nor in the lexicon included by Leonardo Arroyo in his edition of Antonil's *Cultura e opulencia do Brasil* published by Editora da Universidade de São Paulo and Editora Itatiaia in 1982.

dealing with the larger amounts of cane that could be grown in Hispaniola' (69), the author used De Bry's image and distinguished only between *trapiches* (identified as an edge-runner) and *ingenios* (with overshot water wheels) from the point of view of the type of propelling force used (human or animal force versus water power, respectively) but without entering on the matter of the milling mechanism per se (67). That same year Dominican historian Roberto Cassá only briefly mentioned the mechanics of the sugar mills in sixteenth-century La Española, indicating that the type of mill used 'in many cases was vertical but in others, more often, was horizontal' (69), without providing any additional explanation.

During the 1990s, Spanish historian Justo del Río Moreno, in his various important studies on sixteenth century La Española, contributed what turned to be an evolving interpretation on the milling structures that were probably used in La Española's sugar estates during the century. In his major monograph of 1991, Del Río clearly sustained that the milling mechanism used in the island until 1570 was that of stone or wooden grinding 'wheels,' not rollers (1991:492), with two variants: 1) one that consisted in two thick horizontal wheels, laid one on top of the other and both around a common vertical axis, the lower one fixed onto the ground and the other one spinning horizontally on top of the lower one, grinding the canes that were thrown in between the adjacent horizontal faces of both; 2) another variant with one lower horizontal fixed round stone and another vertical round stone that ran on (and around the perimeter of) the upper face of the horizontal wheel, spinning on a horizontal axis that was attached to another, vertical, axis that rose from the center of the horizontal stone, describing in its run a circular movement around the vertical axis and in doing so grinding the pieces of cane laid on the upper face of the horizontal wheel (350). Both variants, according to the author, were

borrowings taken from the traditional wheat and olives milling industries, the first one more used at the *ingenios*, the second one more used in the *trapiches* (351).[38] As a consequence, in this 1991 work all the details of the textual description of both forms of mills seem to refer, respectively, to two types of mills: the traditional medieval olive mill or *almazara* with stone grinding wheels (*muelas* or *rulos*), on the one hand, and to the flour mill of horizontal, superimposed stone grinding wheels similarly of medieval tradition (Fig. 6), on the other.[39]

[38] In his 1991 monograph, Del Río wrote the following:

> 'The mills that we have studied in Santo Domingo, Puerto Rico and New Spain were propelled by vertical wheels of upper or lower propulsion that transmitted the energy to a receiving mechanism to convert it into motion. This was transferred to a stone wheel via a vertical gear that firmly engaged the latter through a piece inserted at its center. The upper wheel used to be wooden and toothed, its base spinning horizontally on another, lower one, fixed and made of stone. On the contrary, it seems that trapiches had only one vertical stone wheel that ground the cane with its edge, spinning around a vertical beam met by another axis of directly horizontal rotation to which animals or slaves were hooked' (Del Río 1991: 350).

In the next page Del Río added:

> 'The wheels employed in grinding the cane during the first half of the XVIth century in the Mediterranean, in the Atlantic islands and in the entire Caribbean were, simply, of stone the lower one and of rock or hard wood the upper one. It is very possible that the technology used in the *ingenio*, in what the milling system and the transmission of the hydraulic energy were concerned, copied the mechanism applied in the Spanish rivers for the obtaining of flours. The trapiche, on the contrary, dragged by animal power, would adopt the methodology of the oil and wine making industry' (351).

The use of the term 'wheel' in this descriptive context, in our judgment, appears ambiguous, since it was also (and maybe, *mainly*) used in the sugar manufacturing jargon of the times to refer to, or signify, the wooden wheels moved by a water current and employed as the main mechanism propelling the machinery of the mill, while the term *muela* seems to have been used more specifically –in the Iberian traditions of milling wheat and other cereals— for each of the two round grinding pieces. The using of the term alternatively by Del Río leaves us as readers with an imprecise visualization of his description, with which the enormous research effort of the author in this sense is rendered very limited in its results.

[39] Of the two illustrations used by Del Río in his 1991 monograph, one is taken from the manuscript *Los veintiún libros de los ingenious y de las máquinas*, attributed to Juanelo Turriano, and the other one from the work of Flemish engraver Theodore de Bry (Del Río 1991: 346 and 347).

Nevertheless, the two illustrations from the period provided by Del Río in his monograph (346 and 347) both seem to clearly represent one single type of mill (Fig. 1 and 2).

Also in 1991, at the international seminar on the history of sugar held in Motril, Granada, when commenting on one of the papers presented in the seminar, Del Río reiterated the theory on the use of two types of stone milling wheels in La Española, indicating that the cane roller mill seemed an invention made in Brazil in the late 1500s (*Producción y comercio de azúcar* 1993: 149).[40] The rollers or cylinders, therefore, the way Del Río understood them at the time of these studies, had not been used in La Española during the sixteenth century. Only the circular grinding stones had been used, and it was the *number* of grinding stones or muelas what in his opinion distinguished, in La Española and the Indies in general, the *ingenios* from the *trapiches*, the *trapiches* using one single 'wheel' and the *ingenios* using more than one. Del Río also referred at the time to the use of beams (*vigas*) or presses as complement of the stone mills and

[40] At the 1991 colloquium, Del Río stated: 'The roller mill at least so it seems that is clear among Americanists, appears already in the last third of the 16th century the first cases in Brazil. The mills, whether of animal or hydraulic power, use wheels, for instance one drawing that appears in my book on agriculture, of a *trapiche*, uses one only vertical wheel that grinds on its edge. A more complex topic is realizing how many wheels the *ingenio* has because what is clear is that it has more than one and that is the difference, at least for the case of the Americas between the *ingenio* and the *trapiche*. The *ingenio* uses more than one wheel, the problem is knowing whether that wheel is conical like an *almazara* and whether there are two wheels. That is what is difficult to determine' (*Producción y comercio de azúcar de caña* 1993: 149).

The comments –presumably verbal originally—by Justo del Río and other authors, like Lorenzo López Sebastián, present at the colloquium were all made in the verbal discussions that followed the presentation made by Margarita Birriel Salcedo that is commented upon further ahead in this essay. That is why we prefer to make the references in parentheses given in the body of the text of this essay referring to the title and the pages of the 1993 volume in which the transcription of these oral comments was printed, rather than to the title of the specific paper presented by Birriel Salcedo.

of the roller mills when these began to be used, since the latter were not capable of squeezing the canes thoroughly 'until it comes the time of the rollers covered with metals' (154).

At the same debate during the 1991 seminar in Motril historian Lorenzo López Sebastián, who co-authored with Del Río several studies on sugar production in the 16th century, indicated, as Barros de Castro had pointed out in his 1980 article, that the cylinder mill had been introduced with the purpose of avoiding the more ancient system of the medieval mill, in which it was necessary to chop the canes into small pieces before they were ground so that they could fit within the perimeter of the horizontal lower grinding stone of the edge runners and could be effectively ground by the mobile upper stone (*Producción y consumo de azúcar* 1993: 149, 150). Exactly as Maranhão in his studies of 1953-1955 and Barros de Castro in his of 1980 had done, López-Sebastián explained then how the cylinders or rollers allowed for an initial squeezing of the whole canes, which could be slid in between the roller whichever their length, and how therefore they avoided the labor and time of chopping prior to the milling that had been the practice used to make the milling of the sugar canes possible in the traditional mills of the olive and wheat milling agro-industries.

The 1991 Motril congress also included another discussion in which the matter of the milling equipment used in the sugar manufacture by the 16th century Spaniards was addressed briefly, and more concretely the issue of the degree to which the old type of mill of circular grinding stones or *muelas* might have been replaced or not by the rollers or cylinders mechanism. The comments arose specifically during the discussion on the paper by Margarita Birriel Salcedo on the Andalucian sugar industry during Modern Times. Once again the questions, guesses, and

theories discussed by the scholars participating in the seminar reveal the state of research at the time, which was still –in our view—of a limited knowledge on the subject. In any case, Birriel warned in an explicit manner about the scarcity of data found until then in her research, and in an equally explicit manner refused to advance conclusions with any degree of certainty or validity. Besides insisting that terminology in the 16th century Andalucian mills was always that of *ingenios*, regardless what type of energy was used and the milling mechanism applied, the author underscored as well the fact that several of the mills identified used the second squeezing mechanism represented by the *prensas de viga* or beam presses, the same used during centuries in the pressing of olives and grapes in the Mediterranean area (Birriel 1991:148, 154). It must be noticed, though, that despite the relative uncertainty of her conclusions, the work by Birriel made contributions, in the form of document excerpts cited, that in fact seem to be useful –as we will see further ahead in this study— for constructing an interpretation somewhat more definitive about some of the aspects dealt with by the important study of 1991.

In 1992 Dominican historian Genaro Rodríguez published his first comment on the milling technology used in La Española's sugar estates or plantations in the sixteenth century. 'Both the *ingenios* and the *trapiches* milled using two cylinders between which the canes passed through.' (Rodríguez Morel, 1992: 6) 'Later on,' the author tells us, 'mills of three vertical cylinders were used,' one of them being La Vera Cruz de Ocoa mill, property of Alonso Zuazo. No specific reference to document sources was provided in the study to substantiate this interpretation in relation to the use of the milling rollers, but a reference was indeed given to Fernando Ortiz 1962 article that we commented on earlier in this essay (Ortiz 1962: 6, note 11). It seems then fitting to interpret that in 1992 Rodriguez Morel was basically borrowing from

Ortiz, even when implicitly, the lexicological argument relative to the meaning of the word *eje* used in the archival sources pertaining to the 16th century *ingenios*, the kind of analysis originally posed, as we have seen, by Gil Methodio Maranhão in 1953-55 for the Brazilian case. Like that of Fernando Ortiz, therefore, Rodríguez Morel's interpretation would certainly benefit from a direct, explicit reference to the said lexicological evidence.

Five years later, in 1997, Justo Del Río and Lorenzo E. López Sebastián, in another, less lengthy study signed by both as coauthors, seem to have drastically modified their 1991 interpretation, defining this time around the sugar mills of both La Española and Puerto Rico in the 16th century as 'two long horizontal *ejes* and a system of a press with several metal boxes with a screw or *tórculum*,' similar to the type that are supposed to have prevailed in Cuba, and consisting of 'the short vertical *ejes* of the *trapiche* of animal traction' (Del Río and López 1997: 151). In other words, the authors tell us, 'the hydraulic scheme of two horizontal *ejes* is practically abandoned, the procedure of two vertical *ejes* being adopted, to which a third *eje* is added –called "bagacero"—in the late 16th century, this being one of the few technical advancements that are introduced in the new century.' In neither of these publications, though, the authors provide data nor precise sources with which we can back up their interpretations.

Also in 1997 an overview essay was published on the beginnings of the sugar manufacture in the Americas by Manuel Moreno Fraginals. The essay included direct comments on the production of sugar in 16th century La Española. In his essay Moreno Fraginals sustains that the existing archival sources on 16th century La Española, like sales contracts, inheritance documents, and judicial law-suit records, tend to indicate that the type of mill used in the

Americas then was the 'Arab *trapiche* inspired in the olive-oil fabrication techniques to which the press for the grapes' marc is added,' meaning apparently the traditional medieval type of mill with grinding stones ('a large circular stone that spinned, in the way of a draw wheel, on top of a surface also of stone, slightly inclined' and which 'went passing over the canes, chopped in small pieces, and placed for the purpose under its running area'). This type of mill a number had already considered by a number of historians to be in reality a technical borrowing taken by the Arabs in Late Medieval Times from the ancient Roman-Mediterranean agricultural tradition and subsequently applied to the Mediterranean Arab agriculture of the sugar-canes.[41]

Moreover, though the Cuban historian also considered (when examining the famous but rather imprecise comments by Bartolomé de Las Casas about the early cane-milling devises used in La Española) the possibility that either wooden presses or double roller mills may have been used in the cane-sugar manufacture (Moreno Fraginals 1997: 214), he seems to conclude that it was the ancient type of heavy stone-made mill the one that prevailed there, since he theorizes that --possibly due to its slowness, combined with 'the high costs of the shipment'— 'the sugar of the Americas at the beginnings of the conquest/colonization could not compete with the sugar from Europe and the Atlantic islands (Sao Tomé, the Canaries, the Azores).' This in turn would imply that, initially, the technology used on the Eastern side of the Atlantic would have been more productive than that used in La Española, though the author did not add any description of it in his essay. It would have also meant that the transition towards the use of the *horizontal*

[41] According to the historians who have dealt with the topic of medieval Spanish sugar production, the word *trapiche* in itself is likely to come from the word *trapig* (pronounced *trapich*) of the sugar jargon in the medieval Catalonian-Valencian language of Spain's *Levante* region, inherited in turn from the Arabs that established themselves in that area, were the introducers of the sugar cane cultivation in the Mediterranean and the Iberian Peninsula, and 9possibly took the term from the Latin-Roman *trapetum* that in more ancient times designated the mill with stone grinding wheels that the Arabs in turn adapted for the milling of sugar canes.

triple roller mill in Brazil during the second half of the sixteenth century, according to Moreno, was possibly 'a fundamental cause of the sudden Brazilian sugar predominance from the second half of the sixteenth century on' (215). Unfortunately no detailed source references were provided in his overview by the author, the validity of his assessment only to be assumed based on his authority status, and on the ample curiosity in travelling and searching for evidences of all sorts that is reflected in this essay itself.[42]

Finally, in the same essay of 1997 Moreno Fraginals laid out as well the alternate possibility that the *double vertical cylinder mill* could have been used for the first time on the island of Madeira. As to the possibility of a diversion of this technology to the Americas, and specifically to La Española, via the Canary Islands, Moreno did not volunteer any judgment, declaring himself scarcely familiar with the Canarian case (218).

There is as well another study, by historians Victoria Carmona and Antonio Acosta, published in 1999, that is worth mentioning for our purposes since, even when it does not deal directly with the history of sugar making, it does include information about a Peruvian sugar mill in the 1550s that gives us a sense of the larger context of the use of the roller mills and beam presses for early colonial sugar production in the Americas with details that may complement those the scholarship has uncovered about the beginnings of sugar making in La Española. In studying the local colonial treasury office that collected the imperial taxes in Perú during the 16th century, the authors came across a 1556 inventory of a sugar mill in which the presence of *exes* or rollers, *prensas* or presses, and *cajas* or compressing boxes is clearly mentioned as part of

the milling equipment. This data helps us in the construction of an overall chronology of the diffusion of the roller mill across the Spanish colonial empire during its first century, and in passing it helps us as well in placing in a more complete perspective its presence in La Española since several decades earlier.[43]

In the year 2000 two opinions appeared on the theme of early modern sugar from the pen of Spanish medievalist Adela Fábregas. In one of them, the author adheres to the thesis that the roller mill probably appeared in the Americas at some time after the decade of the 1570s (2000a: 65). In the other piece, apparently following authors like González Tascón, Galloway, and Moreno Fraginals, Fábregas presents the notion that the roller mill appeared first in the Americas around 1577 in Brazil and around 1610 in Perú (2000b: 54 and 282). In respect to the rollers used in the Americas, the interpretations by these authors, as we have posed before in this study, suffer from some limitations in their explanatory power.[44] As to the use of the rollers in

[43] The sugar estate, which may have been functioning already in 1546, seems to have been located in the Collao Valley, 'jurisdiction of la Nazca (subsequently district of Ica)' (Carmona and Acosta 1999: 48). Amongst the parts of the machinery of this Peruvian sugar mill, the inventory mentions the following: 'A submerged horizontal water wheel and a shaft and a large wheel and another small one, and two rollers; all of it [made] of *guarango* and fastened with iron sheaths and armors with which the mill is milling and running, without lacking anything. # Two wooden presses with their boxes fastened with iron as they should be, with four boxes'. In the 'ironsmith house' specifically there were the following components: 'Two large axes of iron for the rollers. Four teeth of the small wheel of the mill.' […] 'Three iron (…?) for boxes in which they squeeze the bagasse' (Carmona and Acosta 1999: 58). Furthermore, in the 'house of the carts' there were 'One roller of the mill with its iron axes which is being finished' and 'another pole for an exe' (59).

[44] Nonetheless, in her 2000 book , Fábregas does contribute some considerations on the, let us say, socio-technological context of the Andalucian cane-sugar manufacture at the beginning of the Modern Times which are useful for a more comprehensive understanding of the roller mill in the region during this period. More concretely, Fábregas stated that 'at least in Southern Spain, the technical changes as to the speed and efficiency of the squeezing of the canes did not have as much importance in this phase as some authors had believed.' Other economic factors, in turn, would have had more importance in this regard. The most noticeable change did not occur,

the sugar industry in Peninsular Spain, Fábregas did not find evidence on the matter until 1679 at the famous sugar-making town of Motril, on the coast of Granada, and even then the mill appeared combined with the use of presses (2000b: 55) area.

In another study published also in 2000 historian Genaro Rodríguez Morel again commented on the issue of the cane milling technology of sixteenth-century La Española, and reiterated that the cane-crushing element used in general in the sugar estates of the island-colony in the period were the rollers. Yet, because of the way the author listed the milling parts ('los rodillos, ejes, prensas, etc.') he seems to identify the *ejes* as an element of the mill's machinery different than the rollers or cylinders themselves, maybe as the modern type of axes, that is, as bars around which other pieces turn around, or something else (2000: 134).[45] The predominant use of the rollers in the beginning of sugar production in the colony in the 1510s was underscored by Rodríguez Morel in the following page, indicating that 'around that time the *ingenios* that were being constructed all milled using this type of gear, that is, that of the cylinders' (135). But again no evidence seems to be provided to sustain the claim, except for a reference to Fernando Ortiz's article, already commented upon here, on the early mechanisms of milling used in La Española (134).

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according to Fábregas, but until 'the middle of the 16th century, when important innovations coming from the new productive areas in the Americas are introduced' (Fábregas 2000b: 51). The Spanish medievalist went on to argue that, at least during this period the technology changed little and that only variations took place in the type of energy used (animal, hydraulic, or a combination of both) that may be worth mentioning (49). The author insisted on the coexistence that occurred between the roller mills and the more traditional type of technology (Fábregas 2000b: 282).

[45] Yet, this apparently ambiguous naming of the parts of the milling machine was later modified on the 2004 chapter by Rodríguez Morel on La Española's sixteenth century sugar published in English that year (Schwartz 2004:93).

Rodríguez Morel also offered, in the same 2000 study, a theory proposing that the invention itself of the roller-mill had taken place in La Española when cane-sugar production was launched there in the early sixteenth-century. A similar theory had been considered by the Daniels in their 1988 article, except that they still considered it a possibility insufficiently proven (Daniels and Daniels 1988: 516-517). Rodríguez Morel, noticing the use of the word 'invention' in some of the sources in the late 1510s when they refer to the milling device constructed by physician and sugar entrepreneur Gonzalo de Vellosa at the time in La Española (of which one source at the time said that it had been quickly replicated throughout the whole colony), concludes --along the same line as Fernando Ortiz (1961: 14; 1962: 47-49, and especially 51-52)-- that Vellosa was the individual inventor of the sugar roller mill, and that the invention took place in La Española (Rodríguez Morel 2000: 135).[46]

As a negative argument, Rodríguez Morel presents the fact that 'up to now we have not found any document making reference to the use of stone rollers for milling canes'(135, note 7),

[46] The entire quote of Rodríguez Morel is the following:

> 'This invention must have been rather innovative since, according to the inhabitants of Santo Domingo, it spread around with great velocity throughout the island's geography. Which leads us to think that it was an ingenio of cylinders is the fact that around that time the ingenious that were being constructed all milled using this type of gear, that is, that of the cylinders. In reality, as much the ingenio as the trapiche departed from a same mechanic logic' (Rodríguez Morel 2000: 135).

These concepts were repeated by the author in 2004 in a publication in English:

> 'This invention must have been a great innovation, since according to the residents of Santo Domingo it spread so rapidly across the island. I believe this to be the *ingenio* of vertical cylinders, for after that date all the mills constructed made use of his system' (Schwartz 2004: 98).

but the claim in itself appears weakened when we consider that the same could be argued about the lack of explicit mentioning of *rodillos* or rollers anywhere in the sources available so far, unless we want to apply the lexicological argument that Gil Methodio Maranhão began to use in the mid 1950s, adopted later by Fernando Ortiz, and later still by Barros and the Daniels--that the Spanish word *exe* or *eje*, as its Portuguese equivalent *eixo* and when used to describe the sugar mills in the sixteenth century, meant wooden rollers or cylinders.[47] Yet, like in the case of Justo Del Río, this lexical issue is never addressed in Rodríguez's interpretation (135, note 57), which in turn makes it difficult to understand the basis of the author's theory that roller mills were indeed used at the time in La Española.

[47] There is a minor and isolated documentary evidence, though, apparently not referred to by scholars of the early colonial Dominican cane-sugar manufacturing so far, of the use in Hispaniola –at least during the late 1530s-- of what seems to have been a Medieval type of stone-wheels mill for its distinct traditional Old World function of crunching or milling grains. In a royal decree of July 2, 1540, apparently issued in response to at least one request of March 17, 1537 by Hispaniola's sugar-estate owner Hernando Gorjón for some tax exemptions over his properties in exchange for a proposed donation of some of them to the local church, it is indicated that Gorjón's sugar estate *Santiago de La Paz* in Azua included 'a mill for milling corn' ('vn molino de moler maiz') that could not have been other than one of the two types of stone wheel mills traditionally used for grinding wheat grains into flour: either an edge-runner or a horizontal double stone-wheel mill, since we know that practically no other type of mills were used in the Iberian and Western worlds during modern times for grains until they were mechanized and made completely metallic.

The 1537 request of exemption submitted to the Crown by Gorjón understandably includes a description of his sugar estate, and it does mention the grain mill as well, though in the edition we are using here, the only one published so far, the mentioning of the mill ('vn molino') besides the *yngenio* or cane-sugar mill itself, appears followed by ['…'] and we cannot tell whether this represents an interruption on the original text or a voluntary ellipsis by the author of the transcription that may have left out some other detail about the mill potentially mentioned on the original (Marino Incháustegui, 1958: I, 229 and 226, respectively). For images of the edge-runner type of mills, see Figures 1-5. For an image of the double horizontal milling wheels mill, see Figures 7 and 8.

In his 2000 piece Rodríguez Morel reported as well to have also found references, in some of the sources from early colonial La Española, to improvements reportedly made in the colony in certain other aspects of the milling technology. One was attributed, as Fernando Ortiz had already done in 1962 (Ortiz: 58) to early sugar producer Gonzalo de Vellosa, 'who after having constructed the machinery for the *trapiche* modified the part that propelled the mechanical gear of the mill with a larger and more potent one.' Another one was supposedly achieved by sugar estate owner Hernando Gorjón, consisting in the application of the water current used to move the water wheels or propellers of the *ingenios* to the lower edge of the wheels rather than the top edge, which in turn would have lowered the production costs because it avoided the need to elevate the stream of water by means of a channeling that was very costly. Finally, another advance was, according to the author, a not completely specified innovation in the technology of boiling the cane juice or *guarapo* that reportedly allowed for the saving of half of the traditional quantity of wooden fuel required up to then to heat the cauldrons in the boiling house, though in this regard the author was inclined to conclude and warn 'that not all producers were able to adapt their mills to the new technologies, this being a fact that prevented a larger development of said economy' (Rodríguez Morel 2000: 135-136, 2004: 98-99).

On the other hand, the notion of an introduction of the roller mill in cane-sugar making in the Americas rather late in the sixteenth century, and the concomitant view of the prevalence of earlier milling technologies like the edge-runner during most of the that century, seems to have persisted in important pieces of the most recent scholarship. In a 2000 insightful and stimulating essay on the transfer of cane-sugar production from the Old World to the New World by medievalist Adela Fábregas, the arrival of the roller mill in the Americas was still being dated

in 1577. Fábregas apparently followed Moreno-Fraginals and Galloway, and maybe the Daniels as well, but did not provide any additional substantiation on the matter (Fábregas, 2000: 65). In 2006, Aurora Gómez-Galvarriato, in her chapter on *The Cambridge Economic History of Latin America*, still relied on De Bry's engraving as evidence on the supposed use of edge-runners in Hispaniola's sixteenth century sugar estates, just distinguishing between *trapiches* moved by animal force and 'other, larger mills (*ingenios*) moved by water wheels' adding that the mills 'were supplemented with presses in order to extract the juice that the mill left in the cane' (Bulmer-Thomas 2006: I, 361-362).[48]

Also in 2006 a path-breaking Ph.D. dissertation was presented by archaeologist Robyn Woodward about the site of the *Sevilla la Nueva* sugar mill, an early Spanish cane-sugar estate in Jamaica in the 1520s (Woodward 2006: 57).[49] Following apparently Deer and Galloway, Woodward reproduces De Bry's image, and adheres to the notion that edge-runners (which the author identifies with the type of mill called *trapiches* in the Spanish world) were used in the Caribbean (21-22, 215) and the Americas (27) in the sixteenth century, until the 'vertical roller

[48] Gómez-Galvarriato's depiction of Hispaniola's sixteenth century cane mills is somewhat understandable once we see the bibliography used for the author's chapter section on colonial sugar in Latin America (Bulmer-Thomas, 2006: I, 557-559), which misses many of the more monographic publications of recent decades on the topic, and more importantly the author's reliance on Theodore De Bry's famous 1595 engraving (361), so pervasive in the bibliography on early modern sugar, depicting a purported sugar estate in Hispaniola. Yet among the scholarly sources cited both in the expository part of Gómez-Galvarriato's text (359) as well as in its corresponding bibliographical essay (558), two works by Sidney Mintz and Stuart Schwartz, respectively, are cited where explicit reference had been made to the use of roller mills in Hispaniola and explicit questioning posed about the content veracity of De Bry's image (Mintz, 1985; Schwartz, 1985).

[49] Woodward mentions the building of two sugar mills by owner Francisco de Garay in Jamaica the 1520s, but the only reference date given is 1523, when the *Sevilla la Nueva* one –we infer-- was already producing, and the second one was still under construction (Woodward 2006: 88).

mill' appeared in Brazil 'in the early seventeenth century' (28).[50] A graphic reconstruction of the possible structure of the milling equipment of the site by the author actually proposes a medieval flour-mill type of mechanism with horizontal stone-made grinding wheels propelled by what the author describes as 'a sophisticated structure for its time' that indeed greatly departs from anything known in the Iberian sugar world at the time (216).[51] The fact that the proposed system differs so much from anything known immediately before or afterwards in the sugar-making world, where tried productive innovations tended to disseminate sooner or later, plus the absence of any documentary evidence showing the presence of any of these elements in the mill at the time, leads us to look at Woodward's interpretation as one still far from been proven.

Still in 2010 the notion of the prevalence of the edge runner in cane-sugar making in the Americas before the vertical triple roller was adopted makes its way into specialized publications. In *Sweet Cane: The Architecture of the Sugar Works of East Florida*, for instance, historian Lucy B. Wayne, following Galloway, sustains that, before the seventeenth century, 'sugar was milled using systems adapted from processing flour, olive oil, and grapes,' subsequently describing more specifically an edge-runner without naming it: 'An upright wheel with a horizontal drive shaft turned in a depression into which the cane was placed' (Wayne

[50] No reference is made by Woodward, in her comments on the cane-milling mechanisms, to either Methodio Maranhão, Soares Pereira, Barros de Castro, nor the Daniels. In the bibliography section of her dissertation, though, both Mintz and Schwartz are cited.

[51] The presence at the *Sevilla la Nueva* archaeological site of what seems to be two parallel water wheel pits (111,119) aligned in the same direction with the remains of three brick arches (114) located above the pits within the site's structures, has led the Woodward to propose the use at this Spanish mill of a double water wheel propelling system where the common horizontal axis of the wheels rested on top of the apex of the stone arches and, by means of a gear and axles system engaging the end of the axis to the horizontal stone grinding wheel of the mill, located further above, moved the mill (216).

2010: 21-22).

Finally in the spring of 2012, Genaro Rodríguez Morel's very informative monograph *Orígenes de la economía de plantación de La Española* appeared, including a section on the technological evolution of the mills (283-289) of Hispaniola's sixteenth-century *ingenios* and *trapiches*. Yet, though the author mentions the 'cilindros' (cylinders) and the 'sistema de rodillos' (rollers system) as the 'tipo de engranajes' (type of gears) that was either universally or generally used to mill the canes in La Española at the time (285), the fact that they are also referred to as a single 'sistema de engranaje' or 'gear system' composed by 'rodillos, ruedas, ejes, prensas, etc…' ('rollers, wheels, axes, presses, etc…') (284) and as 'el sistema de ejes y cilindros' ('the axes and cylinders system') (285) still seem to indicate an ambiguity as to a perceived difference between the terms 'ejes' or 'axes' and 'rodillos' or cylinders. Since no description or discussion is provided about the milling mechanism's individual components, this impression is maintained when, in another section on the internal structure of the *molienda* or milling mechanism (309-312), no explicit mentioning is done whatsoever of the *rodillos* (rollers) or *cilindros* (cylinders) and only 'la rueda, la prensa y los ejes' ('the wheel, the press, and the axes') are cited by the author (309), followed by paraphrases of the listings of the parts of the mills as they appear mentioned in sixteenth-century inventories, where only the term 'exes' (axes) is used to refer to the squeezing parts of the mill (310-312). Thus, given that, as we have seen, the interpretation of the sugar-milling terminology of the sixteenth-century and its meanings as used in the documents of the time is of the essence in constructing our current understanding of how the milling machinery of these sugar estates or plantations was assembled

and how it functioned, it seems fair to say that the monograph still does not clarify enough this specific matter.

As to the cane milling mechanisms used in the Canary Islands' sugar industry during those same early decades of the sixteenth-century, there seemed to be still by 2008 a similar type of scholarly confusion in the Canarian historical scholarship, with the persistence (and maybe the prevalence) of publications that assert the use of the more traditional, old medieval types of stone-made mills in the sugar estates there. An otherwise great overview was published that year on the beginnings of sugar manufacturing in the Islands.[52] Through the hand of some of the most important specialists on the matter, the book updates our knowledge with the latest research on a number of aspects of the industry. Yet when it comes to the milling technology, we still find in the book a view that postpones the incorporation of the roller mills into the islands' sugar manufacturing to the beginning of the ensuing century, after in happens in Brazil.[53] The case in fact may be a good indicator of the need to redouble the scholarly efforts to disseminate the new information that we are precisely trying to highlight in this essay.

[52] Ana Viña Brito, Mariano Gambín-García y Carmen Dolores Chinea Brito, coords., *Azúcar: Los ingenios en la colonización canaria (1487-1525).* Tenerife: Organismo Autónomo de Museos y Centros and Excmo. Cabildo Insular de Tenerife, 2008.

[53] Ibid, 149-150.

New evidence and interpretation about the use of the horizontal double roller mill in Hispaniola (and, before then, in the Canary Islands)

As we have seen, the existing historical scholarship on the sugar farms, estates, or plantations of the colony of La Española in the 16th century believes to have found the use in them of both the old mills with stone wheels (*molinos de muelas o rulos*) in some cases, as well as the more innovative or modern roller mills in others. Yet, whatever the perspective held on the topic, it seems reasonable to state that until now the interpretations have been based on what we might define as indirect or partial evidence, possibly resulting from the scant details mentioned on the sources themselves available until very recently[54] and, maybe even more frequently, by the scarce application of demonstration and explanation included in many of the existing interpretations.

In spite of the above, we would like to propose hereafter that a comprehensive and meticulous review of the evidence and the interpretations put forth by historians that, let's say, since the mid twentieth century have studied the history of the cane sugar industry of the Western Hemisphere (and of both shores of the Atlantic, in particular), combined with new archival data gleaned by this author in an ongoing study on some cane mills or farms of La Española in the 16th century, already allow –in our view— for a consolidated theory on the use of the horizontal double roller mills in those estates from the beginning, precisely in La

[54] Even the few inventories of original *ingenios* or sugar farms from the 16th century that have survived, a type of document descriptive by definition, do not provide as many details as historians would like when it comes to the milling or smashing equipment of the mills at the time. A consequence of this is the need for an extremely meticulous reading of the contents of these sources to maximize the utilization of their potential informational value.

Española, of the development of this manufacture or industry in the Americas. And not only that. We believe this review could allow for an extension --totally unforeseen at the beginning of that research--of a number of the considerations applied here to La Española (as to the use of the roller or cylinders mills) to the Canarian sugar manufacture of the 16th century as well, which predates that of La Española in around a quarter of a century and whose scholarship has barely analyzed the issue of the sugar milling technologies.

As it has been indicated before in this essay, one of the main bases for clarifying this technical aspect of the colonial sugar has been laid by the Brazilian historians that already in the 1950s identified lexical elements in the sugar manufacturing jargon in the colonial archival sources that, curiously, had survived in the centuries-long Brazilian sugar tradition at least until the 18th century, and whose semantics had been furthermore described by colonial chroniclers. The most important of these elements is the Portuguese word 'eixos,' which was used in the Luso-phone world –apparently from the beginnings of the last quarter of the 15th century in the Madeira islands at least—to designate the 'new' wooden rollers or cylinders, parallel and adjacent, used to squeeze the canes and which began to substitute for the ancient and heavy milling stones or *muelas* traditionally used in the medieval milling industries.

When we take into account this meaning of the Portuguese term and we find its equivalent in Spanish –the word 'exes'— already being used in the first decade of the 16th century in no other than the sugar-cane industry of the Canary Islands –which, according to the current scholarly consensus, was founded and developed by immigrant Portuguese technicians from precisely the Madeira Islands-- it seems fairly clear that we are in front of solid and certain

archival indications that the wooden roller mill for squeezing canes was not only used in the Island of Madeira at the end of the 15th century but that it was used as well in the Canary Islands already in 1506 and, possibly, from the very start of the transferring of this commercial manufacture into the Canarian archipelago before the beginnings of the 16th century. The archival documents dusted by pioneering researchers like María Fabrellas and Guillermo Camacho in the decades of the 1950s and 1960s, and, much more recently, by historian Mariano Gambín García in 2008, seem to leave no space for doubts on the matter, and it is reasonable to suppose that any additional archival documentation of similar content that may still be found in Canarian or Madeiran archives is likely to yield the same type of information on data that were already part of the ordinary life of the cane-sugar world at the time. The same could be argued – we would like to propose here-- as to all the other lexical elements of the cane sugar manufacturing jargon used to name the multiple parts of the milling mechanisms and the related tools that appear reflected on the documents.

The 1952 piece by María Fabrellas in particular has special importance because of the documentary details it provides on the issue of the milling in the Canaries at the beginning of the 16th century, even when the author herself at the time maybe was not aware of this. Fabrellas did not allocate any space in her work to discussing the smashing mechanisms used in the *ingenios* of Tenerife, simply commenting that in most cases these were machines propelled by water (Fabrellas 1952: 466). This silence by the author is the reason why her work is not mentioned in the review of the scholarship about the sugar milling that appears in the first part of this study. Yet in the source references included by the author in her study indeed there is evidence that already in 1506 there was in Tenerife at least one mill, in the place named Tanganana or

Taganana, where the 'axes' or cylinders were used. The same 'axes' that in that same year of publication, Brazilian historians led by Gil Methodio Maranhão, in a totally unrelated research effort, had identified as the fundamental technological component of the colonial sugar mills of the Americas.

On the other hand, the evidence, in the same notarial document of 1506, of the combined use of several of the other parts of the squeezing and milling equipment that, like the *prensas* or presses in that same *ingenio* in Tenerife, would end up constituting a sort of emblematic technical system of the Atlantic sugar manufacture of the 16th century together with the sugar-making rollers, could be an indication –if we assume that such assembly took some time to consolidate-- that the roller mill was possibly already in use in Tenerife at least quite before 1506. Similarly, the fact that the presence of a Portuguese carpenter, in charge literally of the entire construction of the said mill, is mentioned in the same source seems to substantiate the already admitted notion that the Canarian sugar industry was to a great extent a techno-economic transplant made from the island of Madeira. It also sustains the view that part of said transplant during a prior period may have included from the start the *molino de 'exes'* or roller mill as a central part.[55] In fact, in 2008 Canarian historian Mariano Gambín García has published an

[55] The following passages or excerpts of archival documents taken from the publication by María Luisa Fabrellas of 1952, both taken from documents held at the time at the Archivo de Protocolos Notariales de Tenerife (APNT), seem to speak by themselves on how and who constructed the first Canarian sugar mills. 'APNT, S. Páez, fol. 599, of September 12th, 1506. Gonzalo Yanes and Francisco Bernal, ironsmiths, residents, oblige themselves to make for Diego Sardina tools and ironware needed for the mill that he is building in Taganana, that is to say: all the tools and folded pieces convenient for the axles of the said mill and for the press, two screws and their irons 'de *macete*' and nails for the wooden boards and for the '*picadero*,' and all the nails that may be needed; the wheel and 150 nails for the water feeding duct, of the mark given to them according to what the master were to order; four fasteners for the axles and another four for the press' boxes, with their hammer; five rods, one '*hurgonero*,' one roller, planks for the mouths of the burners, a bar, one '*almadava*,' etc. D. Sardina provides the iron and steel and

informative and comprehensive monograph in two volumes on one of the oldest sugar estates of the Canary Islands on record, the *ingenio* of Agaete, showing clearly that already in 1503-1504 this mill was equipped with rollers ('los exes'), as well as iron covers ('chapas de hierro'), iron fasteners ('cinchos'), and wooden toothed gears ('las dentaduras de los exes') to protect and get the rollers moving, respectively. It also had wooden boxes ('caxas') almost certainly for the presses (Gambín García, II: 16 and 18).[56]

It must be said that, in what probably constitutes another instance of the difficulties of dissemination of historical research on these very specialized issues, by 2003 at least two researchers of the Canary Islands, local historians Rafael Sánchez Valerón and Felipe Enrique Martín Santiago, in a historical study about the town of *Ingenio* of the island of *Gran Canaria* in the sixteenth-century,[57] theorized in very similar terms to those expressed above in relation to the

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will pay for this job 11.000 *maravedis*.' (Fabrellas 1952: 470, note 27). 'APNT, S. Páez, fol. 111, of 17 of September of 1506. Luis Afonso, carpenter, Portuguese, resident in Tenerife, commits himself to build for Diego Sardina, a [citizen/denizen] of said island, a mill in Taganana, in what is to be done in carpentry, which is: the wheel, axle, press, cureños and other things, as well as the channels for the *ingenio.* D. Sardina has to provide the timber and L. Afonso commits to give it finished in three months from the date and will receive for all of it 31.000 *maravedis*. He also requests to be given men to help him in the job' (Fabrellas 1952: 470, note 26). In fact these descriptions of a mill in Taganana happen to be more detailed than most of those published until now or that we may have found from La Española and other Spanish colonies of the Americas.

[56] More specifically, the data found by Gambín García appear in an 'Account of the expenses that have been made in the mill and farm of Agahete' ('Relaçion de los gastos que se han fecho en el yngenio y fasienda del Agahete') which covers what seems to be a production cycle or 'zafra' going from June of 1503 to February of 1504. Gambín García's book appeared roughly two years and a half after the original Spanish version of this essay was written and submitted to the conference 'O Açúcar Antes e Depois de Colombo' held in the summer of 2006 in Santo Domingo, Dominican Republic. It actually appeared before the papers of this conference were finally published in a compact disk format in 2009. Still, we have considered it useful to include a reference to Gambín García's monograph here to update the reader as much as possible on the available knowledge on the matter.

[57] Rafael Sánchez Valerón and Felipe Enrique Martín Santiago, *Génesis y desarrollo de Ingenio*

early presence of the horizontal double roller mill in the first Canarian sugar plantations. Furthermore they posited the possibility that a triple roller mill, either horizontal or vertical (potentially pre-dating the Brazilian vertical rollers by almost a century), may have been used as well (Sánchez Valerón and Martín Santiago, 2003: 88-89). [58] Though the documents they used to substantiate the point pertain to a slightly later moment (the years 1517 and 1536), respectively) than the earliest ones we have already referred to in this essay, it seems clear that the authors –who as per their own indication did comparative field work that involved sites in the Madeira Islands and the Mediterranean coast of the former Kingdom of Granada in Peninsular Spain, besides *Gran Canaria* itself— posited a view of the mills that incorporated implicitly –like Fernando Ortiz four decades before, but this time without citing at all the Brazilian historians of the early 1950s-- the lexicological notion that identifies the words '*exe*' and '*exes*,' as they appear in the documents, with those of '*masas*,' '*mazos*' or rollers.[59] They also

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durante el siglo XVI, Ingenio: Ilustre Ayuntamiento de la Villa de Ingenio, 2003. In the book, after quoting the historical documents, the authors note that 'In it only two axes are pointed out, that is to say, we could be facing a mill propelled by a hydraulic wheel that has a larger axis hooked to it and, through a mechanism of a toothed gear, the latter moves a smaller axis; it would be a mill with two horizontal rollers or *mazos*' (88). They also posed that 'The existence of three axes in the document of the year 1517 allows us to affirm that the triple roller hydraulic mill, introduced by the Portuguese, was applied in the Canaries before than in Brazil. The doubt, we insist, is the horizontal or vertical placement of the cylinders' (89).

[58] The book, distributed as per all indications in a digital format only and sponsored by the local city council of the town of *Ingenio* itself, is a very interesting attempt at re-constructing not only the town's sixteenth-century history, but more specifically the history of local cane-sugar manufacturing, with an effort in identifying the remains of the town's sugar mills of the time, including their water channeling system, all with an eye on their potential as cultural tourism patrimony.

[59] Whatever the source of the authors' notion, they do not cite or describe it explicitly. Considering that they do not mention Brazilian historians Gil Methodio Maranhão nor Antonio Barros de Castro, the disseminators of the *eixo*-roller lexical equivalency in Brazilian scholarship, but that they do mention an interview with historian Alberto Vieira conducted as part of their fieldwork (Sánchez Valerón and Martín Santiago, 2003: 85) it may be legitimate to speculate that the Canarian authors may have learnt about this lexical history item through the

understood the presence of the cane roller mill in the Canaries as introduced by the Portuguese cane-mill builders from the Madeira islands. Yet, maybe because of the local context in which the authors worked, apparently external to academic institutions, their interpretation of the cane milling mechanism does not seem to have achieved a large audience either in the Canarian historical scholarship or anywhere else.

Taking into account the above considerations, finding as in fact we do find --in the sources related to the sugar plantations of La Española of the second and third quarters of the sixteenth century-- the presence of the terms '*exe*' and '*exes*,' and others pertaining to the relatively recent, late-medieval cane milling machinery apparently adapted in Portugal or in the Portuguese islands,[60] and made mostly of wood and iron, we consider this to be a pretty solid evidence that indeed the roller mills were used in La Española since very early in its colonial period to squeeze the sugar canes in the *ingenios*. This analysis, then, allows us to reconstruct, for the first time in so far as we know, a firm basis for the theory that in this same regard was partially advanced by Fernando Ortiz in 1961-62, and, after Ortiz, by Genaro Rodríguez Morel and Justo del Río Moreno and Lorenzo López Sebastián in 1997.[61]

Madeiran scholar, who –following Gouveia-- has consistently and rather singlehandedly highlighted in his work (Vieira, 2000: 18) the application of the '*eixo*' denomination to the cane-milling rollers of the Madeiran *engenhos* in late-medieval Portuguese sources.

[60] Again, the terms *eje*(s) and many others in the early-early modern cane-sugar making jargon, according to every indication, were adopted from the Portuguese language as linguistic borrowings (or translated in some way) into the Spanish language of the time. As it has been said before, we know they come from the Portuguese sugar linguistic tradition and from the Portuguese socio-cultural milieu associated with it since the late 15th century, the same that seems to have generated innovations such as the roller mill, or at least to have begun using them at a time when no other socio-cultural setting has left any similar traces of having done so that we know of.

[61] It seems reasonable to imagine that, if Fernando Ortiz had had the occasion, for instance, to

Exactly how early did the *ejes* or cylinders or rollers began to be used in La Española's *ingenios* should be the matter of more research to be done in the future, but we already have indications –as we will see heretofore—that it may have been either from the very beginnings of the industry or from very few years afterwards, in any case before 1520. From the start it is convenient to remember that there seems to be total consensus in the scholarship about the topic that it was in La Española where sugar canes were first milled in general in the Americas, and where it was for the first time possible to mill it profitably from the entrepreneurial point of view. And this in turn is attributed to another primacy also accepted in the scholarship: that the first exportable sugars to go out from the Americas could be produced precisely when the first sugar technicians considered professionals in La Española were hired and brought over *from the Canary Islands*. Considering what has been already explained in respect to the use of the roller sugar mills in the Canaries at least already during the first decade of the 16th century, it does not seem unrealistic to theorize that the technicians brought from the Canaries to La Española by the renown entrepreneur Gonzalo de Vellosa possibly had known not only the procedures to build this type of mills but that they had also applied them from the very first moment on the first sugar mill they built in La Española.[62]

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read Fabrella's 1952 article while he prepared his 1961-62 pieces on the beginnings of the Spanish-American sugar production at La Española, it is rather probable that Ortiz –apparently already armed with the argument about the word 'exes' taken (and translated, if we may say so) from the interpretation done by Gil Methodio Maranhão about the Portuguese word 'eixos'— not only would have strengthened with the data provided by Fabrellas his theory about the use of the roller mill in La Española as a pioneering case of the Americas, but perhaps would have theorized proposing the beginnings of the use of the double roller mill in the sugar industry as a process taking place in the Canary Islands, rather than in La Española.

[62] For the time being our preferred theory would be that the main problem that the first settlers of La Española would have faced for the construction of sugar mills was possibly the fact that there were simply no carpenters in the colony, in the 1510s, who were sufficiently

More concretely, historian Genaro Rodríguez Morel has recently provided data, in a 2004 publication, that seems to leave no doubts about the use of the roller mill in La Española already on a date as early as the year 1519, just three or four years after the date traditionally given in the chronicles as that of the construction of the first mill by Gonzalo de Vellosa. Indeed, according to Rodríguez Morel, on a contract signed in November of 1519 between settlers Pedro Vázquez, *alcalde ordinario* of the City of Santo Domingo, and Diego Morales, City Council member of the city of Santiago, both acknowledge to have built an *ingenio* whose equipment included, besides the typical hydraulic power wheel, presses, and copper pieces, the paradigmatic *ejes* or

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knowledgeable of the construction of sugar cane mills, maybe because this type of artisans did not feel attracted to traveling to the new colony on the other side of the Ocean in its beginnings, when it was probably better known for its mining activities than for its capacity for reproducing an agriculture or an agro-industry of Iberian type in which they would have found great opportunity for enrichment. As a matter of fact there is evidence that the first attempts to produce locally in La Española some harvests of the main products of the Southern Spain's diet that the settlers were originally accustomed to (wheat, olives, grapes) were not successful in the colony due to the acute differences of the subtropical climate of the territory. The first historical scholarly contribution to this topic, as it is well known, is the doctoral dissertation by Justo del Río Moreno of 1991.

Different from what has been understood by other authors interested in clarifying this detail, like Ramiro Matos González, it seems to us that nothing in the statements by Bartolomé de Las Casas conclusively indicates or alludes to the use of the Taíno tool that Fernando Ortiz identified by the first Spanish settlers who were the protagonists of the first attempts at cane-sugar making (Matos González, 1995: 165-167). We certainly cannot deny the possibility that this technical adaptation or borrowing by the European may have happened as a fact, simply because we do not have a believable proof on the contrary, but we prefer to suppose that in any case both tools may have been possibly used by the European settlers according to the circumstances and to their own perceptions of need or convenience. In light of the experience of massive indigenous labor oppression that took place during the initial 'mining cycle' of the colony, we may perfectly imagine thousands of Taínos forced to work by the Europeans in the task of smashing sugar canes with the *cunyaya* as the tool with which, because they knew it, the Taínos may have shown to be more effective in milling operation, but we are far –at the actual stage of research—from have trustworthy evidence in this regard.

rollers or milling cylinders (Rodríguez Morel 2004: 93).[63] The author did not make any comment about the milling mechanisms in said publication, for whatever reason, but considering the entire discussion presented in this study, it is a piece of data whose importance is simply fundamental and which deserves to be highlighted. Lacking a textual citation of the expressions used in the documents referred to by Rodríguez Morel, everything indicates –we would dare to argue—that it happens to be an evidence that definitely places in the colony of La Española the commencements of the use of the rollers cane-sugar mill at least on 1519, which implies and undisputed historical primacy of La Española in this regard vis a vis the entire colonial world of the Americas, some fifteen years before the most early date given at one given time, for instance, for the case of Mexico, by historian Horacio Crespo.

Historian Justo del Río Moreno in fact had published a piece of data, in his renown monograph of 1991, which provided evidence of the presence of cylinders already in 1523 in another of La Española's *ingenios*, the *Sanctiespiritus*, where the author found the mentioning of

[63] The piece by Rodríguez Morel, published in English in the multi-authored volume edited by Stuart B. Schwartz, is the only we know by the Dominican historian in which this important historical data is provided. Referring to the partners Vázquez and Morales and to the *ingenio* that on 22 of November of 1519 they declare to have built: 'They stated that their costs, including the purchase of the mill wheel, axles, presses, copper, and furnaces, did not exceed 800 *castellanos* and that included in this price was the purchase of 5,000 molds for preparing sugar as well as the construction of a thatch-roof purging shed.' (Rodríguez Morel 2004: 93, and 111, note 38.) No specific citation of archival sources on this matter was included in the text. As it is well known, the term *axle* refers in English to a mechanical axis, and everything indicates that in this case it is a translation of the Spanish term *eje* that Rodríguez Morel must have found in the documents cited by him as his source and which cannot be, in this context of sugar-making papers of the 16th century, other than the one used to identify the rollers or milling cylinders. No indication is given in Rodríguez Morel's essay of the exact location of the mill, but it could be the area near the village of Puerto Plata where, as Rodríguez Morel says in another of his publications, Pedro Vázquez had committed at some point (possibly shortly before November of 1519) to build an *ingenio* in exchange for a number of Indians that he received through a *repartimiento* (Rodríguez Morel 2000: 121 and 121, note 13).

'axles, boxes, rods, wheel' (Del Río 1991: 363).[64] As to our own monographic research, based on archival documents and on volumes of published documents, the oldest source we have been able to consult that mentions the use of the 'exes' or axles is the one that refers to the *Santa Bárbara* mill of the San Juan de la Maguana village, on the south-central region of La Española, already in November of 1530 and possibly already in 1527,[65] a date earlier in five years than the publication of the first edition of the *Historia* of Fernández de Oviedo and earlier in four years to that used by Mexican historians like Horacio Crespo to sustain the proposing of the Mexican historical primacy in the use of the roller mills in the Americas.

[64] Del Río mentions these components of the Sanctiespiritus mill as 'ejes, cajas, guijos, rueda' in chapter 9, part 2, 'La contabilidad de dos modelos distintos de plantación,' of his book, and cites as the source the 'Relación de las cuentas de Juan Villoria,' Archivo General de Indias, Sección Justicia, Número 2. This mill, according to the author, began milling on May 15th, 1523.

[65]The information on the Santa Bárbara mill of San Juan de la Maguana in 1530, the first of two homonym mills owned in different places (San Juan and Azua, respectively) and on different dates in La Española by the Spanish settler Alonso Hernández de las Varas), is contained in the papers of a judicial law suit between parties of 1535, 'Los herederos de Diego Hernández de Barcelona con Alonso Fernández de Las Varas,' Archivo General de Indias, Sección Justicia, Legajo 12, No. 2, Ramo 2. The inventory of said mill where the mentioning of the 'ejes' or 'axes' as part of its milling machinery appears clearly is dated November 30, 1530. It was published for the first time by Enrique Otte in 1963. Yet in another document, from the same record, from three years earlier, not published by Otte, and which we have examined, a more generic description is given of the same mill citing only its 'molienda' or milling pieces without specifying what type of mechanism was exactly used. We will discuss some details about this mill in particular on a separate study on which we are currently working and which we hope to publish in the near future. Historian Genaro Rodríaguez Morel in fact has mentioned in two of his works that Alonso Hernández de las Varas obtained the loan for the building of his mill already before September 6 of 1520, date on which the Crown issued a royal decree directed to Diego Colón in which apparently it refers to the loan it had granted for the construction of the mill. The reference given by Rodríguez Morel for the document is AGI, Indiferente General 420, Libro 8, f. 319 (Rodríguez Morel 2003: 125-126 and note 28; 2004: 90 y 110, note 26). Though we do not have data yet on the exact date of construction of the mill, at least this indicates to us that already before the mentioned date of September 1520 Alonso Hernández seems to have been taking steps, at least of a financial nature, to build it.

Additional archival evidence on concrete cases of sixteenth-century *ingenios* of La Española that used the *molienda* or mill made of *ejes*, rollers or cylinders, has been found by us for several mills that used to be located in what are today the Dominican contemporary provinces of *Azua* and *San Cristóbal*. In the Azua area, at four locations: at the mill of cleric Alonso de Peralta in 1533—exact name of the mill unknown, at *ingenio Santiago de la Paz* in 1547 and 1560, at *trapiche La Magdalena* in 1556, at *ingenio Santa Bárbara* (homonymous to another older mill located in the San Juan de La Maguana area) in 1557. We found similar evidence in documents of 1565 for *ingenio San Sebastián del Valle* on the Nizao river basin, San Cristóbal Province.[66]

[66] The information on *chantre* Peralta's mill appears in 'Diligencias del oidor Lic. Vadillo, oidor, con Damian Peralta,' Archivo General de Indias, Sección Justicia, Legajo 12, Número 2, Ramo 4, concretely in an inventory presented on November 10th, 1533 in Azua by Damián Peralta, City Council member in the village of Azua, nephew of the late *chantre* Alonso de Peralta and person in charge at that moment of the assets left behind by his uncle. Amongst the inventoried assets was the mill, the machinery of which was apparently half way into its construction, the *ejes* mentioned as some of the pieces that were ready to be installed. Details are mentioned as well about the mill's components in expense accounts that Damián presented as the keeper of the mill after the passing of the *chantre*. There we find mentioned some of the typical pieces of mills at the time: the *molienda* or pair of rollers, the presses and others like some loose *ejes*, and then *pernos*, *cinchos*, *verdugos*, *chapazones*, *guijos*, etc. An interesting reference is made to payments to carpenters who 'turned the rollers in a lathe' ('tornearon la molienda'), a clear indication that rollers were made of thick pieces of timber (tree trunks, in so far as we know) which were then further scraped into the proper final shape. They also constructed the presses. The other pieces mentioned, as we already knew, are said to be the work of the iron smiths.

The same document of 1533, in its own way, offers additional confirmation, arguably much more explicit, of the function of the *ejes* as squeezers or crunchers between which the canes were pushed in or dumped. In an expression we have not found in any other documents from La Española so far, it is indicated that at chanter Peralta's mill a female Indian had been hired for eight days, at the cost of half a peso, so that she would 'give canes to the axes,' a clear indication of how the rollers functioned, fed with canes by a worker, in this case an indigenous woman. (Ibid.) We had already seen the use of female Indian workforce still during the first half of the 1530s in the case of the mill *Santa Bárbara* of San Juan de La Maguana. For more information on the accounting of costs and expenses of some of the pieces of the mill, see Del Río (1991: 363-367).

The mentioning of the use of the rollers at *ingenio* Santiago de La Paz in 1547 is contained in an

inventory of the latter done on Saturday 17th of December of 1547. In the document reference is made, as part of the equipment of the 'the mill's house,' 'a wheel with its axes which is the mill,' clearly alluding, in our view, the rollers or cylinders and the water wheel that propelled them. The inventory was first published, in so far as we are aware, by Cipriano de Utrera in *Clío*, Revista Bimestre de la Academia Dominicana de la Historia, No. 81, Año XVI, enero-junio de 1948, pp. 48-11. It was subsequently published in J. Marino Incháustegui, *Reales Cédulas*, 1958, vol. 1: 239, where the archival reference given is Archivo General de Indias, Sección Patronato Real, Legajo 173, No. 1, Ramo 8. The existence of '*exes*' or rollers in *trapiche* La Magdalena de Azua in 1556, when it was the property of sugar entrepreneur Juan Soderín or Soderini, is mentioned in an inventory of it done that same year. Said inventory is part of a court record 'Autos seguidos entre los hijos y herederos de Juan Soderin contra Melchor de Torres y Ana del Castillo, su mujer, sobre las dos terceras partes del ingenio de Santa Barbola, en el termino de la villa de Azua, y la estancia y hatos de Neiva, anejos a dicho ingenio,' Archivo General de Indias, Sección Escribanía de Cámara, Legajo 1-A, fo. 134r., 163 v., and 178r.

The information on the cylinders or axes of *ingenio* Santa Bárbara of Azua in 1557 appears, as it is frequent in these cases, in another inventory included in sale-purchase contract, dated 15 of June of 1557. The contract is part of the same record of the *Soderín vs. Torres* law suit, and the data is on fo. 489r.

The description of the machinery of *ingenio* Santiago de La Paz of Azua of 1560 is provided in an inventory taken on September 25 of that year , which shows that thirteen years after being inventoried in 1547, the mill continued using the '*exes*' or rollers as essential parts of the *molienda* or mill machine itself. On August 31st 1560 an appraisal was made of the mill on site by a three people commission when the Santo Domingo city council was in the process of auctioning it off. In the testimony of the inspection and appraisal made of the mill it is said that it had 'two presses and two new axes and new iron sheaths [*chapazón*] and iron crunching bars [*verdugos*] with the wheel very good and three boxes for bagasse half worn and the fasteners new and cutting boards [*picaderos*] and ground bases [*bancos*] and chanels [*canales*] and all the amenities of the said mill' (fo. 37v.). The appraisal was presented to notary Hernando de Brenes 'on Wednesday twenty fifth day of the month of September year of the birth of our savior Jesus Christ of one thousand and five hundred and sixty years' (fos. 36r.-36v.). In the document, public notary Hernando de Brenes says there is 'a document and agreement that is made between the said Ruy Hernandez de Fuenmaior and the said Melchior de Torres before notary Diego de Herrera.' (fo. 36v.) The data appear in the law suit followed by Melchor Torres against Ruy Hernández de Fuenmayor, AGI, Justicia, Legajo 22-A. (What seems to be a copy of the same 1560 inventory, apparently made in 1562, is contained in pages 471r. and subsequent of the same *legajo*. Another copy is included in AGI, Justicia, Legajo 22-B, fo. 226v. and subsequent.

As to the San Sebastián del Valle sugar estate, located on the Banks of the Nizao river within the district of Santo Domingo City, the data appear in AGI, Sección Justicia, Legajo 23, 'Juan de Medrano Racionero de la Santa Iglesia de Santo Domingo: con Lope del Castilo, vecino de la ciudad de Santo Domingo sobre cierto ingenio.' In an inventory of this sugar estate presented to the city of Santo Domingo on May 20, 1565 there is mentioning of 'the house of the mill with the milling device milling and running''as well as 'two presses with their boxes' (fo. 170r.) without citing the axes or rollers specifically, though further ahead in the document, while

A separate comment is due in this context on another evidence about the use of the roller mill in La Española during the first half of the sixteenth century which we consider of a fundamental importance for the scholarship on the topic. Published for the first time in the 1990s and having gone by apparently rather unnoticed amongst specialists, we can still consider it a historical novelty. In fact so great is its significance that, while calling the reader's attention to it as a piece of news that has not received enough attention, this author cannot avoid entertaining some doubt as to whether by highlighting it we may be actually announcing something already well known. It is a chronicle, never published until 1992, by Italian maritime merchant Galeotto Çei, largely a virtual unknown until now apparently, who traveled to the Indies in late 1539 and spent more than two years in La Española (a first stay from October 1539 to October 1541) and a number of months in Tierra Firme, especially in what is today Venezuela.[67] In his chronicle, seemingly written after Çei returned to Italy and in the last period of his life between the decades of 1560 and 1570, the author offers an entire gamut of observations about the natural and human environment of La Española at the end of the 1530s that definitively enriches our understanding of the colony at that moment, with the added component of coming from a non-Spanish, maritime-merchant individual. And much more important for the purpose of this essay, in his chronicle offers a contribution that is simply

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describing the other pieces of the mill, reference is made to 'two fasteners of heads of axes' ('dos sinchos de cabeças de ejes') and to 'another fastener of a head of a small axis' ('otro sincho de cabeça de eje chicho') (fo. 171r.) The date of the document shows in fo. 168r., immediately before the inventory itself.

[67] According to what Çei himself tells us, he arrived in La Española on October 22nd, 1539 and remained there until October 1541. He left the island and then was back in Santo Domingo from the beginning of September 1542 until December of that year, when he left for Cabo de Vela. He returned to La Española at the end of April 1544 and left the island for the last time on Saint John's day of that year. (Çei, *Viaje*, 1995: 8, 46, 50-52).

fundamental about the manufacturing of cane sugar in La Española in the decade mentioned, giving us what is possibly, in spite of its brevity, the most detailed description so far known of the mechanics of a cane sugar mill of La Española during the period studied here, surpassing by far in this sense even the data provided by the most visited of the chroniclers about the subject, Gonzalo Fernández de Oviedo.[68]

The following is an English translation of the main passage of Cei's description of the sugar cane milling machinery he saw in La Española's sugar estates:

> […] 'the mill, which is made on the outside like ours, but the water wheel is much larger. From the center of that wheel comes out a transom which enters the house, as long as needed and thicker than an arm and a half and this the Spaniards call eje, in stead of 'axis;' this one is called large axis, whose extreme comes to rest on certain wooden columns, having placed, on its highest part, an iron end,[69] as thick as a leg, which is balanced on another ironed stud, where it rotates by counter-wheight in accordance with the wheel. Underneath this large axis there is another one which they called the small one, thick as the other one, but shorter, because it does not reach to the wheel on one side, it is placed on wooden columns, and on the other side, on the large axis' columns. The large one is

[68] It is no exaggeration, in our view, to say that the publication of Galeotto Çei's narrative, a scholarly achievement of both its original editor in Italian in 1992 and the Venezuelan scholars and institutions that did its translation and publication in Spanish in 1995, is one of the most significant academic events of the last two decades in terms of the salvaging of secondary-source data about the early colonial life of Santo Domingo.

[69] The Spanish translation uses de word 'punta,' point, pike, sting.

> ironed around in the crushing area, with iron bars, thick and elongated like two fingers or more; the small one is covered by iron sheets and both have, on the sides, certain wooden teeth that enter into each other, so that the water, by whirling the large one, spins with this impulse the small one against itself, and between these two axes they stick the cane, passing them in between as many times till it is well broken; below them, there are certain wooden shafts that receive the cane and further below a barrel which receives the juice, which runs down along certain grooves into a pot. On the margin I will put some sample of the milling *ejes* or 'axes'. After the cane is milled they take it to the presses and they take out all the juice that through the grooves runs along towards where the rest is, and it comes out so dry that soon it could burn and it is carried away from and hurled out of the mill, onto a square, and this they call *bagazo*, and in certain epochs they burn it.' […][70]

[70] This translation into English of the passage of Çei's chronicle was done by the author using the Italian edition by Francesco Surdich (Cey, 1992: 24-25) , as well as the Spanish translation by Marisa Vannini de Gerulewicz contained in the Venezuelan edition of the chronicle in 1995 with a preliminary study, notes and indexes by José Rafael Lovera (Cey, 1995: 34). The original text in Italian is the following:

> [...] 'mulino, el quale è fatto, di fuora, como li nostri, ma la ruota dell'acqua è molto maggiore. Del polo di essa ruota esce una trave che entra in casa, lunga al bisogno, et grossa più di un braccio e mezzo di diametro, et questo dicono *escie* li Spagnoli, in cambio di *asse*, et questo si dice *escie maggiore* et viene el polo suo a affermarsi sopra certe colonne di legno, avendo messo, nella *sommità* sua, una punta di ferro, grossa com'una gamba, che sta bilanciata sopra un altro legno ferrato, dove gira sopra per contrapeso et misura della ruota. Di sotto a questo *asse* maggiore n'è un altro che dicono minore, grosso come l'altro, ma più corto, perché non arriva alla ruota da una parte, ma è posto sopra colonne di legno et, dall'altra, sopra le colonne del maggiore. Sono el maggiore ferrato intorno dove ha macinare di spranghe di ferro, grosse et larghe dua dita o più; el minore è coperto di foglia di ferro et hanno, dalli lati, certi denti di legno che entrono l'uno nell'altro, di modo che l'acqua, facendo volgere el maggiore, fa, con quello impeto, volgere el minore contro di sè, et fra questi dua asse mettono la canna, passandola per esse tante volte che sia bene infranta sotto a *essi*, e certe tavole che

In his narrative, Çei confirms that a non specified number, perhaps a majority, of the *señores* or owners of sugar-cane *haciendas* or plantations of La Española were using horizontal double roller mills as the main milling machine in their ingenios at the time, consisting, according to the chronicler, of two adjacent horizontal wooden cylinders made out of tree trunks placed one on top of the other on the same imaginary geometrical vertical plane, assembled inside a heavy wooden frame.[71] They were connected to each other in their movement by means of toothed gears located somewhere around their central longitudinal axes (in the modern sense of the word). Each of them was also mounted on solid wooden columns or pillars. Even more,

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> ricevono la canna e sotto un truogoletto che riceve el sugo d'essa, che per certi canali se ne corre in una *concha*. Di fuori nel margine porrò un poco di mostra delli *esci*, o *axe*, che macinano. Di poi, dimacinata la canna, la portono alli *strettoi* et ne cavono tutto el sugo che, per suo canale, corre dov'è l'altro et di essi resta in modo smunta che subito possono la ardere et la portono e gettono fuora del mulino su una piazza, et questo chiamano *bagazzo* et a certi tempi l'ardono.' [...] (Cey, *Viaggio*, 1992: 24-25)

[71] Mexican colonial technology historian Beatriz Scharrer Tamm --despite citing and referring to the Daniels' essay (Scharrer 1997: 102-104)—when commenting the Mexican sugar mills of the 17th and 18th centuries, has expressed strong doubts about the pre-existence of horizontal roller mills when the vertical roller mills had not yet been introduced in cane-sugar milling (103, 104). 'It was not possible to find graphic representations of the mill with horizontal rollers.' ('No fue posible localizar representaciones gráficas del molino con rodillos horizontales.') (103) Questioning the hints that other authors thought to see in certain sources in this regard she wrote: "I do not think there may be indications in this comment to suppose that the mechanism of the existing mill was horizontal and that it had been modified by another vertical one.' (104) ('No creo que haya indicios en este comentario para suponer que el mecanismo del molino existente era horizontal y que se había modificado por otro vertical.') […] 'Yet, in some of the mills that appear in the inventories consulted, one of the millers was larger than the other, which leads us to think that they were mills whose squeezing mechanism was placed in a vertical plane, since we can hardly imagine that millers of different size functioned horizontally.' ('Sin embargo, en algunos de los molinos que aparecen en los inventarios consultados, uno de los moledores era más grande que el otro, lo que nos hace pensar que eran molinos cuyo mecanismo de trituración estaba colocado en un plano vertical, pues difícilmente nos podemos imaginar que moledores de tamaño diferente funcionaran horizontalmente.') (104) For the case of Hispaniola's mills in the sixteenth century, nonetheless, Galeotto Çei's testimony about the horizontality of the double rollers seems beyond any reasonable doubt.

Çei also remarked on the technical terminology itself used in La Española, clarifying for his fellow Italian readers (and in passing, for us, four centuries and a half later), that the word *exe* (transcribed as *escie* by Çei in the Italian manuscript) was applied by the Spaniards precisely to the milling rollers or cylinders themselves, and that it was used instead of the Italian word *asse*.

As part of his description Çei added that, affixed longitudinally to the exterior surface of one of the *exes* or cylinders of these mills used in La Española, there were a number of iron bars that functioned as protruding teeth that increased the squeezing power of the roller pair. This comment, as may be noticed, sheds light in passing for us on the frequent mentioning of some equipment elements of the mills like the *barras* and the *cinchos* which, as we have indicated, survived in the sugar jargon of other Spanish colonies like New Spain but disappeared in La Española. To the point that –at the beginning of our research, when we used first-hand sources like the sugar estate inventories of the island in the sixteenth century—it was practically impossible to interpret their exact functions and meanings within the sugar mills' machinery. And yet more significant, Çei non only provided a written, textual description but he also illustrated it with a drawing of the piece constituted by the larger roller with its teeth and bars, this being the only representation that we are aware of any part of any sugar mill that is contemporary to the object and events of the 16th century, drawn by someone that we know was a first hand witness. (See Fig. 12) [72] Additionally Çei informs about the use of the covers or

[72] As it is well known, the illustrations that have survived into our times of the sugar mills of the 16th century seem to be images composed by their authors based on data provided by second or third persons through oral narrations or written chronicles. The sketch made by Çei of one of the rollers of a mill constitutes a novelty for the scholarship about the sugar manufacture at the beginnings of the colonization of the Americas in more than one aspect (Çei, *Viaje*, 1995:34). Still in 1980 Brazilian historian Antonio Barros de Castro referred to the fact that at the time of his writing no visual representation was known yet of the early roller mills as they were when they began to be used in the Americas, saying literally that 'não se conhece até hoje nem uma só representação contemporânea da moendade dois rolos' (Barros de Castro 1980: 686).

sleeves of metal sheet used to cover longitudinally as well the second roller of the system along its area of direct contact with the sugar canes. Horacio Crespo (1988) had described this mechanism of external reinforcements of the *ejes* or *mazas* of the mills as they survived in the Mexican sugar-making tradition, dating the most ancient case during the 17th century. We think Çei's represents the earliest surviving direct testimony on its use in La Española during the second third of the 16th century and that we may consider it sufficient indication that the use of these metal covers, sheathings or linings of the rollers was already common at this early date on the island.[73] Figure 11 shows Barros de Castro's illustration of 1980. Figure 13 presents a re-interpretation of Barros de Castro's made by us after incorporating the data provided by Çei.

As to the validity or reliability of Çei's chronicle, especially in respect to these details about the sugar-cane milling machinery use in La Española at the time, there is anevidence that we could consider of a collateral nature that seems to render his testimony rather believable. It is the fact that Çei himself declares in his narration to have lived for a good deal of his time spent

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This design of the milling 'axes' or rollers drawn by Çei, on the other hand, calls our attention because of its considerable similarity with the old wooden axes –in our most contemporary sense of the word—that have survived in some of the few and very old metal laminating mills that have survived in Spain (the fanderías or henderías) as they are shown in photos published by historian of early-modern Spanish technology Ignacio González Tascón in 1992 (Fig. 14) In said publication, incidentally, González Tascón adhered to the theory of a probably origin of the roller mill in the Americas, and more concretely in Brazil, referring to the case of Recife in 1577. Yet at the same time, the author considered the possibility that –given that it was Portuguese technicians that constructed the majority of the first sugar mills built in the Canary Islands—the mills existing in the Canary Islands in the 16th century might have been roller or cylinder mills (González Tascón 1992: 259, 261).

[73] Çei's may be also the earliest surviving description on the machinery of the double cylinders of a particular sugar mill in any given place in Spanish America. John and Christian Daniels, in their 1988 study, identified the description made by cleric Francisco Hernández de Toledo, written apparently in the 1570s, as the first done in the Americas about a sugar-cane mill (Daniels and Daniels 1988: 513, note 72). Çei's, though written years after he returned to Italy, refers to the mills that Çei himself saw in La Española at the beginning of the 1540s.

in La Española at the house of no other than Juan Soderín, the same colonist-merchant from Florence established and married in Santo Domingo who was owner of sugar estates in La Española on whom the author of this essay had already found abundant information while conducting another piece of research. [74] Soderín, whom Çei mentions by his Italian name Giovanni de Luigi Soderini, calling him 'great friend of mine' (Çei, Viaggio, 1992: 4) was an important sugar entrepreneur during the 1540s and 1550s in La Española. He possessed at least a *trapiche* named La Magdalena and part of an ingenio named Santa Bárbara or Santa Bárbola, both in the vicinities of the 16th century village of Azua on the coastal plains of the south-central area of La Española in what is today the Province of Azua of the Dominican Republic. If Çei's testimony of his friendship with Soderín and his residing in the latter's house in the city of Santo Domingo while Soderín was single are true, [75] it is rather reasonable to imagine that Çei must have had more than one occasion to visit and familiarize himself upclose with Soderín's sugar

[74] Part of the alluded research project became the M.A. Thesis of this author cited on footnote 2 at the beginning of this essay.

[75] Çei says in his chronicle that he returned for a second stay in Santo Domingo in early September of 1542 and that he lived in the same house with Juan Soderín and Mauro Fantoni during the following months until both Soderín and Fantoni got married. Soderín according to Çei married 'after May of 1542' and Fantoni 'afterwards in June' […] 'and thus I remained alone and we left the house' (Çei, Viaggio, 1992: 37). He further adds that 'in the month of December of said year I left Santo Domingo to return to Cabo de Vela' (37). Assuming that Çei means that Soderín and Fantoni married about six months after Çei returned to Santo Domingo in 1542, it then seems as if the year of the weddings was in fact the following year, 1543, and that Çei's dating it in 1542 may have been a mistake of memory or of writing. This seems to be confirmed by other first hand data, gathered by us in a parallel research, indicating that the Soderín's wedding (with Santo Domingo resident Isabel de Las Varas) took place in fact in 1543, precisely in the summer (as Çei says, after the month of May). Ultimately, if our interpretation of the dates is correct, this reference by Çei to Soderín's wedding during the summer of that year in La Española could be a further evidence of the credibility of Çei as a chronicler, and therefore of the descriptions he provided of the sugar estate's milling machinery and their mechanical components.

estates, their equipment and functioning, as well as –possibly-- with other estates owned by business associates or acquaintances of Soderín's in the same region of La Española.

The above indirect evidence on the probable first-hand knowledge by Galeotto Çei about the sugar mills of La Española during the 1540s is further supported by another primary source of the time, that shows Çei as a visitor ('estante') in Santo Domingo who got to establish interaction, beyond his fellow Florentian and friend Soderini, with a number of the most powerful members of the cane-sugar oligarchy of the colony at the time, including individuals like Hernando Gorjón, Alonso Hernández de Las Varas, and Francisco Dávila, all of them owners of sugar mills.[76] Taking both evidences into consideration, it does not seem

[76] Indeed. When newly appointed royal governor Alonso de Cerrato arrived in La Española and launched in 1543-1544 the mandatory *juicio de residencia* (the judicial assessment of the tenure) of until-then governor Alonso de Fuenmayor and of the other judges of the *Audiencia*, there were numerous complaints raised about the performance of one of the judges Juan de Vadillo. Hernando Gorjón, one of the most prominent 'señores de ingenious' or sugar mill lords at the time in the island, and one of the most commented upon in Dominican colonial scholarship until today, presented serious accusations of partiality and corruption against Vadillo. And amongst the witnesses that *licenciado* Vadillo, in his self-defense turn, called in to testify in his favor to demonstrate the decency of his tenure as judge, was no other than Galeotto Çei, our Italian merchant, who was comprehensibly described by the judicial clerks of Santo Domingo as 'estante' or visitor in the deposition papers, and whose name, for equally understandable reasons, was spelled out as *Galeote Chey*, partially altering the pronunciation of the last syllable of the first name but at the same time transcribing very faithfully into Castillian Spanish the pronunciation of his surname. In his deposition, responding to questions of the inquiry compiled on behalf of judge Vadillo, Çei said he was at the time 29 years of age. He also declared –and this is possibly the most revealing item—that, while he had known judge Cerrato only for a month, all the others involved in the case he had known 'since four or five years until now' ('de quarto a çinco años a esta parte'), stating in passing that he himself often entered the house of judge Vadillo. This chronology implies that he met them for the first time in 1539, the same year that Çei would cite in his chronicle, written decades later, as the year of his first arrival in Santo Domingo. (See note 67 in this essay.) The archival source of this information about Çei is the record, contained in several document bundles or *legajos*, of the *juicio de residencia* conducted by judge-governor Cerrato when he first arrived in La Española designated by the Crown. See Archivo General de Indias, Sección Justicia, Legajo 59. No. 1. The declaration by Çei, in *folios* or pages 1633r. and the subsequent. Our archival encounter with Çei through this part of the documentation, occurred well after reading his then very little-studied chronicle, was no doubt

unreasonable then to assume that the description provided by Çei of a typical sugar mill of La Española at the beginning of the 1540s might be even based on observations on some of the same sugar estates that appear described in the inventories and other types of documents that we have used for the study mentioned before.

In any case, it seems reasonable to conclude that Çei's description of La Española's sixteenth-century sugar estates comes to corroborate the theory that certain scholarship on the early sugar mills of the Americas, initiated by Gil Methodio Maranhão in Brasil at the beginning of the 1950s, and applied for the first time to the case of La Española by Cuban scholar Fernando Ortiz in the early 1960s, had sustained: specifically, that rollers or cylinders were the central pieces of the milling machinery used in La Española's sugar estates during the second quarter of the sixteenth century. This theory would be picked up in the 1990s by historians Justo del Río Moreno and Genaro Rodríguez Morel.

Finally we would like to present here as well our perspective on the theory, sustained also by historians like Ortiz, Rodríguez Morel, and Del Río Moreno, on the invention of the horizontal roller mill as a technological phenomenon reportedly taking place in La Española as part of the sugar production boom experienced by the colony beginning in the middle years of the second decade of the 16th century. As we have seen, basing themselves on the use of the term 'invention'(*invención*) in several sources of the times, including the very famous chronicle of cleric Bartolomé de Las Casas and a decree issued by no other than Emperor Charles V from his office, when they referred to the sugar mills constructed by sugar pioneering entrepreneur Gonzalo de Vellosa in La Española, the three above mentioned historians have proposed that the

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one of the most rewarding moments of the research process summarized in this article.

application of the term 'invention' to the mechanism built by Vellosa possibly indicates that in fact it was in La Española where this type of milling device was constructed for the first time. In case this was accurate, it would have indeed constituted a major technical revolution of large historical and economic impact for this industry at the continental, the hemispheric, as well as the imperial levels.

Yet we would like to submit that the existing documental evidence --probably more known today that at the time the above mentioned scholars advanced their own theories in this regard—about the presence of the roller mills in the Madeira Islands (from the last quarter of the 15th century) and in the Canary Islands from the early years of the first decade of the 16th century, seems to indicate that, by the time the construction of the earliest economically viable sugar mills of La Española began according to the chronicles and the archival sources so far known to us, this type of milling mechanism had already been invented, or at least used, for a number of years in both two Eastern Atlantic archipelagos. This on the other hand does not seem too surprising if we take into account that the long sugar-making tradition, already firmly established on both Iberian insular territories since at least a quarter of a century before, and exposed to the direct stimuli coming from a consumers market going through a steady expansion in Western Europe, would seem to represent a social climate more prone to technological experimentations and innovations than the local environment of a relatively new and economically small colony like La Española happened to be still in the second decade of the 16th century, when the production of sugar in quantities enough to sustain exporting was in its very beginnings.

On the other hand, the same sources that mention a reported 'invention' of a differentiated type of mill by Vellosa that could be –according to the same interpretation mentioned above—the roller mill, deserve in our opinion a critical questioning. We would argue that the familiarity of Bartolomé de Las Casas with the sugar-cane milling mechanisms was not that encompassing –if we are to judge by the fragmentary and schematic nature of Las Casas' descriptions, and if we compare them, for instances with those by chronicler Gonzalo Fernández de Oviedo, for instance—as for us to take literally his, say, technical comments on the matter. As to the use of the term 'invention' in a decree by Charles V, taken as an isolated evidence, it does not seem necessarily to us a solid-enough proof per se precisely because we do not know of indications, neither specific nor abundant, that in the Spanish court at the time there was a lot of technical knowledge in regards to the production of sugar, yet indeed a desire to stimulate and stabilize the peopling and the settlement of new colonies like La Española, a purpose that could be clearly nurtured with the issuing of acknowledgments –like the one referred to here by the Emperor-- sent in writing of claims of technical achievements from across the Ocean as the reported one by Vellosa, and which –in the case they had been true—would have contributed greatly precisely to the main economic goals of the expanding Empire.

In the process of conducting the research for this study on the sugar mills of La Española in the 16th century, furthermore, some information on the cane-sugar manufacturing in the Andalucian southern-coastal region of Spain during the said period which seem to show without any doubts the use of the cane-sugar roller mill at least by 1571 and at least in some milling houses in the area.[77] This data are of importance for the scholarship because untilnow

[77] The topic of the milling technologies used in the sugar producing areas that survived in the

the interpretations we had seen about the arrival of the roller mill into Andalucía during Modern Times used to located the first documented cases in the XVII and XVIII centuries. Once again the fundamental indication of the use of rollers or cylinders is given by the presence of the term 'exes' in the descriptions of or references to the components of some of these mills in Andalucía during the 16th century. We find it in the 1991 study by Spanish historian Margarita Birriel Salcedo on the history of Andalucian cane sugar during Modern Times, specifically on a quote from a document inserted by the author in her text. Once again, it is an evidence that seems to have gone overlooked during more than a decade and a half of scholarship but which merits discussion and analysis.

In her 1991 study Birriel cited a 1571 inventory of a sugar mill in Motril, one of the main sites of cane sugar manufacturing tradition of medieval andalusí or Southern Spain's Arabic origin, in which there appears described what is clearly a sugar-cane double roller mill, with explicit mentioning of two '*exes*,' one larger than the other ('el exe grande y el pequeño') mounted within a wooden frame, besides another small one ('un exe nuevo pequeño de enzina') loose and apparently defective (Birriel 1991: 128). The document mentions as well 'a large

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Iberian Peninsula during the sixteenth-century, especially the Eastern and Southeastern coasts of Spain, seems to have remained in a state of ambiguity in the scholarship at least until the late 1990s. The early 2000s saw an expansion in Spain of the research on the milling technologies used in Spain's *Levante*, but unfortunately we have not had enough access to that bibliography for the time being. A study published in 1997, for instance, *Los molinos: patrimonio industrial y cultural*, by Efrén Fernández Lavandera and Carmelo-Millán Fernández Rodríaguez, still made a comment on the limited knowledge existing on the evolution of the cane-sugar industry of the 16th century, indicating that apparently the mill equipped with rolling stones or *muelas* continued to prevail, while the date of introduction of the roller mill remained rather obscure, with its first mentioning in the sources of Eastern Spain dated in the 18th century. The authors also pointed out that there were indications that the words *trapiche* and *ingenio* were already being used at least in the coastal region of the Kingdom of Granada around the 1540s with the same differentiated meanings that prevailed in the Iberian colonies in the Americas. Furthermore, said authors located the first sugar productions in the Canary Islands around 1492 (Fernández y Fernández 1997: 98-101).

earthen jar where the juice from the axes falls into' ('un tinajón donde viene el caldo de los exes') a comment that reconfirms the laminating and compressing function performed by the '*exes*' or rollers, from which the cane juice would pour onto a container located at a lower level. It happens to be a description that, even when partial, coincides very well with the one provided by Galeotto Çei in his chronicle when commenting on the sugar mills of La Española at the end of the 1530s.[78]

Thanks to an interesting and informative study published in the 1980s by medievalist José E. López de Coca Castañer on the sugar manufacture in the Andalucian village of Almuñécar during the 16th century, we know that at least by 1516 in this village of Southern Spain where cane sugar mills were traditionally called *aduanas*, the terms 'ingenio' and 'trapiche' ('ingenio e trapiche') appear being used in the local legislation, while as we go

[78] In fact, in her study Birriel Salcedo did not present any specific discussion on the presence of the term 'exes' in the 1571 inventory from the village of Motril, the attention of the author apparently centered, at the time of her research, predominantly on aspects like the existence itself of the mills, their quantity and their sizes, as well as the circumstances of the private property regime governing them within the context of the clash between the Spanish Christians that were settling the area, on the one hand, and the Spanish Morisco population of the place (*Producción y comercio de azúcar* 1993: 128). Nevertheless, in the conclusions at the end of her paper, Birriel in fact indicated that the among the descriptions of cane mills of the 16th, 17th, and 18th centuries from Andalucía that she had found in the archival sources there were scant mentions of stone milling wheels and yet numerous mentions of the 'exes'. But aside from stating that these terms 'may be interpreted in different manners' ('pueden ser planteados de distintas maneras' (137) without describing nor explaining those 'manners,' Birriel did not indicate clearly either the exact dates –throughout the three centuries that her study covers—of those mentions of the 'exes.' In fact, in the oral discussions held after the presentation of her paper, while referring to the mills in the Granada region, Birriel expressed that 'we do not have a clear idea of which is the system in the 16th century.' […] 'Those I have documented in the 16th century I think that one of them is, could be, a cylinder system, of two cylinders' (148). But the author did not add at the time any base or grounding for these speculations. Since we do not know at this time whether the author has since published any study or comments presenting data or sources on the matter, for the purposes of this study, the problem persists, therefore, of whether some other mention on the use of the rollers or cylinders, before or after that of 1571, was ever found at the time by this scholar in regards to Motril in the 16th century.

forward into throughout the century the term *ingenio* becomes more frequent in the documentation, coexisting in the long term with the term *aduanas* (López de Coca 1989: 231, 235-237).[79] This in turn presents a challenge to research in the future whether this presence of the term *ingenio* during the first quarter of the 16th century in the Southern-Mediterranean coast of Spain should be interpreted as an indication that *also* in that region there was already at the time the same type of sugar-making equipment and tools (and especially the mills of cylinders or 'exes') that were being used , associated with the word i*ngenio*, in the Iberian possessions of the Eastern Atlantic and the Americas, as it was the case of the Canary Islands and the island of La Española. If that is the case, we would have to modify the so-far existing notion that chronologically locates the arrival of the cane-sugar roller mill into the Iberian Peninsula as a late phenomenon when compared to the territories devoted to this crop in the Atlantic.

Finally, an examination of the scholarship on Iberian, and more specifically, Andalucian, late-medieval agriculture, in turn, seems to provide us with additional elements with which to better weave this general interpretation on the use of the rollers in the *ingenios* or sugar-cane mills in La Española and the Americas during the first half of the 16th century. We have not found in that scholarship one single mention of the term 'exe' used in reference to any of the components of the milling or pressing used in the food industries of the time, which seems to confirm the impression that the application of the framed double rollers or '*exes*' to the

[79] The words 'ingenio e trapiche' appear in the ordinances of Almuñécar of January 27, 1516 (López de Coca 1988: 231). In those of February 27, 1541 the terms 'aduanas e ingenios' appear (235). The ordinances of February 24, 1552 mention 'el ingenio e aduanas' and 'el dicho yngenio e aduanas,' as if there was only *one* single *ingenio* and the *aduanas* were *several* (236). In the ordinances of November 5, 1574 there is allusion to 'todas las personas que tuvieren yngenios de açucar,' using a plural (237) that is repeated when 'los señores de los dichos yngenios' and 'los dichos yngenios' are mentioned (237).

manufacturing of a food product in this region of the Planet began with the cane-sugar industry and remained circumscribed to it for a relatively long time.[80]

Conclusions

At some point during the colonial times in the Spanish-speaking sugar making world, including places like Mexico and Cuba where the sugar-making tradition seems to have continued uninterrupted until contemporary times, the term 'exes,' used during the late fifteenth century and throughout the sixteenth century to refer to the rollers that milled the canes, was replaced by other terms. Since there were very few instances where the terminology's meaning was described in the colonial sources, both primary as well as secondary, ever since it disappeared from the spoken sugar-making jargon, the word 'exes' became a sort of mystery, to be potentially confused with the more contemporary, non sugar-specific meaning of the term. Conversely and understandably, once the use of the sugar-related meaning of the word (as milling rollers) stopped in the Spanish speaking world, the possibility to easily interpret its presence in colonial documents related to sugar making disappeared as well. For centuries, literally, the only secondary sources that described the meaning of the term went either un-consulted by scholars (case of Francisco Ximenes's *Quatro Libros de la Naturaleza y Virtudes*

[80] In her study about the agricultural farms of the Southwest of Andalucía during the Late Middle Ages, for instance, historian Isabel Montes Romero-Camacho found only references to mills composed by stone milling wheels or *muelas*, and to wooden presses used for the smashing and squeezing of olives and grapes, respectively. The word *exe* simply does not seem to have been part of the machinery or equipment of the agro-industry, or to put it in other words, of the milling practices in Lower Andalucía at the time (Montes 1989: 140-147).

de las Plantas published in 1615) or simply unpublished (like Galeotto Cei's *Viaggio e Relazione delle Indie*, first published in 1992). No Spanish language scholars commented upon the equivalency of the term 'eixo' of the Portuguese sugar jargon, which had survived much longer, and the Spanish word 'exe' present in the colonial documents, until Fernando Ortiz, even when partially, referred to it in the early 1960s, and Horacio Crespo more explicitly in the mid-1980s. In the English language scholarship, only in the mid 1980s the meaning of the terms would be first discussed by John and Christian Daniels.

It seems reasonable to sustain now that, based on the review of past interpretations and the consideration of new evidences as we have presented them in this essay, we may formulate the following conclusions regarding the milling equipment used in the Early Modern cane-sugar making industry of the Atlantic from the last quarter of the 15th century onwards: 1) Whenever the Portuguese term '*eixo*' or the Spanish term '*exe*' appear related to a setting of cane-sugar estates or mills, it seems a firm inference to understand that these terms refer to the structures formed by the horizontal wooden rollers or cylinders adjacent to each other and mounted on some type of wooden frame that were used to squeeze the sugar canes to extract their juice. 2) In the Canary islands the use of the horizontal double roller mills applied to sugar canes seems well documented on a date as early at least as 1503-1504, and indications would point the fact that this system could have been in use well before then, and maybe from the very first moment the cane-sugar production and technology were transferred or imported from the Madeira Islands. 3) In La Española the horizontal double roller mills were used in sugar-cane milling at least by 1519 and possibly from the very first moment, earlier in the 1510s, when the industry was established as an economically viable and competitive enterprise for the times, La Española

having clearly therefore, according to all the existing evidence, the historical primacy in the use of this system of cane-milling in the Americas. 4) The use of the roller mill seems to have arrived to the sugar-making region of continental Spain in Andalucía (especially the coastal strip of the old Kingdom of Granada) at least by 1570, but more research is needed on the existing indications that the technology may have been introduced much earlier in the century, maybe around the same time it was introduced on the other side of the Atlantic in La Española.[81]

As to the future prospects for research on early colonial sugar milling in La Española, it seems reasonable to expect that there may still be potential to confirm with more accuracy in future studies –especially through a deeper and more encompassing analysis of the existing

[81] After the initial version of this essay was presented in Spanish at the conference *O Açúcar Antes e Depois de Colombo* held in Santo Domingo in 2006, and while we were preparing this expanded version of the text in English, we discovered the Ph.D. thesis by Lizette Cabrera Salcedo, 'De los Bueyes al Vapor: Caminos Sinuosos de la Tecnología Azucarera en Puerto Rico y el Caribe (1778-1873),' presented in 2005 at the Universidad de Puerto Rico, Recinto Río Piedras, and published in 2006 in digital format by ProQuest Information and Learning Company. (The dissertation has been published since in book format in 2010 as *De los bueyes al vapor: caminos de la tecnología en Puerto Rico y el Caribe*, as per a review by Daniel B. Rood published in volume 39 of *Caribbean Studies* in 2011, but the author of this essay has not had a chance to consult the publication directly.) Chapter II of the dissertation, for which the author acknowledges receiving assistance from senior Puerto Rican colonial historian Francisco Moscoso in terms of data about one of the earliest Puerto Rican mills (Cabrera Salcedo 2006: 31, note 31), is devoted to 'The origins of the cylinder mill' and in it the reader will find a number of observations somewhat similar to those presented in this essay and based on some of the same sources considered here, especially in terms of the review of the scholarship. Yet at least two differences are worth mentioning. In Cabrera Salcedo's chapter the earliest evidence presented of the presence of roller mills in the Americas is a 1526 inventory of a Puerto Rican mill reportedly constructed in 1522 (31). Evidence on Hispaniola suggests that this type of mill was already constructed around 1514. On the other hand, the roller mills of the time are defined by Cabrera as vertical (32), while we sustain that there is now clear evidence that those used in Hispaniola during the sixteenth-century, and possibly in the other places in the Caribbean to where the industry was quickly transferred from there, were horizontal. In any event, we consider that, aside from the partial disagreement, different styles and different sources used, this essay and Cabrera's chapter actually reinforce each other, and that both together clarify the issue of the use of roller mills in the earliest sugar estates or plantations of the Americas in a rather definitive manner.

sixteenth-century archival sources-- the probable use of the horizontal double roller mill since the very first moment the cane-sugar manufacture, one of the most economically innovative at the time, was established in the colony. Everything indicates that in such endeavor the main guiding criterion should be the searching for the use of the words '*exe*' or '*exes*' in the documentation that has survived related to the earliest sugar mills of the Americas, so far studied more or less partially and only by a handful of scholars whose work we have precisely tried to highlight and comment in this study.

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Illustrations

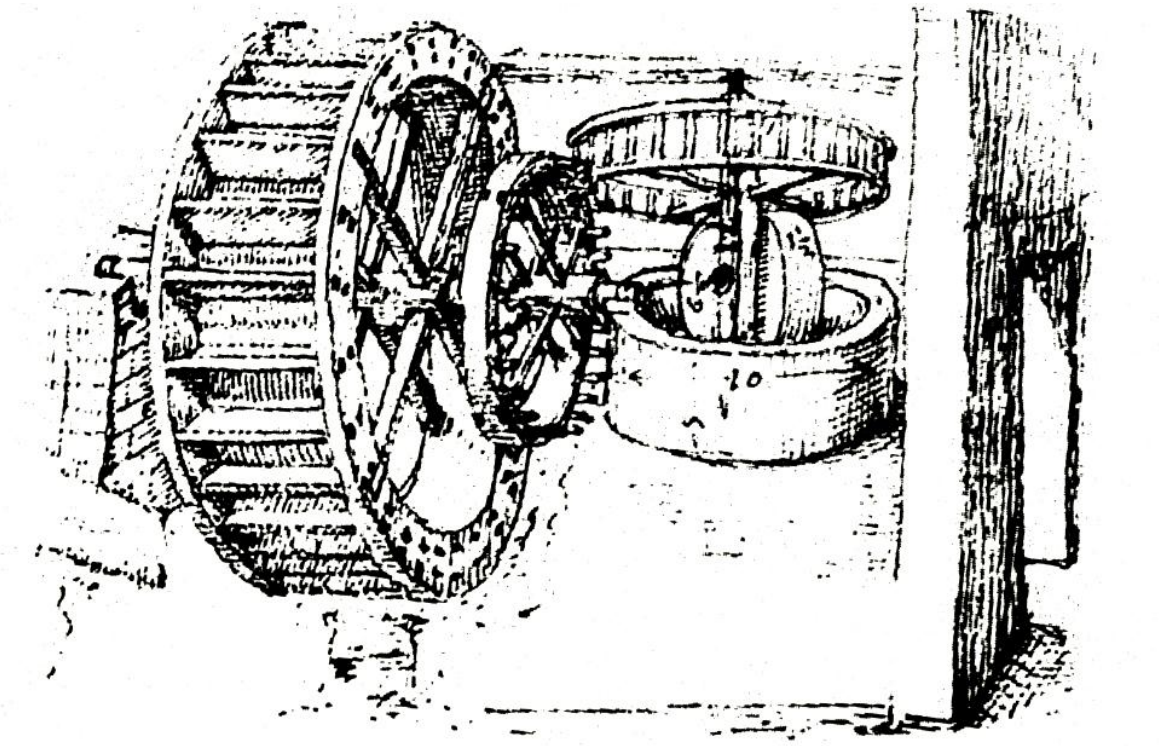


Figure 1. Traditional medieval olive mill, 'edge runner' or *almazara* of one vertical milling stone (*muela* or *rulo*), activated by a hydraulic wheel and a gear of toothed wheels that transmitted the movement to the vertical axis of the milling stone. Image taken from the "Los veintiún libros de los ingenios y de las máquinas" manuscript preserved at the Biblioteca Nacional de España (González Tascón 1992: 248). Olives were poured onto the bottom of the horizontal concave receptacle and crushed by the milling stone as it ran on them swirling around its vertical axes. This basic model seems to have been applied to the manufacturing of sugar in its medieval beginnings, reducing the sugar canes to small chunks before being milled, so that they could fit inside the receptacle.

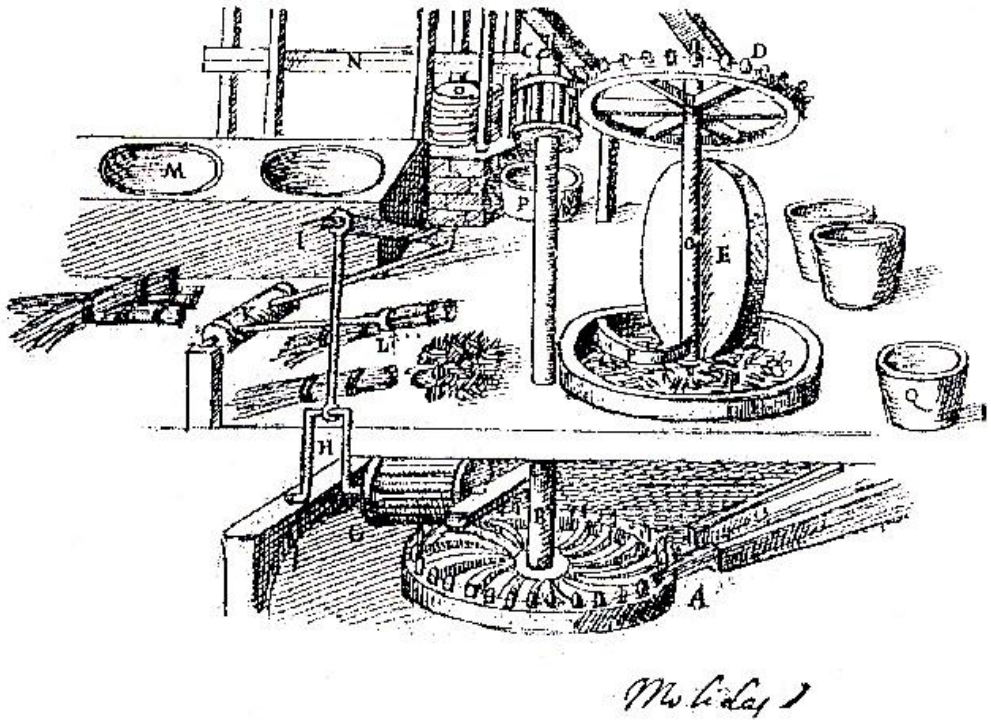


Figure 2. Drawing of a traditional olive mill or 'edge runner' with a vertical milling stone, adapted to the crunching of sugar cane pieces. It is included in the "Los veintiún libros de los ingenios y de las máquinas" manuscript. It was moved by a horizontal hydraulic propeller wheel or *rodezno* located at a lower level below the milling stone (Del Río Moreno 1991: 346; González Tascón 1992: 257).

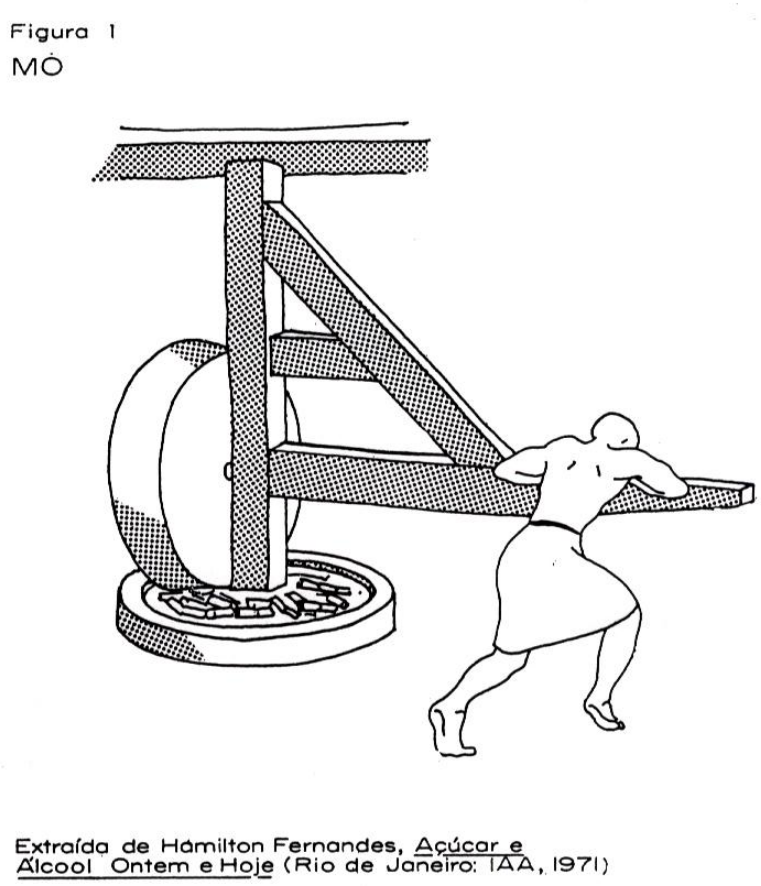


Figure 3. Drawing representing a modern interpretation of the 'edge runner' or vertical stone-wheel mill applied to the milling of sugar canes and propelled by human force, by Hamilton Fernándes (1971), and reproduced by Barros de Castro (1980: 682).

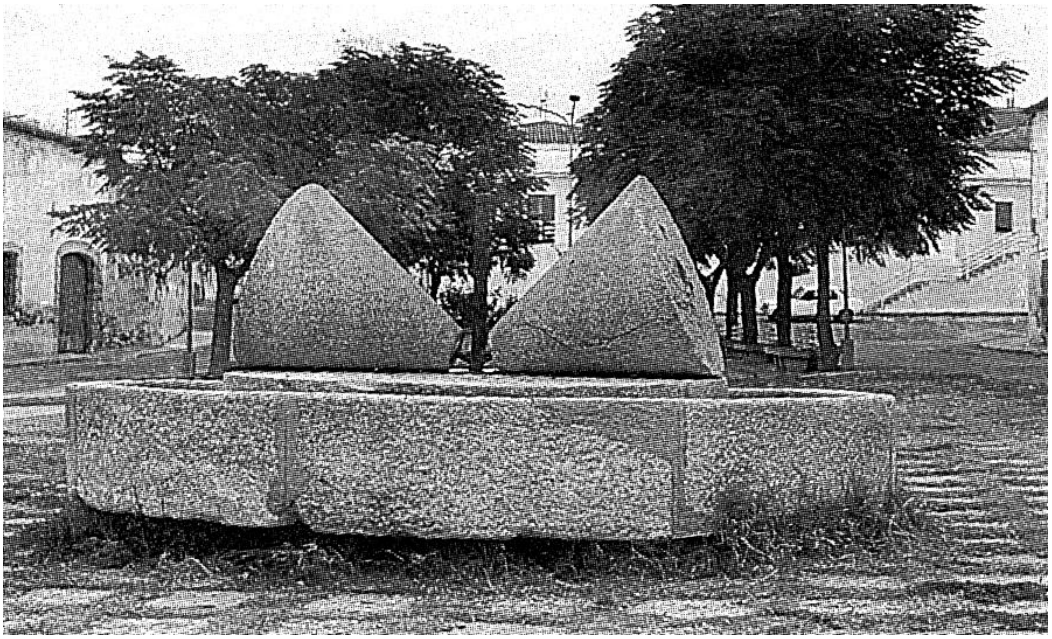


Figure 4. Photograph of the remains of an *almazara* or olive mill with milling-stones of a truncated-cone shape that ran around a common vertical axis. Located in Alcántara, Province of Cáceres, Spain (González Tascón 1992: 252).

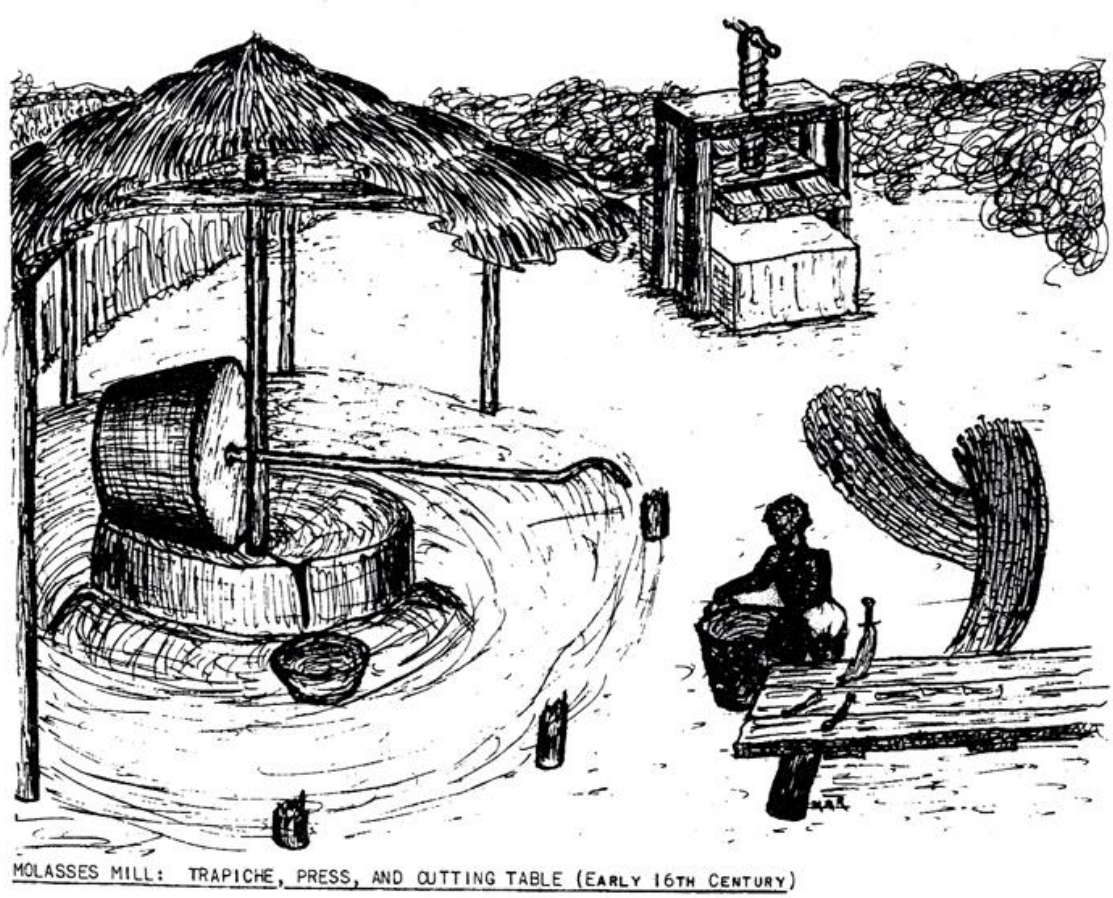


Figure 5. Drawing, included by M. Ratekin in his Master's Thesis of 1952, of a *trapiche*, shown on the left side of the image, and consisting of a vertical, stone milling-wheel with the truncated-cone shape and activated by animal traction. It swirled on a horizontal stone wheel. To the right rear side a screw press is also shown (Ratekin 1952: 37a). The [burden] animal that pulled the round milling stone would have been tied to the curved end of the horizontal rod coming out from the center of the stone.

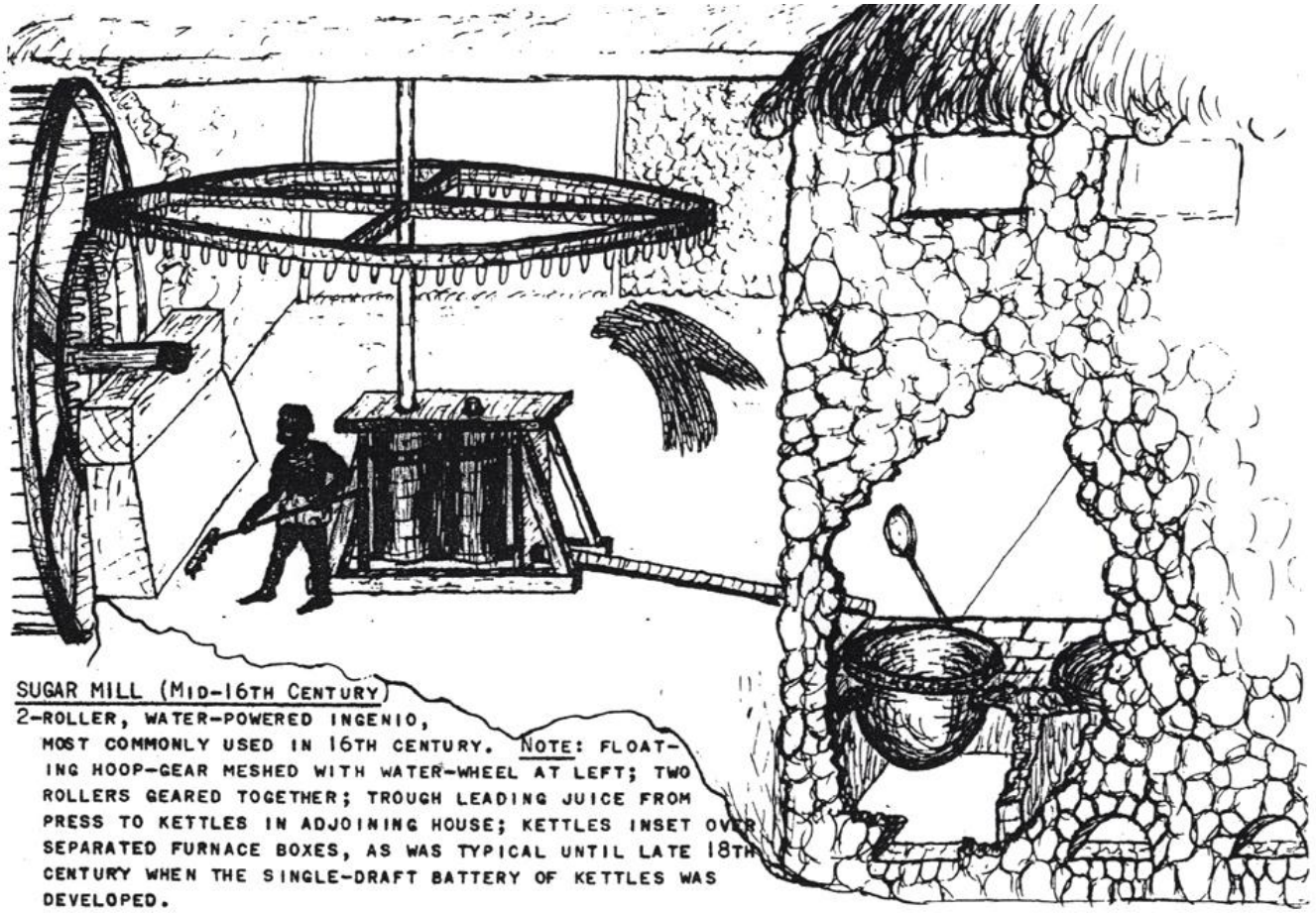
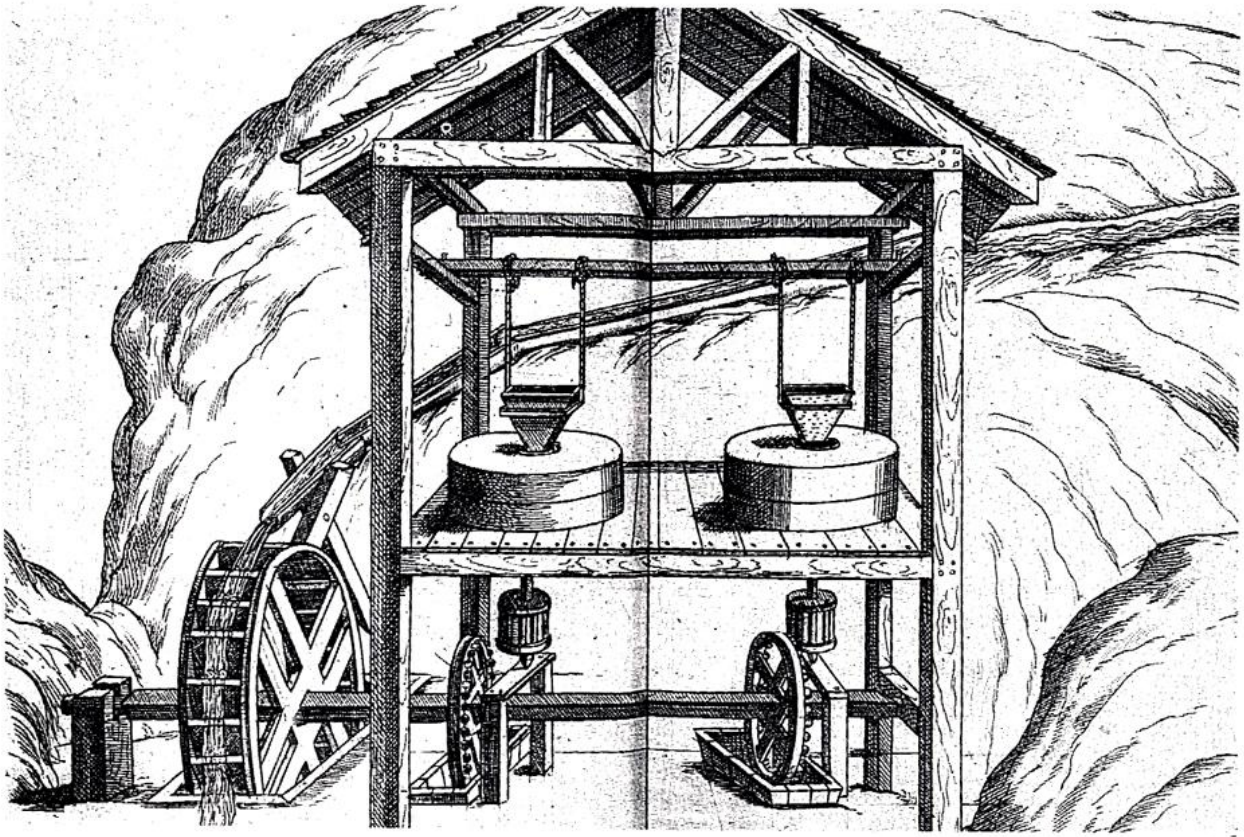


Figure 6. Drawing included by Mervyn Ratekin in his Master's Thesis of 1952, representing a vertical double roller mill, activated by a vertical hydraulic wheel (Ratekin 1952: 16a).



Sistema de engranajes para dar movimiento a las piedras de un molino a partir de una rueda motriz vertical. Figura en la obra de Fausto Veranzio Machinae Novae. Siglo XVI.

Figure 7. Representation of a flour mill composed by horizontal overlaid milling stones and propelled by a vertical water wheel (González Tascón 1992: 174). The grain to be milled was poured in between both stones by means of a conduct in the shape of an inverted truncated pyramid which pointed at a circular hole at the center of the upper milling stone or wheel.

Figure 8. Illustration attributed to Hans van der Straat, reproduced by Soares Pereira (1955: 45), originally published by Lipmann and reproduced also by Deerr. It represents –according to Soares—the sugar making cycle in 16th century Sicily, before the invention of the roller mill. On the front, the officials that sliced the canes. On the left, at mid-distance, the mill of horizontal overlaid stone wheels similar to that on Figure 7 and moved by a vertical hydraulic wheel located below the milling stones. Behind the mill, also on the left, a screw press, propelled by human force. On the back to the right, the work of boiling of the cane juice. In between the cutting and the boiling, on the right, the pouring of the boiled cane syrup into the molds or *formas* where it crystallized into sugar. On the front to the right, the final emptying of the *panelas* or sugar cones out of the molds before hammering them into chunks or grains.

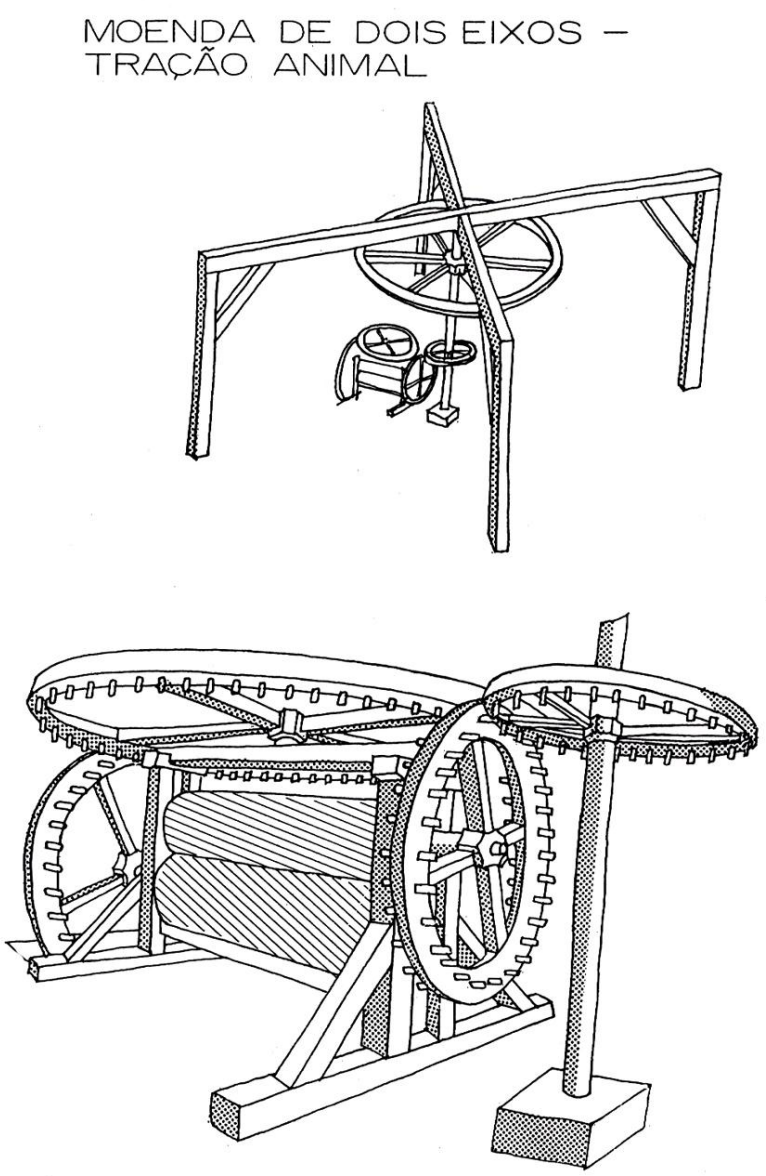


Figure 9. Drawings of a horizontal double-roller mill propelled by animal traction, included by Antonio Barros in his 1980 essay (688). Though the animals are not shown in the representation, the larger 'flying wheel' (*rueda volandera*) seen in the top drawing would have been connected by a rod to the yoked pair of animals that, marching around the entire structure, would make it swirl.

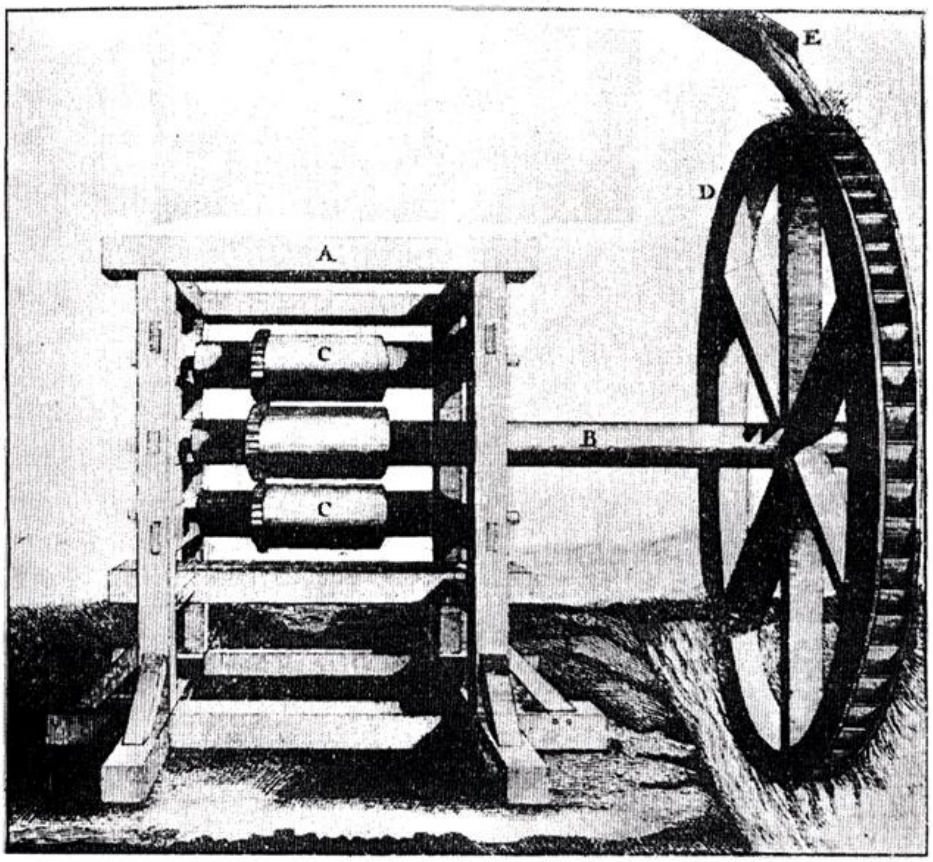


LÁMINA V.—Molino de agua de cilindros horizontales: *A*, armazón; *B*, árbol; *C C*, cilindros laterales o pequeños tambores; *D*, rueda hidráulica; *E*, canal de conducción del agua.

Figure 10. Drawing of the structure of a horizontal triple-roller mill, activated by a vertical water wheel (Pérez Vidal 1973: Lámina V, entre páginas 60 y 61).

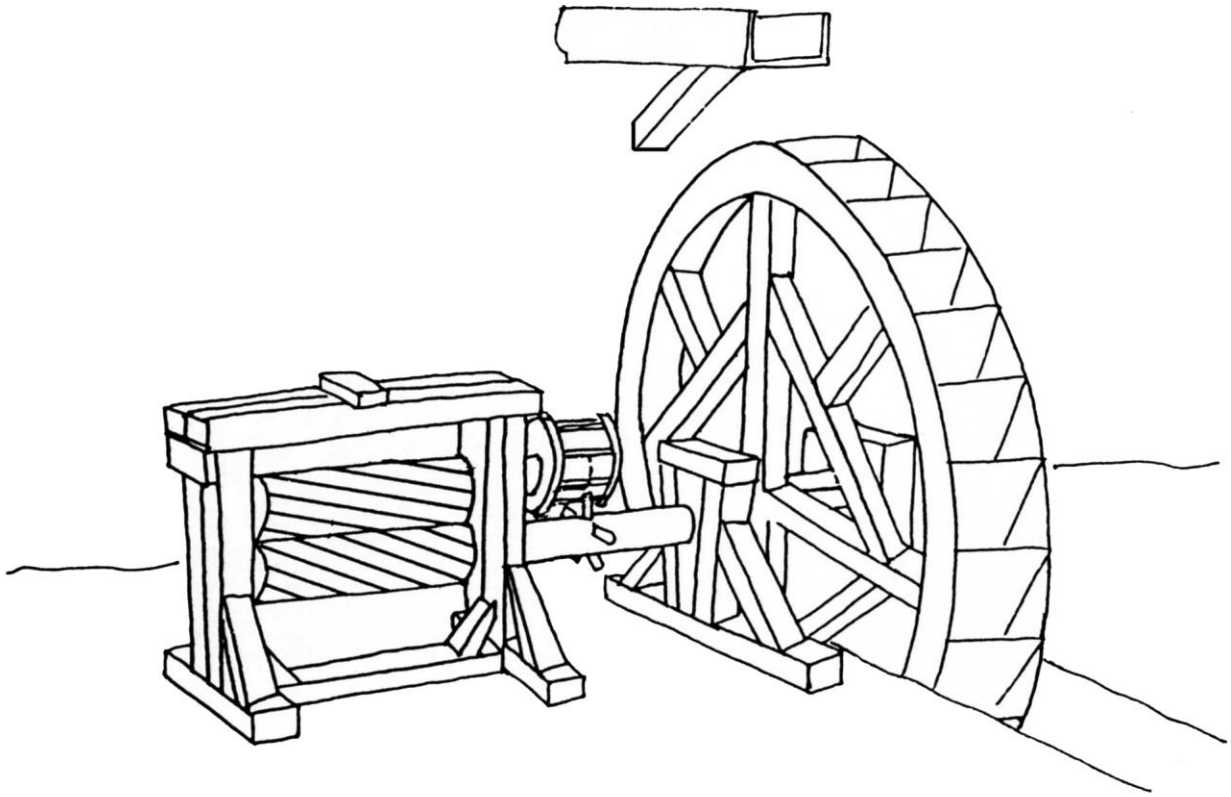


Figure 11. Mill with double wooden horizontal *ejes*, *mazas*, or rollers according to Antonio Baros de Castro (1980: 684). It is the image, out of all published until now, that we consider relatively more congruent with the data that we have found on Hispaniola's sugar mills during the first half of the 16th century. Yet, the relative positioning of the rollers shown in the drawing is just the opposite to that described by Galeotto Cei in the mills that he saw in Hispaniola at the beginnings of the 1540s. In Hispaniola it was the 'eje' or roller stemming from the propeller water wheel the one used as upper roller, also called 'larger roller' precisely because it wass longer than the lower or 'minor' one. As to the horizontal bars or *verdugos* that were affixed to the outside of the larger roller to increase its crunching power, replaced by diagonal notches in this drawing, they are described as longitudinal in the chronicle written by Galeotto Cei, who included in his piece a sketch of a 'larger roller,' reproduced in Figure 12.

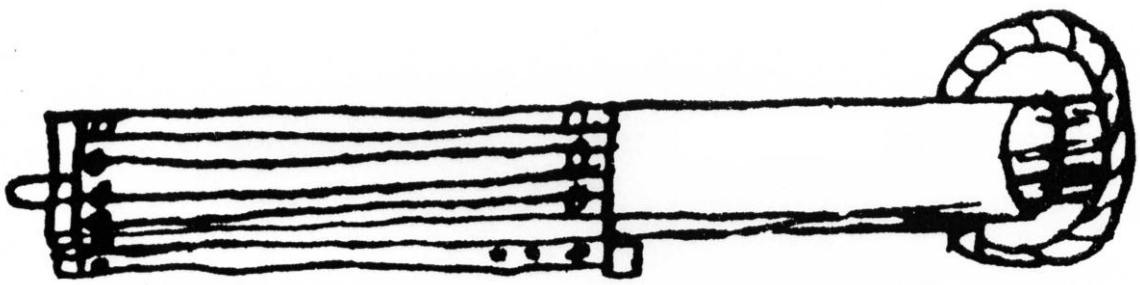


Figure 12. Drawing of the 'eje mayor' or 'larger roller' or cylinder of a roller mill, included by Galeotto Cei in his chronicle narrating his stay in Hispaniola between 1539 and 1541. It has been published by José Rafael Lovera in 1995 in his edition of the Spanish translation of Cei's e *Viaje*, page 34 of the book's section containing the chronicle per se. The image was printed vertically on the left margin of the page, but we know that it was a horizontal piece within the construction scheme of the sugar mills described by Cei. See the longitudinal bars in Cei's drawing on the left area of the roller or 'eje,' as well as the support apex or rod (an axis in the contemporary sense of the term) of the roller on its left end. On the right end of the roller, there seems to be what could be a smaller version of the propeller water wheel, or maybe a toothed wheel to which the roller transmitted a movement.

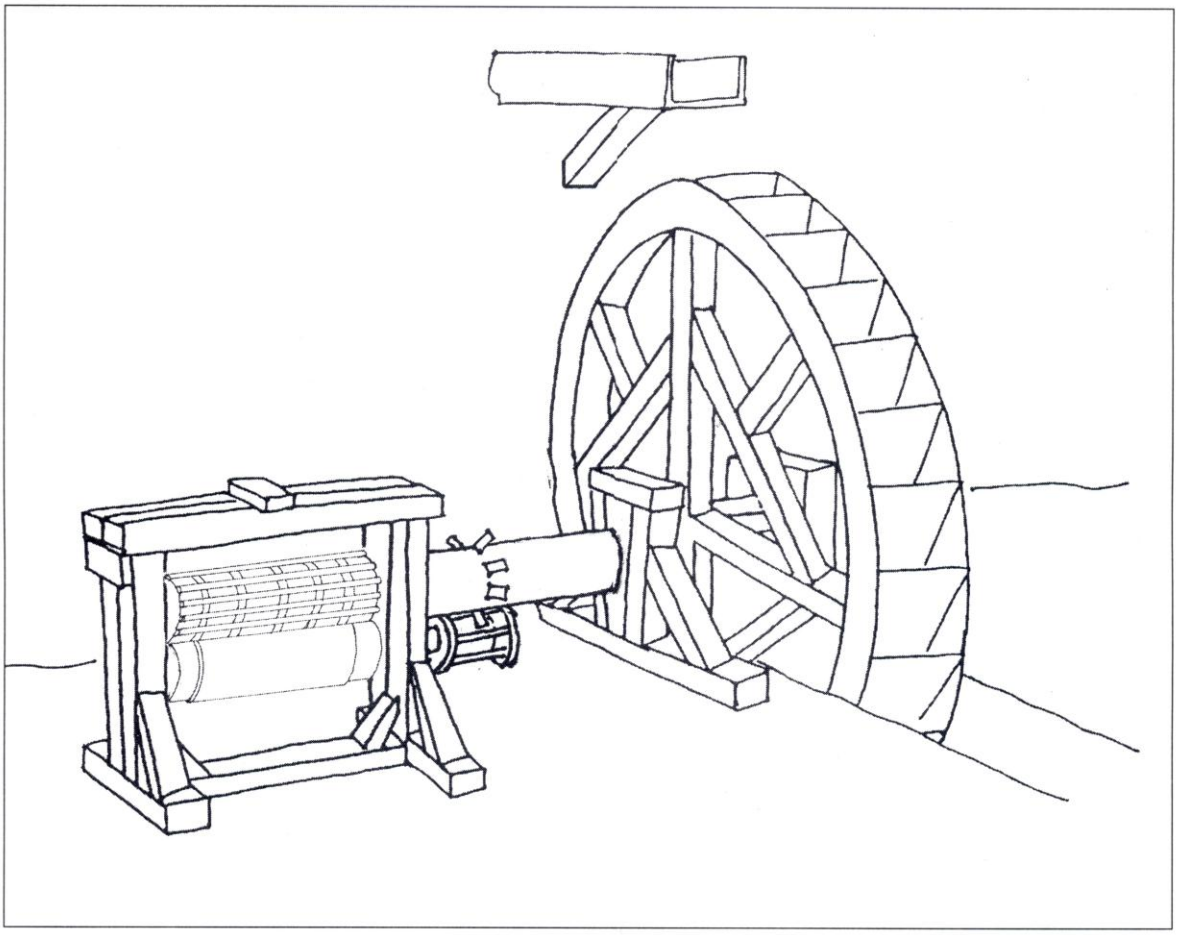
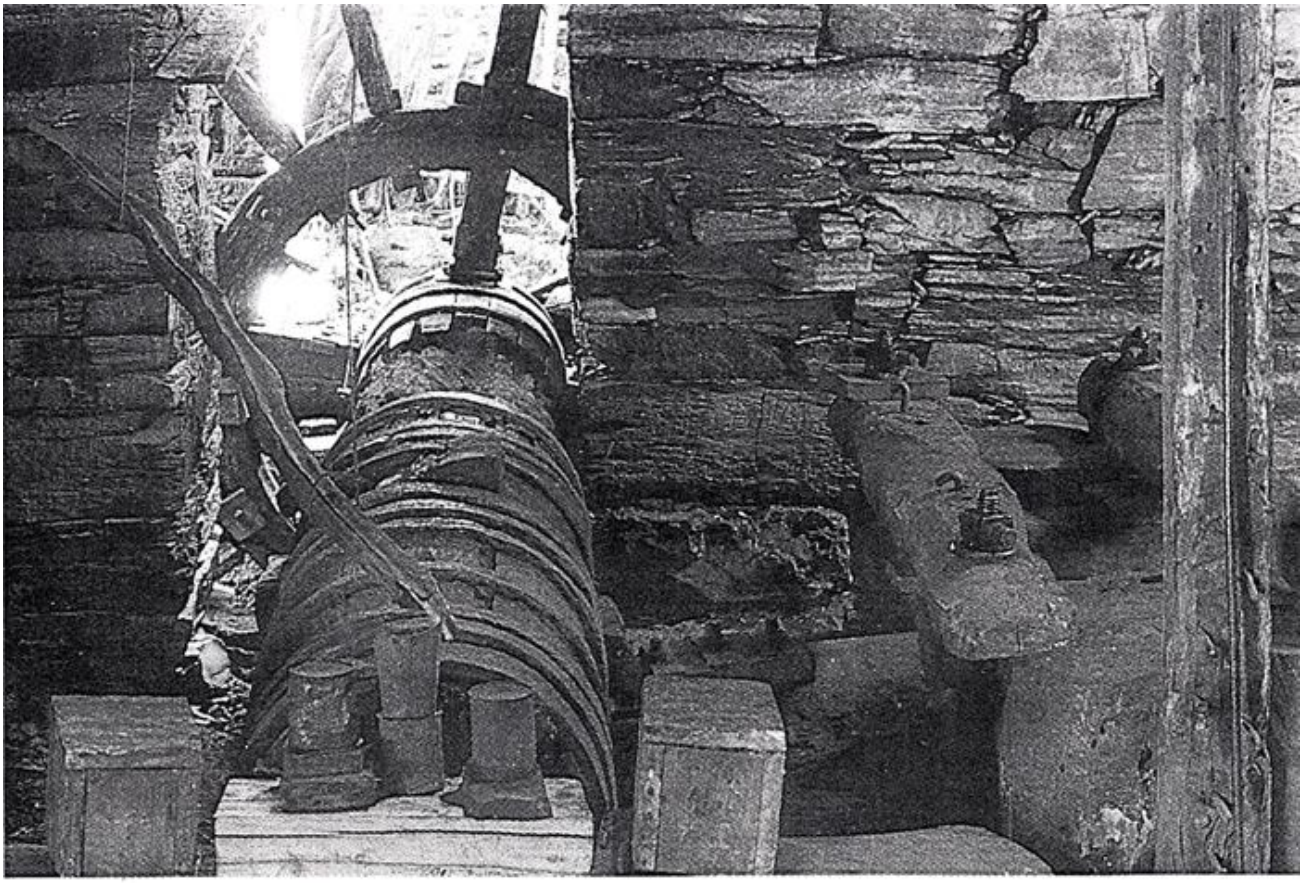


Figure 13. Interpretation of a horizontal rollerss or cylinder mill of Hispaniola at the end of the 1550s, based on a modification of Antonio Barros de Castro's interpretation of 1980 (Fig. 11). It incorporates the description provided by Galeotto Cei in his *Viaggio e Relazione.* It shows the larger roller or *eje* in an upper position, reinforced by round fasteners or *cinchos* on the outside of its periphery, and equipped with longitudinal iron bars or *verdugos* that intensified the crunching of the canes. On the smaller cylinder or roller, a cylindrical metal sheath, encasing, *chapazón*, or *funda* is shown that was used to protect and lengthen the life of the roller from the constant squeezing of the canes.



Rueda hidráulica y eje motor en el martinete de Compludo (León).

Figure 14. Photograph of a section of the interior of the premises of an old *martinete* in the Province of León, Spain (González Tascón 1992: 87). Notice on the foreground the wooden, very thick axis, which goes from the exterior water wheel, visible in the far back in silhouette against the outside light through the window-like opening, to the internal mechanism. Notice as well the fasteners around the wooden cylinder or axis. It is reasonable to imagine that a similar carpentry work may have been used to construct the 'exes' or squeezer-cylinders used in the sixteenth-century colonial sugar mills or *ingenios* of Hispaniola.

Note about the author

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