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ANCIENT OIL MILLS AND PRESSES

BY

A. G. DRACHMANN

WITH 41 ILLUSTRATIONS

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Hoc tamen video, probe esse interpreti Catonis cauendum, ne Stabiensis torcularii formam singulis Catoniani partibus accommodare conetur. Inde enim erroris periculum est manifestum.

Schneider p. 642, e.

PREFACE

The subject of this paper is an old one, and this gives rise to a special difficulty: in how far is it necessary to take into consideration what has been written before? It is very tempting just to write down your own results, and let the old literature take care of itself. But it is hardly right. Old errors die hard; they are difficult enough to kill even by taking trouble, and they positively thrive on silence. On the other hand, it is impossible to correct every silly notion that has been put on paper; a line may, nay, must be drawn somewhere.

At the outset I drew the line at BLÜMNER's book; this was the last authoritative book of reference on the subject: where I agreed with him, I said nothing, where I disagreed with him, I gave my reasons. Of course, BRØNDSTED's results, in the Recherches à Salona, which came out much later, deserved special consideration, as did HÖRLE's book, which came out later still. Then I found TH. BECK's interesting paper in the Civilingenieur, which had escaped BLÜMNER, and so had to take that up, too. To this was added HERO's Mechanics, which because it is preserved in the Arabian text only, has been a sort of philological No man's land; I found it necessary here and there to differ from NIX's interpretations.

Still, all this was no real departure from my original principle. But when I came to study the Herculanensians and La Vega, because they are the only available sources of information about the excavations at Stabiae and the discovery of the first trapetes, a curious and rather unexpected discovery was made: these writers of the latter half of the eighteenth century were, within their limits, far better informed than most of the later authors. An example will illustrate both the fact and the reason for it: the lever and screw press with stone weight, which puzzles both Blümner and Brøndsted very much, was still in use at the time of Meister and La Vega; so to them it is so evident what Plinius meant, that they hardly bother to point it out in detail. Between their time and Beck's this press got superseded almost everywhere; so Beck and Paton had to discover it anew to understand it. To Billiard, on the other hand, it seems once more too familiar, vide his p. 453. I have therefore included far more of these ancient writers in my consideration than I had deemed necessary from the first; partly because they deserve it, partly to show how our knowledge may grow less unless care is taken.

For illustrations I have, apart from a few photographs of actually existing objects, relied almost exclusively on my own drawings. The fact that I have been able to do so I owe to two persons: one is my uncle, P. Bentzon, surveyor in chief to the Danish state railways, in whose office I spent, long ago, five most instructive months, when I learned, among other things, to handle a drawing pen; the other is my brother, stud. polyt. J. Drachmann, who has helped me in word and deed and taught me the elements of perspective drawing. To these two members of my family I offer my respectful and cordial thanks.

My thanks are due elsewhere also. To the museum authorities of the Museo Nazionale in Napoli, and to Professor MANCINI, of the Museo nazionale Romano delle Terme Diocleziane; to Mr. BROHOLM and Dr. BRØNDSTED of the Danish National Museum, and Dr. FREDERIK POULSEN for all sorts of information, to Mag. H. P. L'ORANGE, who verified certain facts for me in Rome. Professor CHR. BLINKENBERG sent me a sketch from which my fig. 33 was drawn, and later did me the great favour of looking through my manuscript, to its improvement, for which I offer my sincere thanks.

The owner of the Palazzo Rondanini, Count SANSEVERINO, on learning of my wish to have the relief in his possession photographed, at once sent me the photograph from which my fig. 10 is reproduced, for which courtesy I wish to present here my most respectful thanks.

The last place on my list I reserve, as a place of honour, for the director of the Swedish Archaeological Institute in Rome, dr. A. BOËTHIUS; I hardly know which to praise most, his kindness to me, when I was in Rome, or his services, when I had returned home. To him I owe the photograph from which my fig. 13 was drawn, the photograph reproduced as fig. 15, and, indirectly, the photograph of the Rondanini relief; when I wrote and asked for particulars about the Bosco Tre Case press, he secured for me the information given in Appendix 1, information scarcely to be found in any other way. For all his *bona officia,* and for the kind interest he has taken in my work, I want to express my deep sense of gratitude.

The outward form of this paper is somewhat out of the ordinary and so deserves a few words of explanation. In a work of this sort it is necessary to pave one's way with quotations and references, if it is to be of any use to the serious student. If these references are allowed to fill the text, they make it almost unreadable to anybody else. Signs or figures referring to the bottom of the page are unsightly; if the references or notes are placed apart after the text, they demand a constant turning backwards and forwards of the leaves that is insufferable. But the problem of placing information in such a way that it is easily available to him who seeks it but does not obtrude itself upon anybody else has been solved long ago in all ordinary editions with critical apparatus: the lines are numbered, which offends nobody, and the references are given at the bottom of the page by line number. In the list of literature, p. 129, an explanation is given about the meaning of any references not at once clear to the reader. As La Vega's book is hard to get, and the work by the Herculanensian Academy is very unwieldy, I have given always, when possible, also the reference to the reprint in Schneider's edition, which will be found sufficient in most cases.

Copenhagen, Langøgade 19, May 1932.

A. G. Drachmann.

PART I:
THE TRAPETE

1. Cato's trapete compared with the existing trapetes.

In order to get the olives to yield their oil, it is necessary first to crush them and then to press them. While Columella mentions four means for the purpose of crushing the olives, Cato has but one: the *trapetum,* as it is generally called, though Cato, who is not very consistent about it, seems to prefer the form *trapetus.* Cato takes it for granted that his readers know a trapete by sight, and so does not give any description of it, though he tells us where to buy it, how much to pay, how to put it together and how to adjust it; also, because it is necessary to have three trapetes of different size, he gives us the dimensions of all three. The reason for having three sizes is this, that a millstone from a larger trapete, when worn out, can be cut down to fit a smaller one. All this is very interesting, but it is hardly enough to give the reader a clear picture of the thing, as is seen by the fact that neither Meister, who wrote in 1763, nor Goiffon, who wrote in 1783, were able to reconstruct it. The excavations at Stabiae in 1779 and 1780, however, brought to light three machines which were readily recognized as oil-crushers and identified with the *trapetum;* against this interpretation, first put forth by Francesco La Vega in

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2 12 : 52. **10** 3 : 5. **11** 135 : 6.

1783, no serious objection has been raised. The only difficulty, stated already by Schneider in 1794, lies in the apparent contradiction of the remark by Columella, that the *mola* is better than the *trapetum* because it can be adjusted to fit olives of different sizes, and Cato's instructions on how to adjust the trapete. That this contradiction is only apparent will be shown later.

One trapete, found at Stabiae, is in the museum at Naples; another, found in 1891 in Boscoreale, is in Pompeji; through the courtesy of the museum authorities I have been allowed to measure them both. The Pompeji trapete stands in the Porta Marina and has been put together for the information of the visitors; the guides will turn it to show how it was worked. The one at Naples is standing together with some grain mills in a garden; the millstones are lying on the earth near by.

The immovable part of a trapete, see fig. 1, is made of lava in the shape of a large cup, the *mortarium;* in the middle of the cup a solid column has been left, the *miliarium;* thus the hollow of the cup is ring-shaped, with a vertical inner side and a curved outer side. The *miliarium* is a few cm higher than the lip of the cup; the lip is called *labrum*. On the top of the *miliarium* there is a square hole, in which an upright iron pin, the *columella,* was fastened by means of lead. The movable part consisted of a wooden beam, the *cupa,* which fitted over the *columella* and rested on the *miliarium* in a horizontal position; on its two arms were threaded two millstones, *orbes,* flat on the side towards the *miliarium,* but convex on the outer side, so that they dipped into the ring-shaped cup. They were kept in their place by

2 618; Blümner 338; Brøndsted 112, n. 1. **3** 12 : 52 : 6. **5** 22 : 2. **7** p. 41.

a system of washers and wedges. When properly adjusted they would keep a distance of exactly one Roman inch from the *miliarium*, from the bottom of the hollow and from its outer, curved side. When the trapete was filled with olives, and the *cupa*, which projected beyond the *orbes* to form handles, was turned, the *orbes* would perform a double rotation, going round the *miliarium* and at the same time turning on their axles. The result was that the olives were crushed, but the olive stones were not, which was indeed the point of the whole arrangement, as the ancients held that the crushed stone spoiled the flavour of the oil.

On two of the *orbes* from Stabiae La Vega found circular abrasions on the convex side, showing that the stone had been touching the lip of the *mortarium*. From this and from some particulars in the iron fittings found in the same room La Vega concluded that the trapete had a double function: first to crush the berries, and afterwards, by a new adjustment, to crush the stones; and he describes at length a system of wedges and washers that would make it possible. On his own showing the trapete did not work well in the second position, as the stones had to be shovelled up all the time; he even had to invent a sort of shovel to be fixed to the *cupa* to make the engine practical. The *orbis* can touch the *mortarium* only at one place, at the edge of the hollow, and a glance at his drawing will show that there is nothing to induce the stones to come up there and be crushed. As there is no tradition to support the theory that anybody ever wanted to crush the stones at all, it would seem more probable that the *orbes* had touched the *mortarium* so as to get scratched through carelessness in the adjusting or

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10 Columella 12 : 52 : 6. **12** 56; Schn. 624. **20** 62; Schn. 629. **25** Tab. ii; Schn. tab. viii.

because the trapete was old and worn; and I should never have mentioned La Vega's ingenious theory if I had not found in recent books dealing with the subject reproductions of the old drawing showing the *orbis* touching the *mortarium.*

In order to compare the existing trapetes with the measurements given by Cato I have measured very carefully the two trapetes I have been able to see, the one in Pompeji and the one in Naples. Cato died 149 b. C., and Pompeji was destroyed 79 a. D., which gives us 228 years between the last possible date for Cato's work and the year when the trapetes were in use. During these years the Greek influence on the Roman culture was steadily growing; from the writings of the elder Plinius we know that the oil-presses were much improved, from Columella that the oil-mill, *mola olearia,* was superseding the trapete. We must therefore expect to find the trapete itself in 79 a. D. differing from Cato's description in some of its details. What I did not expect to find was that neither of the trapetes can be put together and adjusted in the way prescribed by Cato. The *mortaria* are no doubt *mortaria,* and the *orbes* are unmistakably *orbes,* but the *orbes* will not fit the *mortarium* with which they are found. This is unfortunate, for it means that we can draw no conclusions from the relations between the *orbes* and the *mortarium* found about their relations at the time.

La Vega found in Stabiae three trapetes, or rather two trapetes, one *mortarium* and one set of *orbes.* One trapete was found at Oliaro, on February 13. 1779; the other in Casa di Miri, in March 1780. The third *mortarium* and the

3 Blümner 340, fig. 121. **14** 18 : 317. **15** 12 : 52 : 6. **29** 53; Schn. 622; Rugg. 276, 338. **30** 54; Schn. 622.

third set of *orbes* were found not far from one another on the roads to Gragnano and St. Leo. The first trapete was sent to the royal museum at Portici, the second was sent to Pompeji; of the rest nothing is said.

The *orbes* measured by me in Naples form a pair, and are the *orbes* from Oliaro, since the iron ring described and copied by La Vega is still in position; La Vega states expressly that only on one single *orbis* a ring was found. The ring is wonderfully well preserved, so much indeed that I have suspected the *orbes* of not being antique at all, but the *orbes* made by La Vega from the dimensions of the Oliaro *orbes*. That this cannot be the case is shown by the other *orbis* showing traces of having had a ring once, since La Vega tells us that he followed his model so exactly that he put an iron ring on only one *orbis*.

The *mortarium* measured by me in Naples is neither the one from Oliaro nor the one from Casa di Miri, since it does not agree with the dimensions given by La Vega for these two; so it must be the one found in the road to Gragnano, or a fourth *mortarium* of which we know nothing. La Vega gives us the internal radius of the cup; in the Oliaro trapete it was 2 palmi an $^1/_2$ ounce, in that from Casa di Miri 1 palmo and $8^1/_2$ ounce, Neapolitan measure. One Neapolitan palmo being 26.3 cm we get 53.7 cm and 45 cm respectively, while the Naples trapete measures 40.75 cm. Moreover the Herculanensian Academy gives the dimensions of the Casa di Miri trapete, and they do not agree with those of the present trapete in Naples.

The Naples *orbes* are 71.0 cm high by 22.0 cm thick; the

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2 63; Schn. 624. **6** 55, tab. iii; Schn. 624, tab. ix. **7** 56; Schn. 624. **14** 62; tab. iii; Schn. 629, tab. ix. **18** 57; Schn. 626. **26** xiii; Schn. 648.

holes are square, but of slightly different size: on one it is 13.0 cm square on the curved side, 12, 12, 12, 11 cm on the flat side; in the other *orbis* 14, 14, 15, 15 cm on the curved side, 13 cm square on the flat side. Cato gives only one measure for the holes, 8 inches or 14.7 cm; we may therefore take it that the tapering of the holes is a more recent improvement; it would make it easier to make the wooden bushes stick. Across the hole on the inner side of one *orbis* is fixed an iron ring, 9.4 cm in diameter by 1 cm thick, see fig. 2. It consists of two pieces, the middle part of each forming a perfect half circle; where they meet, the ends, keeping close together, span the rest of the hole and are then turned down towards the stone, where they are fastened by means of lead into square cuts made in the edges of the hole. In the two other edges there are two square cuts, too, to show that the ring has been fixed there before; the other *orbis* showed similar cuts, single on two edges, double on the other two, as if the two parts of the ring had been fixed separately into the stone. The inner surface of the ring is flush with the surface of the stone.

The *mortarium* found with these *orbes* is 58.0 cm high, the *labrum* is 8.5 cm thick, the distance from the *labrum* to the *miliarium* 22.5 cm, the *miliarium* 36.5 cm broad and 33.0 cm high, its height over the *labrum* 2.0 cm. The whole diameter of the *mortarium* is 98.5 cm.

If one of these *orbes* were fitted on to this *mortarium*, its lower edge should stand one Roman inch above the bottom of the cup. The *miliarium* is 33.0 cm high, the *labrum* 2 cm lower, or 31.0 cm above the bottom. Deducing our Roman inch, or 1.8 cm, we get the depth to which the *orbis* should dip into the cup, 29.2 cm. See fig. 3. But at

4 22 : 4.

this point the *orbis* is still 22.0 cm thick, and so would fill out the space between the *labrum* and the *miliarium* almost, leaving only 0.5 cm of its 22.5 cm, instead of two Roman inches, or 3.6 cm, as demanded by CATO. This of course will not do; the flat side of the orbis, being only 0.25 cm from the *miliarium,* would crush both olives and stones. If we try to make the distance from the *miliarium* correct, 1.8 cm, and the distance from the *labrum* say 0.8 cm, we must lift the *orbis* till its thickness at the height of the *labrum* is 19.5 cm. But in this position the *orbis* will dip only 20.0 cm into the cup, and so stand 11.0 cm from its bottom, thus leaving there a thick layer of olives that will escape crushing altogether.

The trapete in the Porta Marina in Pompeji was found in Boscoreale during the excavation in 1891. It is worth remarking that the *mortarium* was found in a room, near another room that contained an oil-press, but the *orbes* were found in the peristyle, at least 30 m from the room. As there does not seem to be any reason why the *orbes* should not be kept in the same room with the *mortarium,* it is indicated that they were either taken out because they did not fit, or were just brought, so that they were not yet tried.

The *orbes* are 88.5 cm high by 24.5 cm thick; the hole is 13.5 cm square on the outer, curved side; on the inner side it was hidden by the square part of the *cupa,* so that I could not measure it. The *mortarium* is 64.0 cm high, the *labrum* 12 cm thick, the distance from the *labrum* to the *miliarium* 28.5 cm, the *miliarium* 41.3 cm broad by 35.0 cm high, its height over the *labrum* being 1.5 cm; the whole diameter of the *mortarium* is 123.3 cm.

If we try to fit one of these *orbes* on to this *mortarium,*

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14 MAU 135.

we will see that it is 24.5 cm thick, while the distance between the *labrum* and the *miliarium* is 28.5 cm, leaving 2 cm inside and outside; a very nice fit, as the inch demanded by Cato is 1.8 cm. But the orbis is 88.5 cm high; deducing 13.5 cm for the hole and dividing by 2 we get 37.5 cm for the part dipping into the cup. But the *miliarium* is only 35.0 cm high, the *labrum* 1.5 cm less, or 33.5 cm; deducing the Roman inch, 1.8 cm, we get 31.7 as a maximum; but at this distance from the edge the *orbis* is only 23.5 cm thick, and the distance is increased to 2.5 cm at both sides, or 1.35 Roman inch. Still, no one expects modern standards of precision to apply to the trapetes, which are rather clumsy machines at best, and I should not hesitate to accept the *orbes* as a fair fit, if there was not additional cause for doubt. In order to understand that, it is necessary to consider a little more in detail the way in which the trapete did its work. If we study the form of the ring-shaped cup, we find that it consists of two surfaces: an inner surface, where the *miliarium* is, which is a true cylinder, the axis of which is a vertical line through the middle of the *miliarium;* and an outer surface, which shows a double curvature: seen from above, it consists of concentric circles with their centres in the line mentioned above; when the cup is cut by a vertical plane through the middle of the *mortarium*, it shows a short arc, which has yet to be determined. As the side of the cup has to keep an equal distance from the surface of the *orbis* through the double revolution of the latter, the arc must be part of a circle having its centre in common with the sphere of which the outer surface of the *orbis* is part. But where is that centre? *A priori* I thought that it must be in the axis of the *mortarium*, too, so that this side of the cup formed part of a true sphere. But on reconstructing Cato's trapetes from the dimensions given by him, I soon found that this was not the case; in every single instance the centre of the *orbes* would fall short by a few inches of reaching the axis of the *mortarium*. This cannot be accidental. The reason for it I believe to be this: if the centre of the *orbis* were in the axis, the edges of the *orbis* would be only one inch from the cup, and very few olives would be crushed between the *orbis* and the side; most would go in between the *orbis* and the *miliarium*. By making the diameter of the *orbis* shorter, the *orbis* is made to curve away from the cup at the edge; only along one line, farthest from the axis, the *orbis* will have the distance of one inch from the cup; the rest will form a narrowing gap well calculated to make the olives come in and be crushed. See fig. 4. It is true that Hörle seems to think that all the crushing was done between the *miliarium* and the flat side of the *orbis*, and that the edges of the *orbis* were only meant to shovel the olives about, but that is not consistent with the dimensions given by Cato. When attempting to reconstruct the trapete from Pompeji we find, however, that the centres of the *orbes* will fall on the other side of the axis of the *mortarium*; this means that the middle of the *orbis* will be farther away from the outside of the cup than the edges, and no crushing will be done by the curved sides of the *orbes*. See fig. 4. But if the *orbes* were cut down to fit the height of the *labrum*, from 88.5 to 76.9 cm (31.7 + 13.5 + 31.7), the radius would be short enough, and we get thus a very interesting illustration of Cato's directions about cutting down the *orbes* from the larger trapete to fit the smaller one, and we may assume that the *orbes* in question were waiting for the stone-cutter in the peristyle.

15 192. **28** 3 : 5.

Besides these two trapetes we know the dimensions given by La Vega for the Oliaro trapete and those given by the Herculanensians for the Casa di Miri trapete; of the latter trapete there is a drawing to scale, made by the Herculanensians. In the matter of the Oliaro trapete the case is a little more difficult. La Vega gives only one single dimension, the internal radius of the cup, 2 palmi and $^1/_2$ ounce, or 53.7 cm. Next, he gives a drawing to scale, but not of the actual trapete, as he found it, but of the way in which he reconstructed it for his experiments. So what we get is probably the outline of the actual *mortarium*, but a set of ideal *orbes* for this *mortarium*. Else I fail to understand why the dimensions of these *orbes* are a few cm too large as compared with the actual *orbes* now in the museum at Naples. The figures, measured from the drawing and compared with the scale of the same drawing, are: *mortarium* 108 cm; *labrum* 10 cm; distance from *labrum* to *miliarium* 25.3 cm; radius of *miliarium* 19.2 cm; height of *miliarium* 33.7 cm; height of *labrum* 30.7 cm; height of *orbis* 74.5 cm; thickness of *orbis* 23.7 cm; hole 16.7 to 12.8 cm; radius of *orbis* 41 cm; thickness of *orbis* in the height of the *labrum* 22 cm; depth of *orbis* in the cup 27.5 cm.

The dimensions of the Casa di Miri trapete are given by the Herculanensians in Roman measure; translated into cm they are: *mortarium* 106.9 cm; *labrum* 9.2 cm; from *miliarium* to *labrum* 25.8 cm; height of *orbis* 42.4 cm (! This is a printer's error; the text has 1′ 7″ for 2′ 7″, as is shown by the drawing; read:) height of *orbis* 71.9 cm; thickness of *orbis* 23.1 cm; hole 14.75 to 12 cm.

A trapete of the same shape has been found in Malta

2 57; Schn. 626. **3** xiii; Schn. 648. **4** Tab. ii; Schn. tab. xi. **8** Tab. ii; Schn. tab. viii. **24** xiii; Schn. 648. **28** Tab. ii; Schn. tab. xi.

and published by A. A. Caruana; the dimensions, given by the author in English feet, are: height of *mortarium* 2 ft. 8 ins. or 81 cm; diameter of *mortarium* 4 ft. 2 ins. or 127 cm; height of *orbes* 2 ft. 9 ins. or 84 cm. There is a drawing, but it is drawn to a scale too small to admit of exact measuring.

Turning now to the dimensions given by Cato for his three trapetes we find them as follows:

	I	II	III
mortarium	4′ 8″	4′ 4″	4′
inter miliarium et mortarium ..	2′ 2″?	1′ 1″	1′
labrum	1″?	5″	5″
orbis altus	3′ 8″	3′ 5″	3′ 3″(?)
orbis crassus	1′ 4″	1′ 3″	1′ 2″

Two of these figures are most obviously wrong; in the largest trapete the distance between the *miliarium* and the *labrum* must be 1′ 2″, and the *labrum* 5″ thick. In the first case the text runs: *P. II digitos II*, while in almost all other cases there is an *et* between the *pedes* and the *digiti;* the missing *et* may explain the superfluous *I;* in the other case the difference between *digitum* and *digit.* $\bar{v}$ is very small. The corrections were made by Meister in 1763, and I fail to see why the text is still burdened with these manifest errors. It is tempting with Meister to correct the height of the *orbis* of III to 3′ 2″, since the figures are as nearly proportional as they can be, if no fractions are used, except for this single figure. Still, this single inch makes hardly any difference in this place, being only 2 $^{0}/_{0}$ of the whole height, so I do not consider the correction worth while.

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1 The American Journal of Archæology 1888 : 4 : 453, fig. 18. **6** 135 : 6. **21** 35. **23** 36.

The *pes* at Cato's time was 29.5 cm and held 16 *digiti* of 1.844 cm each. To make the figures more handy I have reduced them all to inches; the reduced and corrected table takes this form:

	I	II	III
mortarium	72″	68″	64″
labrum	5″	5″	5″
inter miliarium et labrum	18″	17″	16″
orbis altus	56″	53″	51″
orbis crassus	20″	19″	18″

From the figures thus given we will try to reconstruct, say, the second Catonian trapete, (II). See fig. 5. A horizontal line is drawn to represent the middle of the *cupa*; a vertical line is drawn to form the flat side of the *orbis*; their point of intersection is called A. The hole through the *orbis* is 8″ square; so 4″ are measured off above and below A, at B and C; two horizontal lines are drawn through B and C, the thickness of the *orbis*, 19″, is measured off, and we get the points D and E. Half the height of the *orbis*, 21.5″, is measured off above and below A, at F and H. The centre of the arc of the *orbis* is found where the normal through the middle of DF intersects the middle of the *cupa* at G; with this as a centre the arcs FD and EH are drawn, and the *orbis* is complete. Still using the point G as a centre, but with a radius 1″ longer than GH, we draw an arc to represent the curved, inner side of the *mortarium*. A straight line, parallel to CH at a distance of one inch, represents the side of the *miliarium*; where it intersects the inside of the *mortarium* at I is the bottom of the cup. The distance between the *miliarium* and the *labrum* is 17″; a line is drawn parallel to the *miliarium* at this distance; where it intersects the curved side of the cup is the inner edge of the *labrum*, K. 5″ outside this is the outer edge of the *labrum*, at L. The whole *mortarium* is 68″ across; measuring 34″ from the outer edge of the *labrum* we reach the middle of the *mortarium* at M; a vertical line through this point is the axis of symmetry; the other half can be reconstructed from the first half. Two dimensions cannot be found directly from Cato's figures: the height of the *mortarium* and the height of the *miliarium*. These points will be discussed below, p. 21.

There is now material for a comparison between the existing trapetes and the Catonian trapetes; in table 1 all measures are given in Roman inches; to emphasize the fact that the Pompeji and Naples *orbes* do not belong with the *mortaria*, I have put them into separate columns; as I believe that the Naples *orbes* belong with the Oliaro *mortarium* I have repeated the dimensions of the latter in the column of the former; the difference between La Vega's *orbes* and the Naples *orbes* I have already explained.

The Naples trapete is altogether smaller than Cato's, but the Pompeji trapete is very nearly of the same dimensions as the trapete III, while the Malta trapete resembles trapete II. In one particular, however, all the later trapetes differ from the Catonian trapetes: the cup is far deeper. See fig. 6. The cup in III is 16″ broad and 12.36″ deep, while the cup in the Pompeji trapete is 15.45″ broad and 18.24″ deep. The Naples trapete shows similar proportions: 12.2″ broad and 16.8″ deep. As far as we can judge from our material, the trapete has developed towards a narrower and deeper cup. If we look at the *orbes* we shall find the same development. The *orbis* of II is 53 by 19; that of the Pom-

19 p. 16.

Table 1.

	Catonis			Pompeji		Naples		Mi-ri	Oli-aro	Mal-ta
	I	II	III							
Mortarium	72	68	64	62	..	53.5	58.5	58	58.5	69
Labrum............	5	5	5	4.3	..	4.6	4.9	5	4.9	..
Inter milliar. et labr.	18	17	16	15.5	..	12.2	13.8	14	13.8	..
Radius of milliarum	13	12	11	11.1	..	9.9	10.5	..	10.5	..
Height of milliarum	..	..	..	19	..	17.9	18.3	..	18.3	..
Height of labrum ..	14.4	12.8	12.4	18.2	..	17.8	16.7	..	16.7	..
Height of orbis	56	53	51	..	48	..	38.5	39	40.5	45.5
Thickness of orbis..	20	19	18	..	13.3	..	11.9	12.5	12.9	..
Radius of orbis	29.6	29	27	..	27.3	..	21.6	..	22.2	..
Orbis thick in labr..	16	15	14	13.5	..	10.2	11.9	..	11.9	..
Orbis high in labr...	13.4	11.8	11.4	17.3	..	15.8	14.9	..	14.9	..

Table 1 shows the dimensions of all known trapetes compared with Cato's dimensions; all the figures represent Roman inches.

Radius of *orbis* means the radius of the sphere of which the *orbis* is part. *Orbis* thick in *labrum* means the thickness of the *orbis* at the height of the *labrum*; *Orbis* high in *labrum* means the height of the part of the *orbis* that dips into the cup.

peji trapete 48 by 13.3 The Pompeji *orbis*, to be proportional to the II *orbis*, should have been 17.2 thick; the Naples *orbis*, with its height of 38.5, should have been 13.7 in stead of 11.9 thick. Cato's *orbes*, as will be seen from the table, dipped into the cup to less than one quarter of their height; it is very probable that the *orbes* of the later trapetes dipped down almost to the hole; indeed, they must have done so. From the ring on the Stabiae *orbis* we know the thickness of the axle to have been 9.4 cm or 5″; from the drawings of La Vega, who found traces of the *cupa* in the rust of the iron fittings, we know that the middle of

31 tab. i; Herc. tab. ii; Schn. tab. v.

the *cupa* was only slightly thicker than the axle, about 6″. This means that the axis of the *orbes* can only have been 3—4″ above the *miliarium,* allowing 1″ or so for the thickness of the iron plate. But the holes in the *orbes* were 13 cm or 7″ square, showing that the edge of the hole was about at the height of the top of the *miliarium.* In CATO's trapetes we know nothing of the height of the *miliarium* over the *labrum*; but the axis of the *orbes* would come some 14—15″ above the labrum, so unless we suppose a monstrous *cupa* 2′ thick we must imagine that the *miliarum* was some 9—11″ higher than the *labrum.* The reconstruction by the Herculanensian Academy shows just such a *miliarium;* and they mention that a *mortarium* of this shape has been found in Careri.

Another point not mentioned by CATO is the height of the *mortarium,* or rather, the height of the *cupa* above the floor. On seeing the trapete at Naples I was astonished to see how low it is. The top of the *miliarium* is only 60 cm over the floor, where 90 cm at least would seem to be the most effective height. The findings at Stabiae show, however, that the trapete was not put on the floor, but on a basis of stone or bricks to reach the proper height. The reason for this is not far to seek. The stone from which they were hewn was found only near Pompeji, so that they had to be transported all over Italy, and it would be a great economy of time and labour to make them just as low as possible; if there was material enough between the bottom of the cup and the under side of the *mortarium* to stand any reasonable strain, added material would only make the transport still more expensive and troublesome.

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11 tab. ii; SCHN. tab. x. **13** xxi; note 29; SCHN. 654. **20** LA VEGA tab. i; Herc. tab. ii; SCHN. tab. x.

The reason for the developement towards a deeper cup is not difficult to understand. In this way both the surface and the volume of the cup increased; it could hold more olives and crush a certain quantity in less time than the old trapete.

2. The details of the Catonian trapete.

So far I have dealt with the general aspect of the trapete only; when it comes to a study of the detailed instructions about how to set it up and adjust it, as given by Cato, there are still several points on which no generally accepted explanation has been given. Before entering upon an examination of the details of Cato's chapters 20—22 it is necessary to discuss Hörle's contribution to the interpretation of these chapters as a whole. Hörle writes: "*Die Trapetum-Beschreibung* **(cc. 20/22)** kann überhaupt nur "dann voll verstanden werden, wenn wir sie als eine plan-"mässige Weiterführung des Textes von c. 135, 6/7 be-"trachten. Fällt schon in der jetzigen Überschrift des c. 20 "'Trapetum *quo modo* concinnare *oporteat*' eine Form "auf, die uns auch bei c. 149 befremdete, so wird ihre "Unechtheit ganz offenkundig, wenn wir die zweifelsfrei "überlieferte Überschrift des c. 22 mit ihr vergleichen: "'Trapetum *hoc modo* accommodare *oportet*.' Und "wirklich bedurfte es keiner besonderen Einleitung des "c. 20, wenn sich nachweisen lässt, dass es unmittelbar an "c. 135, 6/7 anschliessen sollte; denn dort steht ja schon "das Thema der cc. 20/22 als letzter Satz deutlich auf-"geschrieben: 'Trapetum ubi arvectum erit, ubi statues, "ibi *accommodato concinnatoque*.' Diese zwei Punkte "führen die cc. 20 und 22 weiter aus: c. 20 das 'concinnare', "c. 22 das 'accommodare'.

"Vor allem inhaltlich wird c. 135, 6/7 hier ohne Zweifel "vorausgesetzt. Es wäre doch gar zu sonderbar, wenn im "Anfang des c. 20 von den steinernen Teilen, die recht "eigentlich die Maschine darstellen, gar nicht gesprochen "würde. Es konnte aber unterbleiben, weil alles dies schon "im c. 135 stand. Auch in der Formulierung herrscht "Übereinstimmung, indem genau wie im c. 135, 6/7 so "auch im c. 20 auffallenderweise unter der III. Person ohne "weiteres der ausübende Handwerker (faber) verstanden "wird: vgl. 'caveat, faciat, figat' (c. 20); zur Erklärung "vgl. c. 21,5 'idem faber figat (ferrum)' u. ä. Es kommt "noch hinzu, dass die gleichen Bezugsquellen in c. 22 und "135.2 genannt sind, nämlich 'Pompeis' und '(Nolae) ad "Rufri macerias'."

I find all this extremely unconvincing. Cc. 20—22 tell us how to put up and adjust a trapete, a task to be done every year before the gathering of the olives; 22:3—4 CATO has added the cost of a trapete, if it should be necessary to buy one; also where to get it; in case an *orbis* has got broken, he adds the proper dimensions to order, so that we can have it cut down at home to the proper fit. In 135: 6—7 Cato gives us the dimensions of a whole set of trapetes, if we should want to buy them, surely a most rare occurrence. That these chapters were not written straight away, one after the other, is obvious: if 20—22 followed directly on 135:6—7, which ends: *trapetum ubi arvectum erit, ubi statues, ibi commodato concinnatoque,* he would hardly have added 22:3: *domi melius concinnatur et accommodatur.* As to the argument that the words: *ibi commodato concinnatoque* 135:7 give the theme of 20 and 22, it has no force whatever. What Cato wants to say is this: when you buy a trapete, do not set it up till you have it in the place where you are going to use it. This has to do only with the buying of new trapetes, and has no necessary connection with the yearly setting up of the old trapetes. The last argument, that Cato mentions the same dealers in both places, I fail utterly to understand. It seems quite in order that he should name the dealers both where he is discussing the replacing of the *orbis* and later, where he is giving a list of all his providers. And that they are the same dealers — why, what would you expect? Hörle's chief error seems to me to be that he takes these chapters to contain a description of the trapete, "Trapetum-Beschreibung". They contain no such thing. Cato assumes that his readers are familiar with it; what he wants is to protect us from being cheated by the workers or the dealers.

Hörle next goes on to show that c. 21 is a later interpolation, by Cato, and without logical connection with cc. 20 and 22. As his argument is mainly technical, it will be better to discuss the technical details first and his argument afterwards.

In describing how to set up the trapete Cato follows a strictly logical order: first he describes how to fasten the iron pin on to the *miliarium;* that is all that has to be done to the *mortarium.* Then he explains how to put the wooden bushes into the *orbes* and fit the iron fittings. The *orbes* are now ready. Then he tells us how to make the *cupa,* beginning with the middle and working out towards the ends. Everything is now ready; only he adds, as an afterthought, what sort of wood to choose for the *cupa*; the rest of chapter 21 tells us how much to pay for the work.

21 p. 36.

Fig. 7 is meant to illustrate the details of the trapete as arranged by CATO. His text runs:

c. 20. *Trapetum quo modo concinnare oporteat.* "How a "trapete should be put together." HÖRLE's objections to this form for heading are based on his theory, that *De agricultura* is a collection of loose notes, and so carry no weight unless that theory is accepted.

Columellam ferream, quae in miliario stat, eam rectam stare oportet in medio ad perpendiculum. "The iron pin that stands "in the *miliarium* should stand exactly in the middle and "perpendicularly."

Cuneis salignis circumfigi oportet bene. Eo plumbum effundere caveat, ni labet columella. si movebitur, eximito; denuo eodem modo facito, ne se moveat. "It should be fast-"ened well all round with wedges of willow wood. Here "he should pour out lead with great care so that the "pin does not shift. If it gets moved, take it out again; "then proceed in the same way, so that it does not move." The sentence *eo plumbum . . . columella* is rather hard in its construction; HÖRLE reads: *eo plumbum effundere* (*oportet*). *Caveat ni labet columella.* I should not put it beyond CATO to have written the sentence as it stands. WEISE reads: *eo plumbum effundito. caveto, ni labet columella;* he argues: "As it is now, it gives no sense, for how "it could be brought about by pouring in lead that the "*columella* should move, I indeed do not understand; the "lead is poured in, on the contrary, in order that the *colu*-"*mella* does *not* move." I am inclined to understand the passage exactly in the sense that WEISE rejects. The wedges, being made of willow wood, were obviously only meant to hold the *columella* in position while the lead was being

4 45, 117 sqq. **20** 190 n. 1. **23** 99.

poured in. It was of course of the greatest importance that the pin did not move during this process, as it would then not stand exactly in the middle and perpendicularly. But as the pin filled out the hole as nearly as possible, it would be necessary to come pretty near to it with a heavy and hot casting ladle, and the pin might easily get touched. So Cato warns us not to try to put together a trapete with the *columella* awry; better have it right out at once and fix it properly. This interpretation seems to dispel also the objection raised by Keil to the word *effundere*. It is while the lead is being poured *out* of the ladle that care must be taken.

20:2. *modiolos in orbis oleagineos ex orcite olea facito, eos circumplumbato, caveto ne laxi sient.* "Make the navels for "the mill-stones of olived wood, the sort called orchis, "pour lead in all round them, take care that they are not "loose." The *modioli* are wooden navels to go into the square holes in the *orbes*. Cato tells us to make the holes $^{1}/_{2}'$ or 8″ square; in the now existing *orbes* the holes are narrowing towards the flat side, but that probably is a later invention unknown to Cato. It would make it easier to make the navels stick. La Vega found in one of the *orbes* traces both of wood and of lead, as if in illustration of Cato's words. Blümner, on the other hand, interprets this passage in quite another way. He takes *modioli* to mean axles, remarking, however, that the word is used nowhere else in this sense. According to him, these axles were fastened to the *cupa*. This interpretation is very rightly rejected by Hörle. The length of the *cupa* is given as 10′, which shows that the whole thing, handles, axles and middle, were one piece. If the axles had to be fastened to the *cupa*, the *circumplumbato* must refer to this fastening; but surely nobody ever fastened wood to

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10 Comment. 46. **17** 22 : 4. **21** 55; Schn. 624. **22** 341. **27** 195.

wood by means of lead. Schneider has the right explanation, having got it from La Vega, although Hörle accuses him of giving the false interpretation.

in cupam eos indito. "Put them on to the cupa." As *eos* must mean the *modioli,* the meaning might be rendered: "Make "them fit the *cupa.*"

cunicas solidas latas digitum pollicem facito, labeam bifariam faciat habeant, quas figat clavis duplicibus, ne cadant. habeant is a conjecture by Schneider. "Make solid bushes, "one inch broad, let him (the smith) make them so that "they have a double lip, which he should make fast with "double nails, so that they do not fall." The word *cunica* is found here only, so we know nothing of what it means except from this text. From its place in the description it must mean some iron fitting to be put on to the *orbis* to take the wear from the axle. As it is only one inch broad there must have been 4 of them altogether, two to either *orbis.* The double lip and the nails must be meant to fix it on the *modiolus,* as the function of the *modiolus* is to carry the iron fitting. So we get the idea of an iron ring with two outstanding ears through which the nails went into the *modiolus.* The iron ring on the Naples *orbis* would then seem to be a direct descendant of the Catonian *cunica.* Hesychius has a word, χοινικὴ, meaning an iron navel; it seems most tempting to take the Latin word as a latinization of the Greek word. If we try to get a clear idea of its shape, we see that it can hardly have been fixed on the outside of the *modiolus* only, by means of its nails, as this would have been rather insecure; also Cato's instruction about the *labea bifaria* seems to indicate that this is something over and above the usual; nor can the *cunica* have

1 74. 9 75.

been placed right inside the *modiolus,* with only the lips outside on the flat side of the wood, for then the lips and nails would have been worn out by the washer, *armilla,* outside; nor can it have been inside, with the lips sunk into the wood, for then the wood would have to take the wear. So it would seem to have been sitting half inside and half outside, with an outer edge to protect the lips from wear, and the rest inside to get a good grip on the wood. If this is right, Cato's *cunica* with its double lip represents an improvement upon an oldfashioned one which sat in the wood only, and which might fall out if the wood shrank. See fig. 8.

c. 21. *Cupam facito p. X, tam crassam quam modioli postulabunt.* "Make the *cupa* 10′ long, and as thick as is required "by the navels."

mediam inter orbis quae conveniat, crassam quam columella ferrea erit, eam mediam pertundito, uti in columellam indere possis. "The middle which fits in between the *orbes,* make "a hole, as thick as the iron pin, through that middle, so "that you can put it on to the iron pin." *conveniat* for *conveniant* is a conjecture by Politianus. The obvious interpretation "Make the middle . . . as thick as is the iron pin" gives no sense; there is no need at all for making the thickness of the *cupa* agree with the height of the *columella.* Hörle has seen, quite rightly, that there is no need to put in *eam* between *in* and *columellam,* with Keil, or delete *in,* with Schneider; the *cupa* is put on to the *columella,* not vice-versa. The middle of the *cupa* is left square, to rest on the *miliarium,* while the two arms are made into axles for the *orbes,* and the ends are made into handles.

eo fistulam ferream indito, quae in columellam conveniat et

25 194.

in cupam. "Fit into this hole an iron tube that fits both the "*columella* and the *cupa.*" Blümner translates *fistula ferrea* by "an iron bolt" and explains it as sitting on the top of the *columella* to keep the *cupa* from jumping off in case the *orbes* met some resistance. But this purpose was served far better by having the *columella* rather long; indeed, the result of having a bolt through the *columella* just above the *cupa* would probably be that the *columella* would easily get bent, if one of the stones met too much resistance. There is no evidence that *fistula* means "bolt", while "tube" seems to be its most original meaning. So once more Blümner's interpretation must be rejected. The purpose of the iron tube is clear enough: the wooden *cupa* must be guarded against the wear of the iron *columella*; when the tube was worn out, it might be replaced, which was cheaper than having to make a new *cupa.*

c. 21:2. *inter cupam dextra sinistra pertundito late digitos primoris IIII, alte digitos primoris III, sub cupa tabulam ferream, quam lata cupa media erit, pertusam figito, quae in columellam conveniat.* "Make in the *cupa* between (the "*orbes*) right and left holes 4″ broad and 3″ high; fix underneath the *cupa* an iron plate, as broad as is the middle of "the *cupa,* with a hole in it, so that it fits the *columella.*" The purpose of the iron plate was to take the wear between the under side of the *cupa* and the top of the *miliarium.* La Vega found traces of such a plate on the Stabiae trapete. The reason for the square holes is given further on in the text.

dextra sinistra, foramina ubi feceris, lamnis circumplectito, replicato in inferiorem partem cupae omnis quattuor lamminas: dextra sinistra foramina utrimque secus lamminas sub lammi-

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2 341. **26** 54, tab. i; Herc. xii, tab. ii; Schn. 623, tab. v.

nas pollulas minutas supponito, eas inter sese configito, ne foramina maiora fiant, quo cupulae minusculae indentur. "To the "right and the left, where you have made the holes, put a "piece of iron plate round it (the *cupa*), and fold all four "plates down under the *cupa;* on both sides of the holes "to the right and the left put very small iron plates under "the plates and make them fast to each other, so that the "holes, where the small axles are to be put, shall not grow "larger." The square holes, then, are to take the *cupulae,* whatever they are. Goiffon explains them as wooden blocks, meant to be inserted under the *cupa* to take the wear from the top of the *miliarium,* the reason for this arrangement being that they might be exchanged when they wore out. The holes then are on the under side of the *cupa*. This ingenious theory is hardly tenable, however, as there would be no sense in guarding the under side of the *cupa* by an expensive *tabula ferrea,* if the wear was taken by loose wooden blocks. Hörle sees in them handspakes to go right through the *cupa;* they were meant to help in lifting the *cupa* with the *orbes* when need arose. Accordingly Hörle describes the holes as horizontal; the first *laminae* according to him are square plates with a square hole in them, fixed on the side of the *cupa* and having their lower edge turned in below the iron plate.

Though I admit that Hörle is right when he describes the *cupa* with the *orbes* as very heavy, I am not at all convinced by his reconstruction of the *cupulae* and the *laminae*. There would be no need of lifting the *cupa* very often; the crushed olives could be scooped out and fresh olives put in all day long; for cleaning purposes every square inch of the *mortarium* and the *orbes* could be got at if the *cupa*

10 214—15; Schn. 676, tab. ii. **18** 195. **22** Fig. 9, pag. 197.

was turned and the *orbes* rotated. When it was necessary to get out the *cupa,* there were several ways of doing it. If the trapete was under roof, a tackle might be used; or the *cupa* might be prised up by means of levers, using the *miliarium* as a fulcrum; if the *orbes* were pulled outwards, there would be room to insert a board, 2″ by 5″ or 6″, on edge just inside the *orbes,* or handspakes might be lashed to the *cupa* — in short, there were many ways of doing the thing without taking the drastic measure of cutting square holes right through the *cupa.* Even if we disregard the work of cutting the holes, it is clear that they would materially weaken it, as is shown by the necessity for having it strenghtened by iron plates. This shows that there must have been a strong necessity for the holes, a necessity not explained by Hörle's theory. Moreover, Hörle's explanation is disproved by the shape and size of the holes. If they were meant for lifting, there would be no reason for making them broader than they are high. Their shape shows quite clearly that the *cupula* had to take its greatest stress in a horizontal direction; and a plank of no more than 3″ in thickness would come pretty near to its breaking point, if it were used to lift the largest *orbes,* which weighed about 450 kg.

By its form the word *cupula* would seem to be a diminutive of *cupa,* and so the *cupulae* would be handspakes with which to help in turning round the *cupa,* if it was too heavy for two men alone. This explanation is not mine: it is given by the Herculanensian Academy.

As to the iron mountings, it is clear at first sight that Hörle's explanation cannot be right. The *tabula ferrea* must be thicker than the mere *laminae;* if they were folded down below it they would be worn out very quickly. Also

27 xix, tab. ii; Schn. 651, tab. x.

an iron plate in the position drawn by Hörle would be of very little help in lifting anything as heavy as the *orbes.* What is needed is something to strengthen the *cupa* where it has been weakened by the holes, and that is done by putting iron bands round it. This is quite compatible with the text. There is no object to *circumplectito,* and it seems more reasonable to supply *cupa* than *foramina*; the words *dextra sinistra, foramina ubi feceris* should mean, then: "to the right and left of each hole;" in this way we get four bands, and we understand why they are bent down under the *cupa.* There remains but one difficulty: if the bands were to go in between the *cupa* and the *tabula ferrea,* why is the *tabula* mentioned before the bands? The reason probably is this: the *tabula* had to be fastened to the *cupa* in some way, by means of nails or, rather, by going into a shallow cut at the bottom of the *cupa.* In neither case the bands could be fitted before the *cupa* was prepared for the *tabula,* and this is why the *tabula* is mentioned just here. The last passage: *dextra sinistra foramina utrimque secus lamminas sub lamminas pollulas minutas supponito* is attacked by Keil, who deletes *dextra sinistra foramina* and so reads: "*replicato in inferiorem partem cupae omnis quat-*"*tuor lamminas, utrimque secus lamminas sub lamminas* "*pollulas minutas supponito,*" his argument being that *dextra sinistra* can mean only the same as *utrinquesecus.* Hörle takes the text as it is; "'*dextra sinistra*' (ist) auf das "Achsenmittelstück zu beziehen, 'utrimque' dagegen auf "die Innenseiten der Löcher. 'foramina', als Akkusativ, "ist von 'utrimque secus' abhängig, in dem die ganze ur-"sprüngliche Kraft des 'sequi' noch lebt." In this way the grammatical part of the question is in order, but still it

21 48. **26** 196.

seems queer that CATO should have written *dextra sinistra* if he only meant "both holes". Professor, dr. MARTIN KNUDSEN has suggested to me, that *dextra sinistra* should mean "the right and left sides of the holes," i. e., only the vertical sides, not the horizontal parts of the holes were lined. *Utrimque secus* then means "at both ends of the holes." This explanation fits in very well with the conclusion, already stated, that the holes were meant for something that worked sideways, not up and down, and it is borne out by the rest of the passage: *sub lamminas . . . supponito*, which I take to mean that the ends of the lining were folded down along the outside of the *cupa* and held down by the iron bands running round it.

cupa qua fini in modiolos erit, utrimque secus imbricibus ferreis quattuor de suo sibi utrimque secus facito qui figas. The text here is unmistakably corrupt; but the sense is not hard to find. The first words indicate that we are dealing with the part of the *cupa* that forms axles for the orbes: *cupa qua fini in modiolos* (*-lis?*) *erit*. The next mentions four *imbrices*, or half-cylindrical mountings; the word means a gutter. Out of the next words we get clearly the sense: "contrive a way in which to fasten . . ." HÖRLE reads: *cupam qua . . . ferreis quattuor* ⟨*circumcludito*⟩. *De suo . . . figas imbrices; medias clavulis figito*. The words *de suo sibi* he takes to mean that the ends of the mountings had to be fastened by some means contrived from themselves, not, as the middle, by nails. This may be right, or the words are just reliques of something that remains to be conjectured.

imbrices medias clavulis figito. "Fasten the mountings in "the middle with nails." If my interpretation of the *cunica*

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22 196.

is right, the wear would fall only on one inch of the *imbrices* on either end; so the middle could safely be fastened with sunk nails.

supra imbrices extrinsecus cupam pertundito, qua clavus eat, qui orbem cludat. "Make outside the *imbrices* (on the out- "side) through the *cupa* a hole, through which the bolt "that locks the *orbis* can go." If *supra imbrices* means "outside the *imbrices*," *extrinsecus* seems quite superfluous; it might be either a corrupted *utrimquesecus,* or a gloss to explain *supra imbrices.*

c. 21:4. *insuper foramen librarium ferreum digitos sex latum indito, pertusum utrimque secus, qua clavus eat.* "Put on "(the *cupa*) over the hole the iron adjusting muff, with "holes right through it, where the bolt can go." The name *librarium* was explained by the old commentators as derived from *libra,* a pound; it meant either that the muff weighed a pound, or that it was cut out of a sort of iron plate named by its weight. Hörle derives the word from *liber,* a book: "Wie der Scheffel, (modius) wegen seiner zylindrischen "Gestalt den Einsatzbüchsen seinen Namen gegeben hat "(modioli), so auch die bekannte Bücherkapsel (librarium) "einem ähnlich geformten Werkstück." I would prefer to derive the word from *librare,* to adjust; later on Cato mentions a *librator,* which I take to be some fitting connected with this part of the trapete. Hörle's explanation of this muff, which he shows on his drawing as far thicker than the *imbrices,* is that it should on one hand give the bolt a firm hold, and on the other hand keep the edges of the *imbrices* together and guard them against wear. This last remark seems to indicate that Hörle intends the muff to go right in under the *orbis,* and his drawing, which is not

15 Schn. 77. **18** 199. **23** 22:1. **26** Fig. 9, p. 197.

quite clear, seems to bear it out. This would mean either that a similar muff must be placed under the inner side of the *orbis,* which would make the *imbrices* quite superfluous, or that the *modiolus* was recessed to take the muff, of which there is no trace either in the drawing or the explanation. The muff then must be outside the *orbis* altogether. It might keep together the *imbrices,* if they were long enough, but it could not take any wear from them. But this arrangement is also very improbable. If the muff has to give the necessary firm hold to the bolt, it must be fixed on the *cupa* very firmly. But then it would have to be taken off whenever the *orbis* or the *armillae* had to come off the *cupa,* — surely a most unpractical arrangement. Hörle quotes as his authority the drawing of the *cupa* found at Stabiae reproduced by Blümner. It is true that such a pair of muffs are found in this drawing. But they are not found in the original drawing, made by the Herculanensian Academy, — which drawing, by the way, represents the *cupa* as reconstructed by the Academy; of the real *cupa* nothing but rust was found — here the muffs are drawn as they must have been: flush with the *imbrices.* From the way in which the whole trapete is constructed it is clear that the principle is that iron should wear on iron, never on wood. So the bolt has to have this iron muff to go into. But this does not explain the name *librarium.* The explanation is this: a simple bolt was enough to hold the *orbis* secure; but there must be some contrivance to take up the slack, when the *armillae* were worn, for the *orbis* could not be allowed to wobble. This thing I take to be what is called the *librator,* which I figure as a sort of wedge which was put into the same slot with

13 199. **15** Fig. 123, p. 341. **17** Tab. ii; Schn. tab. x. **19** Tab. ii; Schn. tab. v.

the bolt, but behind it; in this way the *orbis* could always be kept nicely in its place. The slot in the muff (and in the *cupa*) must then be broader than the bolt; but as the muff was 6″ broad, there would be room enough for it.

haec omnia eius rei causa fiunt, uti ne cupa in lapide conteratur. "All this is done so that the *cupa* shall not be worn "out within the stone." *Haec omnia* is the whole arrangement from *cupa qua fini* . . .

armillas IIII facito, quas circum orbem indas, ne cupa et clavus conterantur intrinsecus. "Make 4 washers, which you "put on on either side of the *orbis,* so that the *cupa* and "the bolt are not worn out on their inner side." The flat side of the *orbis* runs against the breast formed by the square middle of the *cupa*; here a washer is put in between; the other side runs against the bolt; here is need for another washer. The wear, I take it, is taken by the washers and the *cunicae.* The form *orbem* is strange; *orbis* was to be expected, since 4 washers are mentioned, unless *utrumque* is supplied.

cupam materia ulmea aut faginea facito. "Make the *cupa* "of elm or beach wood."

The rest of the chapter deals with the cost of the iron and the work.

Against this interpretation Hörle objects that c. 21 is a much later interpolation by Cato himself; I prefer to give his argument in his own words: "**c. 21** fällt auf 1. durch "seine ungewohnte Ausführlichkeit, 2. dadurch, dass an "seinem Schluss das 'accommodare' schon verrechnet ist, "das im c. 22 erst beschrieben wird, 3. dass die eben er-"wähnte Gewohnheit, in der III. Person zu sprechen, die "den cc. 135, 6/7 und 20 gleich altertümlicher Weise eigen "ist, mit c. 21 auf einmal in die II. Person wechselt. 4. Eine

23 46.

"genaue Analyse des technischen Inhalts von c. 21, wie sie "später versucht werden wird, ergibt, dass in den cc. 20 "und 21 zwei grundverschiedene, aber selbständige Kon- "struktionen vorliegen: dort in c. 20 eine recht schlichte "Befestigungsweise der Mahlsteine auf der grossen Achse, "hier in c. 21 dasselbe Problem in weiter fortgeschrittener "Weise gelöst.

"Kapitel 21 ist also ein Fremdling, erst später von Cato "in die alte Folge der cc. 20. 22 eingeschoben, was evident "wird, wenn wir beim Nachrechnen wiederum auf den "gewohnten Textgruppenumfang von 26 bzw. 24 Zeilen "für jeden der beiden Teile stossen."

Taking the points in order we find that 1. is due to Hörle's own peculiar interpretation of c. 20:2; as interpreted by all other commentators there is no difference in explicitness in 20 and 21. Point 2 proves nothing at all. 21:5 Cato tells us, that we have to pay 8 sesterces to the man who makes ready the *cupa* and fixes the navels into the *orbes;* then he adds: the same man must adjust the trapete, viz. for the same money. I fail to see how this could run at variance with Cato's telling us afterwards how a trapete is to be adjusted, so that we may see if the man is doing it right. As to point 3, it is true enough that there is a curious shifting from the III. to the II. person from 20 to 21; but as there is a II. person, *expleas,* in 22, it might be argued also that 21 and 22 belonged together; at any rate, interesting as it is, this observation is no proof that 21 is interpolated between 20 and 22. So the full burden of proof falls on point 4, the exact technical analysis; for it is clear that even if we admit for the sake of the argument Hörle's theory, that Cato always wrote in lumps of 24—26 of Keil's lines, that does not compel us to divide a lump of 50 lines, unless the text itself is evidently disconnected.

Where Hörle's interpretation differs from all others is 20:2, *in cupam eos indito*. He translates: "Put them (the "*orbes*) on to the *cupa*," and, taking it quite literally, he explains *cunica* as a locking muff, fixed on the *cupa* by means of nails through the double lip, which is contrived on the outer side of the muff. The words *ne cadant* he refers to the *orbes*, quoting three other sentences, none of which, however, show the feature that is characteristic of this, in Hörle's interpretation: a subject to be supplied from several sentences back. The obvious interpretation, taking *cunicae* as subject, does not agree with his interpretation of that word. But quite apart from grammatical considerations Hörle's interpretation is impossible: how and where could the *orbes* fall? The muff is there to keep them from touching the *mortarium*.

In strict accordance with this idea, that this trapete has nothing to do with what is mentioned in c. 21, Hörle has made a drawing of the plain trapete, with a wooden *cupa* turning directly on the iron *columella* and resting on the stone *miliarium* without any iron plate; there are no washers between the *orbis* and the *cupa* or between the *orbis* and the *cunica*; the wooden navels turn on the wooden axles. This arrangement is on the face of it extremely improbable. The wear of the *columella* on the *cupa* alone would make it useless very soon; a play of $^1/_4''$, or less than 5 mm, at this place would make the *orbes* touch the *miliarium*. But it is also quite inconsistent with Cato's text. The next thing to do, if we cut out c. 21, is to adjust, *accommodare*, the trapete. But once Hörle's *cunicae* are fixed with nails, no adjust-

3 190. **20** Fig. 8, p. 191.

ment is possible in a horizontal direction. Yet it is obvious from Cato's text that the trapete is first put together, and then adjusted. And his first instruction runs: *librator uti statuatur pariter ab labris.* This must be an adjustment horizontally. On this sentence Hörle has no word to say. Yet it is clear that if the *librator,* as I believe, has something to do with the *librarium,* this one word alone is enough to undo Hörle's theory.

If Hörle is right, and c. 21 is another, independent description of how to put up the trapete, we have a contra-verification to make, by seeing if it is complete. And we very soon find that it is not: there is no mention of the iron bushes to go into the *orbes,* a thing so necessary that Hörle has put them on his drawing of the improved trapete and called them *modioli* without any authority from the text.

All these difficulties arise out of the attempt to interpret the word *cunica* as a locking device, instead of the necessary iron guard for the *orbes*; once the correct interpretation is given, we find the whole sequence of Cato's description clear and logical.

c. 21:5, which tells the cost of putting up a trapete, must be taken together with 22:3—4; here follows first the interpretation of c. 22.

c. 22. *Trapetum hoc modo accommodare oportet.* "The tra-"pete should be adjusted in this way."

librator uti statuatur pariter ab labris. "The adjuster should "be fixed at the same distance from the sides of the *morta-"rium.*" This seems to be a rather short way of saying that the *librator* should be adjusted in such a way that the *orbes* have the same distance from the *labrum.* The *librator*

14 Fig. 9, p. 197.

I have already explained as a sort of wedge which is placed behind the bolt to take up the slack, when the *armillae* get worn. Still the whole sentence seems a little self-evident; what is expected, and nowhere given, is the distance between the *orbes* and the *labrum*. I prefer to read: . . . *pariter ab labris digitum. digitum minimum* . . . In this way we get the information needed, and the correction is not very violent. Hörle's idea, that the *orbes* had to go quite near the *labrum* in order to shovel the olives, I have already dealt with.

digitum minimum orbem abesse oportet ab solo mortarii. "The *orbis* should be at least one inch from the bottom of "the *mortarium.*" *Digitus minimus* generally means the little finger; but in the absence of any evidence that this was ever used as a measure, I prefer to interpret it the other way.

orbes cavere oportet nequid mortarium terant. "Care must "be taken that the *orbes* do not chafe the *mortarium* in any "way." Even if the *orbes* were one inch distant from the *labrum*, and the bottom of the *mortarium*, they might chafe it if their curve did not correspond with that of the cup; also if the *cupa* did not fit the *columella.*

inter orbem et miliarium unum digitum interesse oportet. "Between the *orbis* and the *miliarium* there should be a "distance of one inch." Here ends, I think, the instruction on how to adjust the ordinary trapete, that is a trapete where the *orbes* and the *mortarium* belonged together and fitted as they should. But sometimes it was necessary to work with less perfect materials, so Cato tells us how to make the best of them.

si plus intererit atque orbes nimium aberunt, funi circumligato miliarium arte crebro, uti expleas quod nimium interest.

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1 p. 35. **8** 192. **10** p. 15.

"If the distance is greater and the *orbes* are too far away, "wind a rope tightly round the *miliarium* in many coils, "so that you fill out the distance that is too great." If the *orbes* were too thin for the distance between the *miliarium* and the *labrum*, the *miliarium* was the only place where it was possible to do anything; but of course it was only a sort of first help to an otherwise useless trapete: nobody wanted to grind against rope.

22:2. *si orbes altiores erunt atque nimium mortarium deorsom teret, orbiculos ligneos pertusos in miliarium in columella supponito, eo altitudinem temperato.* "If the *orbes* are "too high and the *mortarium* chafes too much in the bottom, "put wooden disks with holes in them on to the *miliarium* "over the *columella* and adjust their height in this way." This is the other possibility: the *orbes* are too large. Then the *cupa* must be lifted till they clear the bottom of the *mortarium*. But this is also clearly a temporary affair: the wooden disks would soon be worn out between the stone *miliarium* and the iron plate of the *cupa*.

eodem modo latitudinem orbiculis ligneis aut armillis ferreis temperato, usque dum recte temperabitur. "In the same way "make the horizontal adjustment by means of wooden "disks or iron washers till it is well adjusted." The too large *orbis* may need adjustment also horizontally; if you have no iron washers, wooden disks will do — temporally. Blümner translates *orbiculi* by "wedges", which should be placed in the *miliarium* under the *columella* — an altogether impossible arrangement.

This chapter, from *si plus intererit*, has been taken to prove that the *trapetum* mentioned by Columella cannot be the Catonian trapete, because Columella writes: *molae*

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26 342. **31** 12 : 52 : 6.

quam facillimam patiuntur administrationem; quoniam pro magnitudine baccarum vel submitti vel etiam elevari possunt, ne nucleus, qui saporem olei vitiat, confringatur. The *mola olearia,* as has been shown by Brøndsted in the most convincing manner, consisted of two cylindrical millstones, rotating on a horizontal axle, which was carried by a vertical beam, that turned round also, and was placed in the middle of the flat surface, on which the grinding took place. See fig. 9. Brøndsted has found this type of mill on a sarcophagus relief, and shows us a photograph of a modern mill in Dalmatia, built on the same principle. To this may be added another sarcophagus relief, which is found in the Palazzo Rondanini in Rome; this relief, which has hitherto been known only through a drawing, published first in the Archaeologische Zeitung 1877:35:Tab. 7:1, has been taken to represent a trapete, though Brøndsted points out that the single millstone shown on it is not an *orbis,* but a cylindrical millstone. Through the courtesy of the present owner of the Palazzo Rondanini, count Sanseverino, I have obtained a photograph of the relief in question, see fig. 10. In dealing with the oilpress I shall have to speak further about this relief; here it is enough to call attention to its right side. Here is seen a winged amorine holding the *cupa* of a machine resembling a trapete, but differing from it by having a sort of cylindrical millstone, no true *orbis*; the shape of the cup, which is broad and shallow, standing on a foot that broadens out, is also different from that of a true *mortarium.* The *miliarium* seems to be only very slightly higher than the *labrum*; the *columella* is very thick and long, the *cupa* showing a bulge where the *columella* comes through it. The outer end of the cup is broken off, and the broken

4 112. **9** Fig. 108, p. 112. **10** Fig. 110, p. 113.

off part of the *cupa* shows an irregular lump, which Blümner took to be the rest of another millstone, while Duhn sees in it the olives heaped up by the end of the *cupa*. Matz saw, in the collection of A. W. Franks, a drawing of a similar relief, where two amorines were turning the mill; but I admit that the evidence of this drawing is somewhat vitiated by the fact that the second amorine was added on a separate slip of paper. Still, I think that Blümner is right as against Duhn. If the machine, as must be supposed, is a sort of intermediate thing between the true trapete and the *mola olearia*, then the millstone cannot rest on the bottom of the cup, which must be flat, or it would crush both berries and stones. But then it must be balanced by the other stone, or the amorine would have to carry its weight, which is impossible. The fact that the right hand and wrist of the amorine are shown below the handle as if he was supporting it I ascribe to the necessity of having the arm somewhere on the relief: it could hardly have been modelled as pushing the *cupa* from behind. Indeed, Blümner is right in describing this mill as very like Goiffon's reconstruction of the trapete; which is no wonder, since Goiffon's reconstruction is merely a *mola* trying to look like a trapete, while the thing on the relief is a trapete developing into a *mola*. This intermediate form must, however, have had one drawback: if the *cupa* wobbled ever so little on the *columella*, the flat stones would crush the olive stones against the flat surface of the cup. In the Arles sarcophagus we see a further development; the big, vertical beam, with a bearing at either end, would hold the millstones secure. This type of oil mill, which is in use to-day, was the only one known in

1 Arch. Ztg. 1877 : 35 : 53. **2** 2 : 218. **3** 2 : 218; 3 : 294. **19** Arch. Ztg. 1877 : 35 : 53. **20** Schn. tab. ii.

the 18th century; Meister's and Goiffon's reconstructions of the trapete are only modifications of it to fit Cato's figures; that they did not quite succeed is shown by the Herculanensians. But while the type was the same, there was this difference in the use of it, that the secret of crushing the berries only had been lost; the olives were crushed, stones and all, and yielded a larger amount of inferior oil. When the trapetes were found and the Roman agriculturists were read, La Vega reconstructed the trapete twice to try out the new sort of oil; only he wanted to use it for two grindings, first the berries and then the stones, and he found that it did not work well in the second position. But the oil made from the berries alone was far better than any other oil known then. The reason why the experiments were discontinued was probably that they found out that the ordinary mills might be used in the same way, and were then even better than the trapete. From the construction of the *mola olearia* it is clear that if the stones were not allowed to rest on the grinding surface, but carried by their axles, their distance from the surface could be adjusted to any height by means of plates placed under the middle of the axle. So Columella's remark on the *mola* is true enough. And if we look nearer at the trapete we will find that he is right about that also. The under side of the *cupa* is guarded by a *tabula ferrea,* which is fastened to the wood and rests on the *miliarium.* It is impossible to lower the *orbes* except by taking off the plate and taking some wood off the *cupa*; and it is impossible to lift them except by putting something in between the *tabula ferrea* and the *miliarium,* but if that was meant to be done, the *tabula* would be superfluous. It might be done at a pinch, if the *orbes* did not fit,

1 Goiffon tab. ii; Schn. tab. ii. **4** xviii, n. 25; Schn. 651. **9** 41.

but not as a regular thing, to fit the olives. So it is evident that there was no provision made for this adjustment in the construction of the trapete. But indeed the whole idea of the trapete precludes such an adjustment. The meridian of the *orbis* can keep its distance from the cup only as long as their centres coincide. But the moment the *orbis* is lifted or lowered the centres cannot coincide any more. To take a numerical example: If we were able to lower the *orbes* of the second Catonian trapete 0.5″, the lower edge would be 0.5″ from the bottom, but at the lip of the *labrum* the distance would be 0.68″ and the distance from the *miliarium* 1″. If the *orbes* were adjusted to 0.5″ from the *miliarium,* the distance from the *labrum* would be 1.18″, or more than before. Even if we wind a rope round the *miliarium* to make up for the 0.5″, the distance would not be equal all along the curved side of the cup, but growing from 0.5″ to 0.68″. This is not very much, but in the later trapete, from Columella's time, the disproportion would be far greater, as the *orbis* dipped into the cup almost to the hole, so that it would hardly get nearer at all, if it were lowered. All this goes to show that Columella's remark is very much to the point, and that there is no greater difference between his trapete and Cato's than that which is due to the development during the 150 years that separate them.

Of this development we know nothing, as only the two points are known to us; but in time we may learn more, and I have found one small fact that may point a way. Among other fragments placed outside the museum in Nauplion I found and measured a solitary *orbis,* made of a reddish grey stone very different from the dark grey lava of the Roman trapetes. See fig. 11. It is very small, only 60.5 cm high by 13 cm thick; the hole was 12.5 cm square on the curved side (I could not measure the hole on the flat side, as it was wedged in between two heavy objects). But the most remarkable thing was that the round side was cut flat all round the hole, to a distance of 9.5 cm. It cannot fail to strike anybody looking at a reconstruction of a Catonian trapete that the curve of the *orbis* above the cup is of no use at all. Somewhere, probably in Greece, somebody has reduced the volume of the stone by taking off the superfluous curve; this then paved the way for the deeper and narrower cup of the later age. But this is merely a hypothesis that may be confirmed or disproved by future finds.

3. The cost of the trapete.

C. 22:3—4 is a calculation of the cost of a new trapete or a new *orbis* for an old one. This is better taken together with c. 21:5, which deals with the cost of the yearly setting up of the trapete.

c. 21:5. *ferrum factum quod opus erit uti idem faber figat: HS LX opus sunt.* This is generally translated: "For the "necessary iron, which the same smith must put on: 60 "sesterces." But this does not agree with the cost of a new trapete, as will be shown later; the right translation probably is: "For the same smith to fit on the necessary iron, when "made: 60 sesterces." The words *idem faber* might then refer to the sentence just before: *cupam materia ulmea aut faginea facito:* the same craftsman who made the *cupa* would fit on the iron from the old one, *ferrum factum.* It is quite reasonable to expect that the *cupa* had to be renewed from time to time, but not that all the iron fittings had to be made over again each year.

plumbum in cupam emito HS IIII. "Buy the lead for each "*cupa* for 4 sesterces." Lead is used for fixing the *modioli* in the *orbes* and for fixing the *columella* in the *miliarium*, but not in the *cupa*, where the iron fittings are made fast to the wood. So unless *cupam* is a slip of the pen for *columellam*, and even then *in* with the accusative is strange, we must take *cupa* as *pars pro toto*, meaning: for each trapete.

cupam qui concinnet et modiolos qui indat et plumbet, operas fabri dumtaxat HS VIII: idem trapetum oportet accommodet. "For him who sets up the *cupa* and fits the *modioli* into the "*orbes* and pours in the lead, for the work of the craftsman "alone: 8 sesterces; the same man must adjust the trapete." "To set up the *cupa*" must mean to put on the *orbes* and put the whole thing on to the trapete. No one man could do that, as the *orbes* were very heavy; but it needed only one *faber*, the rest might be any strong and handy slaves.

summa sumpti HS LXXII praeter adiutores. "The whole "cost 72 sesterces apart from the helpers." $60 + 4 + 8 = 72$; the reckoning is correct.

c. 22:3. *Trapetus emptus est in Suessano HS CCCC et olei PL. conposturae HS LX: vecturam boum, operas VI, homines VI cum bubulcis HS LXXII: cupam ornatam HS LXXII, pro oleo HS XXV: S. S. HS DCXXVIIII.* "The trapete was "bought near Suessae for 400 sesterces and 50 pounds of oil; "setting up 60 sesterces, transport by means of oxen, 6 days "for 6 men, with drivers, 72 sesterces; a complete *cupa* "72 sesterces, for the oil 25 sesterces, together 629 Sesterces." Hörle is probably right when he suggests that this is a record of an actual transaction, since the price cannot always have included 50 pounds of oil.

Pompeis emptus ornatus HS CCCXXCIIII: vecturam HS CCXXC: domi melius concinnatur et accommodatur, eo

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27 193.

sumpti opus est HS LX: S. S. HS DCCXXIIII. "In Pompeji it is bought complete for 384 sesterces; transport "280 sesterces; it is better to put it together and adjust it at "home, that will cost 60 sesterces; together 724 sesterces." Hörle's explanation of the cost of transport is most convincing: From Suessae 6 men for 6 days at 2 sesterces a day: 72 sesterces; from Pompeji 7 men for 20 days at 2 sesterces a day: 280 sesterces. But the rest is not so plain. In both cases there is an entry of 60 sesterces; in the Suessae calculation it is called *composturae,* in the Pompeji account it is: *domi melius concinnatur et accommodatur.* This then must mean the same thing: the setting up of the trapete. But this same thing is calculated in c. 21:5 to cost 72 sesterces. This divergence is, however, more apparent than real. In a new trapete the *columella* probably was delivered fixed and ready; so there was no need to pay 4 sesterces for the lead; also the price for fitting out the new cupa, 60 *sesterces,* may include the making of it; at any rate, that it was cheaper to get a brand new trapete put up than to set up an old one is not very improbable. But it is clear that the item *ferrum factum quod opus erit uti idem faber figat: HS 60* cannot mean that the iron was included, since the Suessae account has extra *cupam ornatam HS 72,* which can mean only "a *cupa* with fittings." *trapetum ornatum* in the Pompeji calculation must then include the *cupa ornata,* as the two accounts could not be compared otherwise. On the other hand, *cupa ornata* can hardly mean a finished *cupa,* for then the setting up would cost only 8 sesterces; so it must mean: the *cupa* and the iron fittings, which had to be assembled at home.

c. 22:4. *si orbes in veteres trapetos parabis, medios crassos*

5 193.

p. I digitos III, altos p. I, foramen semipedem quoquo vorsum. "If you buy *orbes* for old trapetes, let them be 1′ 3″ thick, "1′(!) high; the hole 1/2′ square." The thickness, 1′ 3″, is the thickness of the *orbis* belonging to the second Catonian trapete; its height is 3′ 5″; an *orbis* one foot high and one foot three inches thick is sheer nonsense, which should never appear in the text.

eos cum advexeris, ex trapeto temperato. "When you have "brought them home, have them cut to fit the trapete."

ii emuntur ad Rufri macerias HS CXXC, temperantur HS XXX. tantidem Pompeis emitur. "They are bought at Rufer's "Walls for 180 sesterces, the cutting costs 30 sesterces. The "price at Pompeji is the same." *ad Rufri maceriam* is mentioned c. 135:2: *trapeti* (sc. *emuntur*) *Pompejis, Nolae ad Rufri maceriam;* Hörle is probably right in taking "Rufer's "Wall" to mean some locality in Nola.

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15 46, note.

PART II:

THE TORCULAR

1. The developement of the oil press according to Plinius.

The olives did not yield their oil on being crushed, they had to be pressed. The same sort of presses, often the very same presses, that were used for the olives, were used for pressing the last juice out of the grape pulp; there is no theoretical difference between the oil press and the wine press.

PLINIUS gives a summary of the development of the press: Hist. nat. 18:317: *antiqui funibus vittisque loreis ea* (sc. *prela*) *detrahebant et vectibus.* "Our forefathers drew "them (the press beams) down by means of ropes and "leather thongs, and handspakes."

The press thus described is the Catonian press, known to us through CATO's book; it will be explained in detail in a later chapter. It consisted of two big pieces of timber, the *arbores,* placed upright near one another and slotted to take a cross piece. The press beam, *prelum,* was a long and heavy balk, one end of which, the *lingula,* was passed in between the *arbores* and caught under the cross piece; the other end was drawn down by means of a rope fastened to a horizontal drum, *sucula,* which was carried by another pair of uprights, the *stipites.* The drum was turned by

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13 18. **14** p. 99 sqq.

means of handspakes, *vectes.* The mass to be pressed, *sampsa,* crushed olives, or *pes,* grape pulp, was placed on a press bed of stone, *ara,* and a lid of wood, *orbis,* was placed over it under the *prelum.* The *prelum* pressed on the principle of a one-armed lever, and as the *ara* was standing quite near the *arbores* and the *prelum* was up to 7 m long, a considerable leverage was obtained. This was further increased by the use of very long handspakes. See fig. 12.

A press of this sort is shown in a wall painting in the house of the Vettii in Pompeji; it shows very clearly the *stipites* and the drum, with two winged amorines working the handspakes. The *prelum* is seen, too; its inner end is fastened not between two *arbores,* but in a hole in a single *arbor,* which agrees with the findings at Stabiae, to be discussed later. There is no *ara,* but a large container, which must be a treading floor for the grapes, once more in accordance with the Stabiae findings. No mass of pulp and no lid is seen; also no rope leading down from the end of the *prelum* to the drum, but several ropes going up from it, all of which makes it probable that the painting represents the amorines not as pressing, but as raising the *prelum* over the empty press before pressing. This could be done by means of a tackle and a rope, which was fastened to the drum. That this rope is not seen may be due to the dark colour and bad condition of the painting.

A *prelum* and a treading floor is seen on the sarcophagus relief shown in fig. 10; but as I doubt whether it belongs to a rope and drum press, it will be discussed in detail later on.

A press built on these lines was still in use in Italy about

9 Blümner fig. 127, p. 347; Brøndsted fig. 99, p. 106. **15** p. 87 sqq. **29** p. 68 sqq.

1792, as described by the Herculanensian Academy; and my friend, Mr. H. C. Broholm, of the National Museum at Copenhagen, tells me that he saw as late as the year 1926 a press of this construction in actual use in Crete. The *prelum* was made of iron, and the rope was an iron chain, but the principle was the same.

Another painting in the house of the Vettii shows a press built on a totally different plan. On a square foundation of stone are placed upright two strong, narrow frame works of timber, facing each other. In the stone is a shallow depression in which the olive pulp is placed; the oil is running through a spout out into a container like a wash basin. On the pulp is placed a plank; above it are built alternate tiers of wedges and planks, four in all, the last plank being caught under the upper cross pieces of the frame works, the vertical sides of which form guides for the planks. The wedges are driven in by two amorines, wielding hammers with long handles; one is working on the front, the other at the back of the press, showing that the wedges are put in from alternate sides. A wall painting from Herculanum shows a similar press; it is placed on the ground, and has only three rows of wedges, but the principle is the same.

Of this press there is, as far as I know, no mention in the antique literature.

Plinius goes on: *intra C annos inventa Graecanica, mali rugis per cochleam ambulantibus, ab aliis adfixa arbori stella, aliis arcas lapidum attollente secum arbore, quod maxime probatur.* "Within the last 100 years there have come into

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1 xxvii sqq. **7** Mau: Pompeji[2] Taf. ix, fig. 1. Blümner fig. 135, p. 364. **20** Herc. Tome 1, p. 187. Mau: Pompeji[2], fig. 185, p. 352; Blümner, fig. 128, p. 349; Meister: title-page; Schn. tab. xi.

"use presses invented in Greece, spars with furrows running "round them in a spiral, some people putting handles on "the spar, others making the spar lift up chests of stones "with it, which is very much praised." This passage has proved very difficult to several interpreters. It will be discussed in detail in the following lines; here I will remark that I take the words *mali rugis per cochleam ambulantibus* to be a description of the screw; to translate *cochlea* as "female screw" with Meister and Blümner would be to argue that Plinius knew a word for female screw, but none for screw, which will be seen to be most improbable. *Stella* is explained by Meister as four handles radiating out from the screw. The only real difficulty lies in the word *arbori.* It cannot mean the Catonian *arbores,* the vertical posts behind the press; it must mean either the *prelum* or the screw. As it would be impossible to fix handles on the *prelum,* remains only the screw; but this does not explain why Plinius has not written *malo,* which would have been unmistakable.

When the screw was first used for the purpose of pressing, the inventor did not find all at once the way which is familiar to us all: that of using the screw directly on the thing to be pressed. At first it was used only to supersede the drum and the handspakes: it had to draw down the *prelum.*

Brøndsted has reconstructed such a press. In his drawing the screw is fixed in the floor, and the nut, carrying four handles and thus forming a *stella,* travels down the screw, pressing down the end of the *prelum,* which has an oblong hole in it for the screw. That such a press is possible

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9 Meister 14, note q; Blümner 348, note 1. **11** p. 84. **12** 14, note q. **26** Fig. 104, p. 109.

is shown by the fact that a press, built on this principle, is found at Fenis, near Aosta. See fig. 13. It differs from Brøndsted's reconstruction only in having the *prelum* rather short. There is a practical reason for this. When a rope is pulled by means of a windlass, its length does not matter: the end of a long *prelum* could go up as high as the roof would permit. But if the nut of the screw has to be turned, it must be within reach of the workers; this limits the length of the screw, and, indirectly, the length of the *prelum*. I am inclined therefore to think that the Fenis press is not identical with the press meant by Plinius; I think that it is rather an intermediate form between the screw and lever press and the direct, twin screw press, to be discussed later on. While there are no technical objections against Brøndsted's reconstruction, it does not seem to conform with Plinius's text. *Adfixa arbori stella* must mean that the handles were put on the screw, not on the nut. This again means that the screw is turned round, while the nut, which is made fast to the *prelum*, travels up and down.

My reconstruction of this press is seen on fig. 14. In stead of the drum, there is a vertical screw, which is fixed in the floor in such a way that it can turn, but cannot give way upwards; this may be done by having it fixed in the roof, too. The end of the *prelum* is forked, and the screw nut is placed across the fork; when the screw is turned, by means of handles fixed on it below the *prelum*, the nut draws down the end of the *prelum*; when the screw is turned the other way, the nut takes the *prelum* up with it; they may be connected, for instance, by iron links. There is no other evidence for the existence of this press than Plinius. The difficulty in making it lies in the joint where the screw is

14 p. 55; 73 sqq.

fixed to the floor. It must be able to turn, but it must not give way upwards, even under strong pressure. This alone would make it difficult to turn. But the end of the *prelum* will not come down straight, but describes an arc, and so will have a tendency to force the screw out of a true vertical position; but this will make the screw apt to jam both in the joint and in the nut. How this difficulty was overcome in the next press mentioned by PLINIUS will be explained a little further on.

In my reconstruction I have incorporated a feature seen in the Fenis press and in other screw and lever presses. Before the *ara* is seen another pair of *arbores,* just like those behind it. They are used in lifting the *prelum.* In the Fenis press, if a cross piece is placed in the slot of these *arbores,* and the nut is screwed down, the inner end of the *prelum* will rise; when the pulp has been placed beneath it, it can be lowered down slowly and carefully; that this was necessary will be shown later. But if the outer end of the Fenis press is to be raised, it must be done by means of a tackle. In my reconstruction the screw will serve in this way not only to raise and lower the inner end of the *prelum;* if the screw is turned "the wrong way," the outer end of the prelum will rise, too. When the actual pressing was done, the cross piece in the foremost *arbores* of course must be removed.

The other sort of press, where the screw took up a chest of stones with it, is very well known to us. HERO has described a press on this principle, to be discussed later; but indeed presses of this sort were in common use far into the 18th century. It is described in works of engineering

9 p. 56. **18** App. 1. **27** 3 : 15. **28** p. 70 sqq. **30** FLORINUS Tome 1, p. 261; Tab. vii, No. iii. BOECKLER Tab. Nn. p. 490.

from that time, Niebuhr found one in Egypt in 1772, Paton saw one still in use in Kalymnos in the eighties of last century, Beck has seen it in use in the Tyrolian Alps, and Professor Boëthius has seen two such presses in Bosco Tre Case, where they were still in use thirty years ago; see fig. 15; the owner of one of them showed him how it was worked, as described in Appendix 1.

The principle of the press is this: the screw nut is contrived in the *prelum* itself, or placed across the forked end of the *prelum*. The lower end of the screw is made fast to a weight of stone in such a way that it can turn, but cannot give way upwards. After a few turns of the screw the stone weight leaves the floor and remains hanging in the air during the pressing. The stone then turns with the screw, so that there is no friction or chance of jamming in that joint, and the screw and stone automatically adjust themselves just beneath the nut. When the pressing is over, the *prelum* is lifted up by the simple means of turning the screw backwards, as described. No wonder Plinius writes: *quod maxime probatur*. See fig. 16.

The next step forward was to use the screw directly on the mass to be pressed. Plinius writes: *intra XXII hos annos inventum parvis prelis et minore torculario œdificio, breviore malo in medio derecto, tympana imposita vinaceis superne toto pondere urgere et super prela construere congeriem.* "Within "the last 22 years people have invented to press with shorter "presses and smaller press houses, with a shorter spar "straight in the middle, bearing down with full weight "from above on the lid laid on the grapes, and to build a

1 Niebuhr 1 : 151, tab. xvii. Paton: Journ. Hell. Stud. 1898 : 18 : 209 sqq. **3** 418. **22** 18 : 317.

"superstructure above the press." PLINIUS here describes a screw press with a single screw in the middle; *tympanum* must be his word for CATO's *orbis olearius*. What is meant by the *congeries* will be discussed later.

HERO knows two direct screw presses, which will be discussed in detail later on; in one of them there are two screws, one at each end of a short *prelum*, in which the screw holes are contrived; when the screws are turned, the *prelum* descends and presses on the pulp. See fig. 25. This press is not mentioned by PLINIUS. The other press has only one screw, the screw nut is contrived in a solid beam, which is fixed to the press bed, also of wood, by means of two uprights; when the screw is turned, the screw itself comes down and does the pressing; the whole system is like that of an ordinary copying press. This, then, is the principle mentioned by PLINIUS: the screw is in the middle, bearing down upon the press lid, *tympanum*, from above. See fig. 27.

BECK and BRØNDSTED translated *prela* by "press beams," and find some difficulty in understanding the principle of the press, which has no real *prelum*, in the sense of lever, in it. BECK supposes a short *prelum* with a heavy weight at the outer end, while the screw was placed directly over the *tympanum*; BRØNDSTED shows a screw fixed in the middle of the press bed, the screw nut, carrying the handles, travelling down it, and a short, heavy beam, of no obvious use, between the *stella* and the *tympanum*. All this I find quite unnecessary. We know that the word *prelum* was used also to denote a press generally, and we shall see that PLINIUS

5 3 : 18 sqq. **6** p. 73 sqq. **19** BECK 427. BRØNDSTED 109, fig. 105. **29** p. 59.

himself seems to have used it in this sense. And then this passage presents no difficulties in this respect, and there can be no doubt that the second Heronian direct screw press is the one meant by Plinius.

There remains to be explained the *congeries* to be built above the *prelum*. In Hero's presses the upthrust of the screw is taken by the "table," the press is sufficient in itself and even transportable. There is no use for any *congeries*. But it must often have happened in Italy that a man wanted to transform an already existing lever press into a direct screw press. He had the press bed, made of stone, with the necessary connections through pipes and canals to his container; he did not want to change all that. If he installed a direct screw press, the upthrust must be taken in some way. One way would be to make the uprights carrying the horizontal beam fast to the stone press bed by means of tenons; in most cases there would be no room for that. If they had to be made fast to the floor, he would have to dig 5 feet down to fix them; witness the press foundations at Stabiae. Remains as the most practicable way to prolong the uprights and build above the *prelum* a weight, *congeries*, of stones or bricks, heavy enough to give the screw sufficient backing. Fig. 17 is an attempt to reconstruct Plinius's press with the *congeries*.

Direct screw presses are well known; many are in use to this day. Paton tells us how the oldfashioned lever and screw press in Kalymnos was displaced by a direct screw press about 1890; Ohnefalsch-Richter shows a press from Cyprus; it has a direct screw in the middle of a fixed *prelum* — quite like Hero's one screw press; Brøndsted

20 p. 87 sq. **26** Journ. Hell. Stud. 1898 : 18 : 211, n. 1. **28** 122, fig. 13. **30** Hero 3 : 20. Brøndsted fig. 106, p. 110.

photographed one in Dalmatia; it has two fixed screws; the screw nuts carry two handles each and press down on a *prelum,* which is split lengthways, so that it can be dismounted without the screw nuts having to come off.

Before his summary of the development of the press, Plinius makes a few remarks on its use. He writes, 18:317: *premunt aliqui singulis, utilius binis, licet magna sit vastitas singulis. longitudo in his refert, non crassitudo. spatiosa melius premunt. antiqui funibus vittisque loreis ea detrahebant cet.* "Some press with one press, but it is more "efficient to use a pair, even if the one is very big. It is the "length that matters here, not the thickness. The roomy "ones press best. Our forefathers drew them down by "means of ropes and leather thongs . . ."

Brøndsted has pointed out the difficulty of this text: while the words *longitudo in his refert, non crassitudo* can refer only to the press beam, *prelum,* the words *vastitas* and *spatiosa* cannot refer to the press beam, but must mean the whole press. If we supply the word *torculum* from the sentence just before, the whole passage is rather disconnected.

But the passage becomes, if not very elegant, at least far more intelligible, if we supply the word *prelum,* in the double sense of both press beam and press. This word is not mentioned till further down: . . . *inventum parvis prelis et minore torculario aedificio . . . urguere . . .* where the sense "press", not "press beam", as we have seen, is to be preferred.

The larger the press, the more it could take in one pressing, but the more unwieldy it would get. There comes a point where it will save time and labour to use two smaller

15 111 n. 1. **27** p. 57.

presses instead. *spatiosa* refers, I think, to the conditions of the press house. If there is plenty of room about the press, it will be worked better than when the workers are cramped for space. To me the whole passage has a very strong suggestion of Plinius jotting down notes while an old *factor* is explaining how to get the best out of the pressing.

2. Regulae and galeagra.

In Bosco Tre Case, according to Boëthius, the wine pulp is placed on the press bed straight away, but elsewhere the grape pulp, *pes,* or the crushed olives, *sampsa,* is placed in some sort of container. From the Digesta we know that there were two ways of pressing: with the aid of *regulae* or without. From Plinius we know that the *regulae* represented a later development; he writes: *sive in sportis prematur, sive ut nuper inventum est, exilibus regulis pede incluso.* "Whether the pressing is done in baskets, "or, as has been invented recently, by inclosing the *pes* "between thin laths." On the strength of his findings in Salone, Brøndsted explains the *regulae* as thin boards, forming a sort of box without bottom or lid, in which the *pes* or *sampsa* was placed. This is borne out by Hero, who describes, under the name of *galeagra,* two different forms of just such a thing, one of which is very like the one described by Brøndsted. Hero describes the *galeagra* as something new, which agrees very well with Plinius; Cato, as might be expected, knows no such thing.

From modern times we have the description by Bosanquet of the grass-fibre envelopes used for olive pulp with the remark that they are in common use in Crete, while

8 App. 1. **11** 19:2:19:2. **13** 15:5; cf. Columella 12:52:10. **19** 105. fig. 98. **21** 3:16—17. **27** Ann. Brit. School, 1901/2:8:265.

bags are used ordinarily elsewhere; Mr. Broholm in Crete saw the men pack the wine-pulp into "something looking like rubbing-cloths." Brøndsted on the other hand heard that in Dalmatia no envelopes were used: the pulp was placed in the press, and a rope was wound round it, and that was all. This sounds incredible, but it is borne out by a fragment of a relief in the British Museum, showing a satyr, and the olives under the press; there is unmistakably a rope wound round them, and nothing else; the olives are escaping here and there — nice, fat olives, that do not look in the least crushed; but then the pulp would hardly lend itself to representation in sculpture. Here once more Brøndsted is corroborated by Hero, who writes that the *galeagra* was invented to replace "the rope that was wound round "the grapes to be pressed and the baskets, in which the "bruised (?) olives are placed." Nix translates حبل by "Netz," but its ordinary signification is "rope."

A basket is shown on a relief on a round base in the museum at Naples, where some satyrs are lifting a huge stone to crush a basket full of grapes — here the grapes also are nice, plump ones, not pulp. It is curious that these two only representations are in direct contradiction to Hero's words: the grapes in the basket, the olives in the rope!

In another antique representation, on a black-figured skyphos, it is impossible to see if there is a rope or a heap of envelopes.

Hero describes two different forms of *galeagra*. The second one is the most simple. It consists of four sides of wood, kept together by three interlocking cross-pieces on each side. See fig. 18. As the cross-pieces must have been

3 107. **7** Brøndsted fig. 102, p. 108. **13** 3 : 16. **16** p. 234. **18** Billiard fig. 143, p. 436. **24** Blümner fig. 124, p. 344. **28** 3 : 17.

horizontal, the boards would seem to have been vertical. This is borne out by the drawing in the Leyden manuscript. The cross-pieces jut out on each side; the free end has a square cut to half its thickness, so that they can be locked together. In order to reach down into the *galeagra* there must be placed upon the square lid, that fills out the *galeagra*, a wooden block as thick as the *galeagra* is deep, as described by Hero in his description of the direct twin screw press. The slits between the wooden parts must be open, so that the wine or oil can come out.

The first *galeagra* consist of wooden planks, 17 cm broad by 13 cm thick; each plank had, at a distance of 13 cm from its ends, four cuts, two to each end, one above and one below, 13 cm broad and 4.25 cm deep; in this way the whole *galeagra* could be built up to any height, as the cuts would engage the planks above and below. See fig. 19. The advantage of this *galeagra* over the second one was that the planks could be removed as the pressing went on, so that the whole space between the upper and lower position of the *prelum* could be used. Hero writes: "In this instrument "the wooden lid that is laid on the grapes, and the planks "laid on it, need not be very thick, because when the grapes "are being pressed the planks (of the *galeagra*) can be re"moved to the same extent as the grapes are pressed down, "so that there can never arise any hindrance from them." This translation is my own, and does not agree with Nix's, which is based on a small, but unnecessary correction of the text. The planks laid on the wooden lid corresponds to the *catenae* of Cato's *orbis olearius*, as described below.

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8 3 : 19. **11** 3 : 16. **26** p. 236, 238. **30** p. 118 sq.

3. Hero's presses.

As a sort of illustration to Plinius we find described by Hero, in the 3. book of his Mechanics, a lever and drum press, a lever and screw press, and two direct screw presses. Just to show us that we are dealing with Greek and not with Roman presses, they are slightly different from those described in the preceding chapters.

Hero's text exists in the Arabic translation only; it has been edited and translated into French by Carra de Vaux, Journal asiatique 1893:9:1—2; a later edition, by L. Nix and W. Schmidt, with a German translation, was issued by B. G. Teubner in 1900, as vol. 2:1 of Hero's works. The French edition was founded on one manuscript only; the German edition on 4.

Hero uses no *arbores;* the short end of his *prelum* goes into a hole in a wall. Also, he does not draw down the end of his *prelum* directly by means of the drum, but uses the drum to lift a stone, which is hung from the end of the *prelum*, by means of a tackle; the stone is lifted as far as it will go, then it is made fast to the *prelum* and carries out the pressing all by itself, till it reaches the floor. The *prelum*, he writes, is up to 25 ells in length, the stone will weigh as much as 20 talents. ذراع must be a translation of the Greek *πῆχυς*, which is 46.24 cm; 25 ells are 11.56 m; this is longer than Cato's, which was 25′ or 7.4 m. If ذراع were the translation of *πούς*, which was 30.8 cm, the measure would agree very well with Cato's; but as we find elsewhere in Hero قدم, which means "foot," we have to accept ذراع as "ell." That the word قنطار is a translation of the Greek *τάλαντον* is incontestable, as it is found in one of

3 3 : 13 sqq. **15** 3 : 13. **20** 3 : 14, 18. **25** 18 : 2. **28** 3 : 19.

the few fragments of the Greek text. One talent was 26.20 kg; 20 talents 524 kg. Supposing the short end of the *prelum* to go one ell into the wall, and the middle of the *orbis* to have been two ells from the wall, we get a leverage of 1:12, which means that the stone will have pressed on the lid to an extent of 6288 kg; add to this the weight of the *prelum* — if it was made of oak, 1′ square, it would weigh 936 kg; its centre of gravity is 11.5 ells from the wall, the leverage is 2:11.5, which gives 5380 kg, and we get a pressure of 11.668 kg.

The stone weight was raised by means of a drum; a rope from the drum went over a pulley on the prelum, then over a pulley on the stone, and was made fast to the *prelum*. See fig. 20. Above the pulley on the stone a cross piece of wood was fastened, so that the stone could be made fast to the *prelum*, probably by lashing, when it was raised. The drum cannot have been placed directly under the stone, but must have been placed inside the end of the *prelum*, otherwise the taut rope would tend to pull the *prelum* out of the hole in the wall. This explains the fact, mentioned as a drawback in this press, that, if a handspake should break, the stone would come down and hurt the workers. To this is added, that if a handspake should slip out of its hole, the same misfortune might befall the workers. But here one manuscript, B, has a curious addition. The text runs: "And for the lifting of the stone it is necessary that "we use long handspakes (and the strong handspakes that "are called in Greek دربا) to turn the drum, and we are "not secure, if the mass to be pressed which is beneath the "*prelum* is great and those who turn this drum with the rope "on it are many, against the breaking of one of the hand-

1 1:1, cf. p. 258. **14** 3:14. **20** 3:15. **26** 3:15, p. 231:4 sqq.

"spakes, when the stone will fall down and hurt them, or "it will slip out of its hole, when it will fall down also and "so hurt them the same way." The words in parenthesis are those found in B only. Nix reads either برنا or بربا, explaining it either as *περόνη* "or its synonym *πόρπη*," as he writes. The two words are not quite synonymous, as *πόρπη* means a buckle, *περόνη* the tongue of the buckle; I take the latter word to be the right interpretation. But the Greek word for hand-spake is *σκυτάλη*, which is translated into Arabic وتد; this is borne out by one of the Greek fragments. So we come to the conclusion that the Greek text mentioned both long *σκυτάλαι* and strong *περόναι*; that this addition has vanished in the three other manuscripts is no wonder. How the text is to be interpreted depends upon how we reconstruct the Greek text. If we take it to have run: (*δεῖ χρῆσθαι*) *σκυτάλαις μακραῖς καὶ περόναις ἰσχυραῖς* it would seem probable that *περόνη* was used here in the ordinary sense of the (iron) bolt or pin, as elsewhere in Hero; it is mostly used to denote the pin or bolt that connects two rods as a sort of hinge; but also an iron bolt going through a strap, the iron pin that holds the dolphin to its axle, and the pin on the axle of the wheel which moves the toothed wheel in Hero's "taxameter." But apart from the fact that the translator can hardly be supposed not to know this word, it is not very obvious where in the press these strong pins or bolts should be used. Neither the handspakes, nor the drum, nor the rope, nor the stone weight call for strong iron bolts as a necessary and characteristic part of the structure. The pulleys run on bolts, to be sure;

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4 Einl. p. xlii. **10** 2 : 1, cf. p. 274 : 10. **19** Vol. 1, 100 : 6; 132 : 13; 202 : 12; 294 : 6; 302 : 28. **20** Vol. 1, 430 : 15. **21** Vol. 1, 438 : 10. **22** Vol. 3, 294 : 3.

but these are always ἄξονες, never περόναι in Hero. So I think that we are thrown back upon the other supposition, that the text has run: (δεῖ χρῆσθαι) σκυτάλαις μακραῖς καί ταῖς σκυτάλαις ἰσχυραῖς ταῖς καλουμέναις περόναις, viz. that Hero himself has used the word in a special sense which had to be explained. The περόναι then are a sort of handspakes, not as long as the others, but stronger. I take it that they were short, strong pieces of wood that were put into holes in the drum and rested against the floor to keep up the weight while it was being lashed to the *prelum*; a sort of primitive pawl. If one of the long handspakes should break during the lifting of the stone, or one of the strong pawls should slip out of its hole, the drum being old and worn, while the stone was being lashed, a serious accident could hardly be avoided. The likeness of the pawl to a buckle-tongue is rather striking, but the whole explanation is only a matter of conjecture.

Another drawback comes from the stiffness of the rope. Hero writes: "The stiffness of the rope occasions some "sort of hindrance to the drawing down of the *prelum* and "the lifting of the stone, because the rope, if it is stiff, will "not run over the pulleys during the lifting of the *prelum* "upwards and in the lowering of the *prelum* downwards." Thus all the mss. Nix in the last sentence reads: "during "the lifting of the stone upwards," a most obvious correction. Only I do not think that it is correct. The stiffness of the rope would be of very little moment when a weight of some 500 kg was being raised; but when the *prelum*, after the pressing, was raised by means of a tackle made fast above it, then the stiffness of the rope and its unwillingness to run through the pulleys, when it was slack, would be

19 3 : 15, p. 231 : 1.

very annoying, as also when the *prelum* was lowered, by means of the same tackle, before the pressing. It is true that the first sentence seems to contradict this. But I take the words "the lowering of the *prelum* and the lifting of "the stone" to be a paraphrase of "the working of the "press."

It is a curious fact that HERO does not mention the simple lever and drum press; also that the only authentic Greek representation of a press, on a black figured skyphos, shows a satyr tying two heavy weights on to the end of the *prelum*; it looks as if the lever and weight press was older than the lever and drum press, and it is doubtful whether the simple lever and drum press ever existed in Greece. But this is an argument *de silentio* and may be overthrown by new discoveries.

A lever and weight press is seen on a relief in the Villa Albani, published by ZOËGA in Li bassirilievi antichi di Roma, vol. 1, p. 129, tab. xxvi; it shows clearly the *stipites*, the drum with the rope round it, the end of the *prelum* with the rope tied to it, and, less clearly, the stone weight. The least clear thing in it is the way in which the rope runs; it looks as if the rope from the *prelum* is connected directly with the drum, in which case the rope from the weight, not shown, must have been independent: the weight turned the drum, the drum drew down the *prelum*. As long as we have only the reproduction, the matter is open to doubt. See fig. 21. The relief has been published in the Photographische Einzelaufnahmen antiker Sculpturen, hrsg. von PAUL ARNDT und GEORG LIPPOLD, Serie XII, Nr. 3584. München 1931. The photograph shows far less details than the drawing in ZOËGA's book.

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9 BLÜMNER fig. 124, p. 344.

On the Rondanini relief, mentioned already in connection with the *mola olearia*, a press is shown. See fig. 10. The relief, which is long and low and broken off at both ends, is divided into two parts by an olive tree standing a little to the left of the middle. To the right of the tree a winged amorine is picking the fallen olives up into a basket; he is facing the tree; behind his back is the amorine with the oil mill allready described. On the other side of the tree is the press. In the background is the *prelum*, its upper end touches the branches of the tree, its lower end is hidden behind an amorine on the extreme left of the relief; this amorine is carrying a burden on his shoulder and walking towards the press. This burden, which he holds by means of a stick in his right hand and steadies with his left above the left shoulder, is not very clear; I take it, by its sleek appearance and queer form, to be a skin full of oil. Under the *prelum* is a square container full of fruits, which are probably olives; in front of the container are four curious objects, looking like four flattened ovals lying on four bricks; they are explained by Zoëga, as we shall see, as four vases for oil. In the container stands an amorine; his left knee is lifted as if he was stamping the olives, which is absurd; his left hand is lifted and holding something. Zoëga in his relief saw a kind of thyrsus; in this relief it looks more like a rope or stick coming down from above and ending a little below the figure's elbow. To the right of the container stands a big bowl; between the bowl and the olive tree is a square block. Turning our attention to the *prelum* once more, we see at its upper end, right over the block, what looks like the windings of a very thick rope; above the block is seen the trace of something showing an

1 p. 42. **20** fig. 22.

outline like half an oval; on the block is a vertical line as if a rope had been running down it. I think that the block is meant to represent a stone weight, the oval shape a tackleblock, and the rope on the *prelum* the rope with which it was drawn down. Some distance from the end of the *prelum* another rope is tied round it; one end of it hangs down to the floor, another reaches the ceiling; the latter has been broken. Zoëga has seen, not a rope, but a forked stick to prop up the *prelum;* in the Rondanini relief it seems to me that a rope is shown; this would then be the rope for lifting the *prelum.* In his Apparatus ad Bassirilievi, Ny kgl. Samling 357^{b} fol. VII pag. 184^{d} Zoëga has described another relief, seen by him in the Museum Kircherianum, which must have been very much like the one in Rondanini. See fig. 22. The likeness is so striking that I might have been led to suppose that it was the same relief, which had in some way escaped from the Museum Kircherianum, especially as the relief now cannot be found in the Museo Nazionale Romano delle Terme Diocleziane, where it ought to be; Professor Mancini took great trouble to locate it, but failed. But Zoëga writes that his relief was di buona maniera, which the Rondanini relief is not; also he shows on his drawing and mentions in his explanation three vases in front of the container, where the Rondanini relief has four. It seems probable then that the Rondanini relief is a copy of the Zoëga relief, or that the subject was a favorite one. I was inclined to suppose that the artist had represented a wine press, since the amorine is stamping the fruits in the container; but Zoëga shows that the berries are undoubtedly olives, not grapes, and so the contradiction must be left as it is.

Because of the two drawbacks found in the drum and weight press, Hero proceeds to describe another way, which is strong, safe and easy. It is a lever and screw press with loose stone; it differs from the presses previously described therein that the screw is made fast to the *prelum*, and a screw nut, as long as is the screw, is made fast to the stone; when the nut is turned, it swallows the screw altogether. See fig. 23. This arrangement is inferior to that used elsewhere, because half the distance between the *prelum* and the stone is taken up by the nut, while in the other press, where the nut is in or on the *prelum*, the screw can have any length, and the *prelum* can come right down to the handspakes. Also it requires a long screw hole with a solid bottom; this could be made only by cutting the block of wood in two lengthsways and fashioning the screw threads in the halves by hand — a most laborious way. The instrument described by Hero for cutting threads in screw holes cannot cut unless the hole goes right through the wood. So probably this press was soon superseded by more practical forms. But when we take into consideration that Hero describes also direct screw presses, a very curious problem of chronology is involved; but that will be discussed at length after all the presses have been described.

Hero explains in detail how this press is to be built. Unfortunately, however, the text in some parts is so corrupt as to be quite unintelligible. The general principle is this: A piece of wood, of the shape of a brick, is fastened on the under side of the *prelum*, in the place where the rope was fastened; the upper side of the brick, where it touches the *prelum*, is round, and it is fastened in such a way that it cannot move more than necessary, but can lean towards both sides; the purpose is obvious: the screw must always

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1 3:15. **16** 3:21; cf. my p. 77 sqq.

be perpendicular, but the end of the *prelum* describes an arc; so the joint must be able to give way a little. But how this joint is made cannot be seen from the text. "Then we "raise the *prelum* to the highest position to which we (ever) "lift it for putting grapes under it" and measure the distance between the brick and the weightstone; one half this measure, or a little more, is the right length for the screw. The screw thread should reach one end of the screw, but not the other end, which is made square; this end has to be fastened to the brick. How this is done is not quite clear from the text; still I think it possible to get some idea of it, even if it is not by any means certain that it is right in all its details. First, then, we must bore in the square end of the screw a hole called طرمس. "This is a round hole which is bored "at the end of the wood so that the wood may be joined to "the beam, to which it has to be made fast." طرمس is explained by Nix as *τόρμος*. Elsewhere in Hero this word seems to be used exclusively in the sense of "tenon", but there is so much evidence to show that it may mean also a hole that it seems impossible to reject the explanation here. As the hole has to carry the screw, it must be made through the square part, not into the end wood. "We then "put this tormos against one of the sides of the brick which "is sitting underneath the *prelum*." Unless this means that the square end of the screw should be placed against the under side of the brick, we get an asymmetrical construction which is rather improbable and will lead to difficulties in the interpretation of the next lines. "We then take iron "cross nails and place their ends against this hole and "hammer the rest of them into the brick." Nix translates:

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3 3 : 15, p. 231 : 17. **14** 3 : 15, p. 233 : 7. **17** Einl. p. xli. Dioptra 3 passim; vol. 3 : 312 : 5.

"... fügen ihre Enden in dieses Loch ein ..."; this is impossible, since there has to be an iron bolt through the hole; also ركّب seems to mean rather "place against", while "put into" is اجاز. I take those transverse nails to be a sort of cramp, the rounded part of which goes below the hole, while the two ends are nailed into the brick; but I admit that طرف is rather a queer word to describe the curved part of a cramp, even if it is long. "Then we "take also an iron axle, put it into the hole and let it go "on to the brick and make it fast so that it may strengthen "the bond and connection with the brick." This would mean, then, that the axle was bent upwards and nailed to the brick. See fig. 24. There are admittedly several objections to this interpretation, but it seems the only way in which the hole, the nails and the axle together may be used for the purpose in question with any reason.

The description of the making of the screw nut presents no difficulties: a piece of hard wood, as long as the screw but thicker, is split lengthsways, and the inside screw threads are cut in the two parts; then they are put together again. The inside screw thread must not go right through; one end of the wooden block is left solid. This end of the screw nut is then made round, a furrow is made in it, not far from the end, and an iron ring is put on just below the furrow; also the lower end of the round part is guarded by an iron ring. A hole is made in the stone to take the end of the screw nut, and iron clamps are put on so that it cannot slip out of the hole, but can turn easily. Nix translates ضباب by "Haken," but as the same word is used to denote the wooden cross pieces that perform the same function in the direct twin screw press, it seems probable

30 3:19, p. 243:11.

that they had about the same form, see fig. 25, 26. Above the neck of the nut two holes are made at right angles to take the handspakes; these go right through the holes, forming four handles. When the screw nut is turned by means of the handspakes, the nut swallows the screw, and the stone is lifted from the earth; the *prelum* will then press on the pulp placed beneath it till the stone reaches the floor. The nut is then turned the other way, and the *prelum* rises again.

Before describing the direct screw presses HERO calls attention to the fact that they differ from the lever presses in this respect, that while in the lever presses, "when you "have hung up the stone and left it to itself, the *prelum* will "do the pressing without your having to repeat the pressure "several times," in the direct screw presses it is necessary to screw down the *prelum* little by little all the time. This is significant, since this is true of lever and weight presses only; it seems to indicate that at this time the simple lever and drum press was not in use here.

The press bed for the direct screw press is a piece of wood, whose dimensions are given thus: 6 spans long, not less than 2 feet broad and not less than 1 foot thick. The arabian قدم can hardly mean anything else than foot, *πούς*; so the bottom is 61.6 cm broad by 30.8 cm thick. But شبر, a span, is known from one of the Greek fragments to be the translation of *παλαιστή*, a hand's breadth, which was 7.71 cm; 6 spans then make 1.5 feet or 45 cm. But a piece of wood, 45 cm long, 60 cm broad and 30 cm thick would hardly be large enough to make a press bed, apart from the obvious absurdity of the dimensions. There must be some error, and it must be that the length is too

12 3 : 18, p. 241 : 11. **21** 3 : 19. **25** 3 : 2, cf. p. 296 : 7.

short. On the other hand, it will not do just to alter the figure 6, for if the press bed should be, say, 4 or 5 feet long, it would hardly be measured in spans. But there is another Greek word, *σπιθαμή*, which is also usually translated as span, measuring three *παλαισταί*, or 23.12 cm or three quarters of a foot. Six of these would be 4.5 feet, which is not only a suitable length for the press bed, but also a dimension that would be given in *σπιθαμή* rather than in feet, so as to avoid fractions; the only difficulty is that we must assume the interpreter to have used the same word for *παλαιστή* and *σπιθαμή*; but then the Heronian system of measures of length is enough to confuse anybody. So I take the press bed to be 140 cm by 60 cm by 30 cm. This piece of wood is called the table.

Near the end of the table two deep, round holes are bored, and to each hole are fitted two cross pieces of wood, which are let into the wood of the table; their ends form hollow half circles, so that, when they meet, a small hole is formed, smaller than the hole in the table. These cross pieces should go into oblique cuts, so that when they are put into their places they will stay and never give way. Nix pictures these cross pieces as a pair of half-round boards, forming together a whole circle, which is held down in an undercut, round excision in the table by means of wedges all round. It seems far more probable, and quite consistent with the text, to picture them as straight pieces of wood, sliding in dove-tail shaped furrows stretching right across the width of the table. See fig. 26.

"Then we take two hard sticks of wood, absolutely "straight and alike, of quadratical cross section;" at one end we leave them square, the rest is made round, and a

22 fig. 59, p. 242. **29** 3 : 19, p. 243 : 14.

screw thread is cut into it. On the square end a disk is placed, with four holes for handles or handspakes. At the other end of the screw stick a big furrow is made, all round it, as far from the end as the hole in the table is deep; the diameter of its bottom should be half that of the cylinder of the screw. This end of the screw is put into the hole in the table, the two cross pieces are driven towards the hole, so that their ends go into the furrow and hold down the screw.

The *prelum* is another piece of wood, as long and thick as the table, but narrower by one quarter; it has two screw holes right through it at the same distance as the holes in the table. "But how to make an inside screw thread will be "explained later."

Then we must make a square foot for the table, the lower part of which foot looks like a step, and whose length is a little more than the breadth of the table, so that the whole thing stands firmly on it. "We must cut out a suitable notch "in the middle of the foot, and we must cut the middle of "the table to fit the notch in the foot; then we put one of "these notches over the other so that the joint will be very "strong." Nix interprets this as a sort of groove and feather arrangement, with a double swallowtail running in grooves in both the table and the foot. The text, however, mentions only two notches, but no feather or tongue. If my interpretation of the size of the table is right, then the foot, which is longer than the table is broad, must be far broader than it is long, and have the grain at right angles to that of the table. But then it seems far more natural to suppose that a shallow cut was made in the top of the foot, as long as the table was broad, and another in the bottom of the

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13 3 : 19, p. 245 : 17. **18** 3 : 19, p. 247 : 4. **22** fig. 59, p. 242.

table, as long as the foot was broad, and the two parts joined in this way.

On the table four walls of thin wood are placed, to keep in the juice; inside the wall a shallow depression is cut out, and the *galeagra* is placed in it. The press lid is a plank of wood, which must just fill out the *galeagra;* on this lid is placed a wooden block, as high as the *galeagra* is deep. When the screws are turned, the *prelum* comes down on the block, the block presses on the lid, and the lid on the pulp. When the screws are turned the other way, the *prelum* comes up, and the pulp can be turned over, till all the juice is pressed out of it.

"There is also a machine with one screw, which is made "in this way, that we fix on to the table two uprights, which "carry the cross piece, in which the screw hole is; and the "screw hole should be in the middle of the cross piece. The "screw is put through this hole and turned by means of "handspakes in the disk till it reaches the lid which is laid "on the *galeagra* and presses it down and the juice flows. "It is necessary to repeat the pressing several times till "there is no more juice left in the pulp to be pressed." (See fig. 27.)

"Besides these there are many other kinds of presses, "but we prefer not to describe them, because they are much "used by the common people and well known by them, "although they are inferior in use to those we have men-"tioned."

The direct, one screw press is very much like Plinius's direct screw press, apart from the fact that Hero's press is portable, and Plinius's fixed; there is no need for a *congeries* in Hero's press, where the press bed and the

13 3 : 20, p. 249 : 4.

cross beam for the screw are held together by uprights. In the one screw press there is no need for the wooden block to be laid on the press lid, as the screw itself will go into the *galeagra*. In the description of the one screw press there can be no doubt that the pulp has to be pressed several times; between two pressings it has to be shovelled about, as it is done to this day. But then it is necessary, I think, in the last sentence of the description of the twin screw press to translate بدل not by "exchange" but by "shift about," as the operation of the two presses must have been the same.

The last chapter of the Mechanics deals with the method of making an inside screw thread. This chapter belongs with the description of the direct screw press, which is why I include it here. As my interpretation differs slightly from that given by Nix, I shall give a complete translation of the chapter, with a running commentary. Fig. 28 shows how I think that the instrument was made.

C. 3:21. "As for the female screw, it is made in the "following way: we take a piece of hard wood, more than "twice as long as the female screw, and as thick as the "female screw; and on one end we make on half its length "a screw as has been described by us; the depth of the "furrow of the screw must be the same as the depth of the "screw we want to screw into the female screw." That is, we make a male screw to fit the female screw we are going to make. "From the other part we turn off the wood to the "depth of the screw thread, so that it becomes like a round "peg of equal thickness. We then draw two diameters "across the base of the wood, and divide each of them in "three equal parts." The two diameters must be at right

23 2 : 5.

angles. Nix corrects the text so as to get one diameter only; it is true that there is no further mention of the second diameter, but I think that it is used for the furrow or canal to be described later on, so I prefer to let the text stand as it is in regard to the diameters. On the other hand, Nix is right to correct the text where it mentions two bases — that is a *lapsus calami* provoked by the dualis of the diameters. "Through one of the two dividing points we draw "a line at right angles to the diameter, then we draw from "the two ends of this normal two straight lines along the "entire length of the peg, and that is possible for us if we "place the peg on a flat piece of wood, and we scribe the "two lines with a point till we reach the screw thread". Nix translates ". . . mit einer Zange . . ." reading بالكلبتين. The mss. have بالكاسكر, بالمكايس, and بالكايس, all of which is manifestly corrupt. Still, I am not sure that Nix's correction is sound. The pincers or compasses would not be of great help for this purpose. The fact is, that there is not the slightest difficulty in drawing a line along the side of a cylinder, if only the cylinder is laid down on a flat board; any straight piece of wood of half its thickness or less will do as a ruler. I might understand it, if Hero had written: "and draw the line by a ruler . . ."; only that would have required على, not ب, on which all mss. agree. When the same word is hopelessly corrupt and without any sense in all mss., it seems reasonable to suspect a Greek word, and I suggest ἀκίς, which would give الاكيس, to be the word.

"Then we use with great care a fine saw, till we have "sawn right through to the screw thread, and we detach the "third of the peg, which we have sawn through, and we cut "out, in the middle of the remaining two thirds, to their "whole length, a furrow like a canal, whose depth is half "the thickness of the remaining wood." There is no mention of how broad the canal should be; but it seems reasonable to think that it may have been one third of the thickness of the peg, in which case the marks on the other diameter would be used to decide its dimensions. Nix shows the canal wedge shaped, growing quite shallow towards the screw thread; for reasons given below I cannot accept this interpretation, which has no foundation in the text.

"Then we take a piece of iron and sharpen it to suit "the screw thread." The text has فنديره "and turn it," in Nix's translation: "und drehen ihn gemäss den Schrau- "benwindungen." This seems to me to give no sense at all. The piece of iron is to be the cutter, which is to cut the inside screw thread; therefore its edge must be fashioned to cut a furrow to take the outside thread. I prefer to read فنحدّده though all the mss. agree. Even if ادار is taken to mean "turn in a lathe," it will not do, firstly because iron could hardly be turned in a lathe at Hero's time, secondly because a round point would not be of any use, the cutter must have sharp edges.

"Then we make it fast to the peg with the groove in it. "Then we make its end come out near the screw thread, "after having made the two pieces fast to one another very "firmly, so that one remains fixed to the other and they can "never come apart at all." What is meant is not difficult to see: the cutter is put into a hole in the side of the peg, so that its cutting edge protrudes in such a way that the screw thread it has to cut comes in continuation of the male screw thread. But the whole description seems to have got mixed up some way. We do not learn where on the peg the cutter has to be placed. It cannot be just after the end of the male screw thread, because the groove stops there, and the wedge, which is to force out the cutter, would be stopped by the end of the groove. Also the cutting is done little by little, the screw thread being deepened as the cutter is being forced out; but if the cutter came just after the screw thread, it would have to cut down to the whole depth at once, or the thread would jam in the cut. It would be necessary, then, to draw a line representing the screw thread on the peg, and to fix the cutter on this line, at some distance from the end of the screw thread. The two first sentences ought not to have been separated by ثمّ, as they are part of the same operation; and the following sentence "after having . . ." really belongs to the next. There is no mention of the side through which the cutter has to come out, but as the wedge must back up against something, it seems likely that it came out through the side of the canal. The sawn off part is replaced to keep the wedge in position; it could not quite fill out its old place, since even the finest saw cut has a definite thickness; but that would be of little moment, since the remaining part of the peg would be enough to ensure a tight fit in the hole in which the screw thread is to be cut.

"Then we take a small wedge and put it into the canal "and knock it along till it forces out the cutter and lies "between the two parts." "The two parts," القطعتين, is a correction by Carra de Vaux for قضبتين, which gives no sense at all; Nix has accepted the correction. Carra de Vaux takes the cutter as the subject of the last sentence, translating: "jusqu'à ce que la verge de fer vienne de sortir "entre les deux segments." I take it to mean that the wedge should stay in the groove; I think that the wedge is a square peg of wood, fitting snugly in the groove, with its inner end cut at a long slant to form a wedge. Then the canal must be of equal depth all along, not growing shallower as shown by Nix.

"When we have done this, we place the screw in a wooden "plank in which we have bored a perfectly straight hole as "broad as the screw thread." The screw thread on the instrument is meant to guide the cutter; to do this, it has to go into a screw nut. Only we have no screw nut, and cannot make it yet; so we must make a make-shift guide for the screw. First we make a hole into which the screw fits smoothly.

"Then we bore in the side of this large hole small holes "one after the other, and put small, oblique, round pegs "into the holes, and drive them in till they engage the screw "thread." "Oblique" seems to refer to the way in which the ends of the pegs are cut to fit the screw thread. These ends forms a provisional inner screw thread to guide the cutter.

"Then we take the plank in which we want to cut the "female screw and bore in it a hole to fit the screw peg." The smooth peg has the diameter of the bottom of the male screw thread, which is the same as the top of the female screw thread, or the diameter of the hole into which the screw has to be cut.

"And we join this plank to the plank into which the "screw is fixed, by two uprights which we fasten very care-"fully. Then we put the peg with the wedge in it into the "hole in the plank in which we want to cut the female "screw, and we bore holes in the upper end of the screw "and put handles in them, and then we turn it till it pene-"trates into the plank, and we keep on turning it up and "down, and knocking in the wedge every now and then, "till the female screw has been cut in the way in which we "wanted to cut it. And so we have cut a female screw. This "is the instrument, and with it ends the book." The last part of the description is quite clear; the plank with the provisional screw thread is clamped to the plank in which the real screw thread has to be cut, in such a way that the two holes come into line; the cutter is put in, and while the small pegs engage the screw threads in the upper part, the smooth peg enters the hole in which the screw thread is to be cut. When the screw is turned, the edge of the iron cutter scratches a screw thread inside the hole, and as it is guided by the screw thread above, the new screw thread is cut to the right gradient. In modern instruments of this sort the screw thread is cut at once to its full depth by means of a hollow cutter; in Hero's instrument it has to be cut little by little, probably with many interruptions to get out the chips. I have already pointed out that the cutter, because it has to cut little by little, cannot have been placed right at the end of the screw thread, since then the screw thread would jam in the partly cut furrow, it must sit some way down the peg. If the canal in the peg is cut at a slant, as shown by Nix, the cutter would have to come either in the lid or the bottom of the canal. Neither is practical, because in one case the distance between the lid and the inside of the hole would deprive the cutter of some of the firmness of its fastening; also the text requires the cutter to be made fast to the peg, not to the lid; in the other case the wedge would have to back up against the lid, where one would think that the solid side of the canal must be better.

By comparing these chapters on the screw presses with Plinius's statement of the time of the invention of the screw presses, WILHELM SCHMIDT reaches the conclusion that HERO lived in the first century after Christ. The argument rests on the assumption that HERO was the original writer of these chapters and did not simply copy them from somebody else. Fortunately it is not necessary here to go into the vexed question of HERO's date; it is enough to point out that this part of the Mechanics dates from about 50 A. D. It cannot be very much earlier, unless we reject PLINIUS's statement; and it cannot be very much later, for reasons it will take some little time to explain. About the testimony of VITRUVIUS see Appendix 2.

In studying HERO's screw presses we will find a very interesting difference between the screw and lever press and the direct screw presses. In the first sort the block of wood for the screw nut is split open, and the inside screw thread cut into the two halves; in the direct screw press the female screw is cut into the hole as it is. As I have pointed out already, the construction of the screw and lever press is rather clumsy; it would work ever so much better if the nut was either cut into the *prelum* or placed across it, and the screw was fastened to the stone weight. Why was it not done? As an appendix to the description of the direct screw press, where the solid screw nut is indispensable, HERO tells us how to make a female screw in a solid piece of wood; more than that, he finds it necessary to promise us this information where he mentions, for the first time, that an inside screw thread has to be cut. The inference seems quite plain: the direct screw press could not be made, till the screw cutter was invented; then the screw and lever press, which lived on side by side with the direct screw presses (and the old lever and drum presses), profited by

1 HERO vol. 1, Einl. xix sqq.

the invention and got its proper shape. But if this is right, then these chapters on the presses must have been written after the invention of the direct screw press, but before the screw and lever press got changed, since there would be no sense in describing an obsolete press, if better presses of the same sort were found. But this definitely fixes the date of the Mechanics at about 50 A. D.

If this is right, we are pledged to the assumption that the screw nut was not invented till about 50 A. D.; is this possible? It is a suggestive fact, that nowhere else in Hero is there any mention of such a thing. He knows and uses the endless screw, which was invented before 212, since it was invented by Archimedes; but whenever else he uses a screw, there is no proper screw nut, but either a smooth hole with a small peg thrust in from the side, or else a *τύλος*, which is a tenon, one end of which engages the screw thread, while the other end slides along double grooves. Of these he uses the hole and peg in his diopter, where some very small parts have to be made adjustable, also in his adjustable water clock, where Pseudo-Hero, in his improvement, mentions, for the first time to my knowledge, a female screw of such small dimensions; the *τύλος* he uses in his automatic theater, where it is used to lift the automaton so as to bring a second pair of wheels into play. He also mentions the use of the *τύλος* in the Mechanics, where he gives the theory of the screw; but his preference is always for the endless screw, and I cannot but think that the *τύλος* used for lifting weights by means of a rope tied to it is meant more for a theoretical illustration than for practical use. I may mention that while the endless screw

18 4, vol. 3 : 200 : 12. **20** Pneum. 1 : 5, vol. 1 : 50 : 4. - Pneum. 1 : 5, vol. 1 : 50 : 17. **23** 10 : 2, vol. 1 : 370 : 10. **25** 2 : 5, p. 107 : 13, cf. 286 : 3.

is still in use, among the innumerable uses of the screw in modern times I can recall only one single instance of the use of the hole and peg method, to wit in the back vise of a carpenter's bench, and only one of the τύλος, in Eversharp pencils and the like; there may be some more, but they are few and far between. The reason is not far to seek: neither the hole and peg method nor the τύλος allow of any great force to be used; this is why the screw nut was used first for the presses, where it was necessary to exert a very great pressure.

To trace the history of the screw from its first beginnings to its present use lies outside the scope of this book; but I think that I may call attention to the fact that it seems to be found in antiquity only in wine presses, oil presses and fuller's presses, apart from the few instances quoted from HERO. I may mention here that the screw clamp which A. NEUBURGER finds on a wall painting from Herculanum is no screw clamp, but an iron hook or anchor, as they are used to this day in old-fashioned carpenter's benches.

In the house of the surgeon, in Pompeji, was found a vaginal speculum, *speculum matris*, in which the three arms are made adjustable by means of a screw with square thread. It is described in detail by BENEDETTO VULPES, in the Museo Borbonico, Vol. 14, 1852, Tab. 36, Fig. 1—2; there was no real screw nut, but a smooth hole with an iron peg to engage the screw thread.

4. The oil press in archaeological findings.

Most parts of the presses were made of wood, and have vanished without leaving any trace. What is found is mostly

17 76, fig. 116, cf. Herc. Tom. 1, p. 181. BLÜMNER 2, fig. 59, p. 346.

press-beds with their *canalis rotunda,* stone press weights and stone *arbores,* which are found in Africa in no small numbers. Most of these belong to screw and lever presses; of direct screw presses very few traces are found; of the old-fashioned lever and drum presses only the press beds and the foundations are likely to be found.

From Stabiae we know about three single and one double press, from Boscoreale about one single oil press and a double wine press; to these are added the two presses found at Salona.

Apart from the oil press, all the presses at Stabiae are built on the same general lines, and quite different from the press described by Cato. Cato's press bed, *ara,* is 1.3 m square, with a *canalis rotunda* on top of it; at Stabiae the floor of a whole room is provided with a very fine pavement, and the pressing took place somewhere on the floor, but the spot is not marked in any way. The whole floor slopes gently towards one corner, where there is a leaden pipe leading to a great container in the floor. The rooms vary in shape from almost square to twice as broad as they are long, and in size from 60 to 18 m^2; but in no case can the press have covered the whole room. The only explanation is, that they were primarily used for treading the grapes, and then the press was built over them so as to save the expense of a separate *ara* with the necessary connections. Even the double press house in Casa di Miri at Stabiae, where the trapete was found in the press house itself, must have been built for wine. In one case, if the

7 Ruggiero 333, tab. xii; 345, tab. xiv; 347, tab. xv; 352 sqq. tab. xvii. **8** Mau 131 sqq., tab. iii; Pasqui 463 sqq., tab. xiv. **10** Forschungen in Salona 2:9, fig. 4. Brøndsted 103 sqq. **26** Ruggiero 333, tab. xii; La Vega tab. i; Herc. tab. 1; Schn. tab. v, vi.

drawing is to be believed, no trace of any press was found; so here we have a place for treading grapes only; some sort of press, to be discussed later, was found in the same house.

Of the press itself next to nothing was found; the exception being two sets of iron rings found in Casa di Miri, in the very place where they must have been left as the *prelum* crumbled away from them; they were 1′ 4″ or 35.6 cm in diameter. What is found is the foundation for the *arbores* and the *stipites;* not CATO's foundations, on which the wooden posts rested, but holes in the floor, into which they went, to be fixed with cross pieces 5′ or 1.5 m below the surface. This makes it necessary that there must be some way to get at the lower end of the posts; so there are built subterranean passages, very narrow, but still passable for a not too heavy person, reached by manholes from above.

This principle is quite different from CATO's: he makes big foundations for his posts, and then places above them masonry enough to withstand the upthrust of the press; here the upthrust is taken by the thick layer of earth above the lower end of the post. The holes are bricked up all round, on the floor they are generally marked by a single slab of lava with a rectangular hole in it.

In every case there is a hole for a single *arbor* only, and it is always square. As it has to come in the floor of the press itself, it is guarded by a small ledge all round; this ledge sometimes includes the manhole, too. In Boscoreale the manholes were placed behind the back walls of the press room, in different rooms altogether. Some times the manhole leads to a passage reaching all three posts of the

1 RUGG. 325 sqq., tab. x. **3** p. 91. **6** Herc. xxvi, xl. tab. i; SCHN. 637, tab. vi.

press; some times it is just for the *arbor*, and the *stipites* are reached from a manhole right in front of them; in Boscoreale one press is constructed in the former, the other in the latter way.

The holes for the *stipites* are always outside the press room, one wall of which is very low, so as to allow the *prelum* to come down, and also the grapes to be dumped on to the press floor. In two cases the *stipites* and the drum and the containers take up the whole front of the press room; then there are windows on one side through which the grapes can come in. The distance from the *arbor* to the *stipites* varies from 6.4 m to 4.9 m in Stabiae; in Boscoreale it is 4.5 m and 3.65 m. The distance between the *stipites* varies from 2.9 m to 2.2 m in Stabiae; in Boscoreale it is 1.6 m and 1.8 m.

In two of the Stabiae presses the holes for both *stipites* are of equal form and size, being about twice as long as they are broad, the long side being parallel to the *prelum*. In all other cases the hole for one *stipes* is narrow, and that for the other is twice as large, being square. It is remarkable that the square hole is never found close to a wall, while the narrow hole is always near a side wall. This cannot mean that the thin *stipes* was reinforced by being connected with the wall, since in the two firstmentioned presses one narrow *stipes* is standing quite as far from any wall as the square ones in the latter.

Hörle explains the difference in the size of the holes by assuming that the square *stipes* was used to support the roof. This explanation is inadmissible. In the first place, if the *stipes* carried the roof, it could not be taken out, and

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8 Rugg. 347, tab. xv; 352, tab. xvii. **16** Rugg. 345, tab. xiv; 347, tab. xv. **27** 218.

then there would be no sense in making elaborate, subterranean passages to get at its lower end. In the second place, while the theory may explain the square *stipites* in Boscoreale and Stabiae, it fails utterly to explain the square *stipes* in the Boscoreale oil press, which was found in a room of very modest dimensions. Further, both *stipites* are put up in exactly the same way; what would be enough for one, must have been enough for the other. Hörle seems to have failed altogether to grasp the essential difference between a press weighed down from above and a press steadied from below. Two *stipites*, fixed to more than half their length in bricked up holes, would need no superstructure to keep them in place.

The explanation given by Pasqui is extremely probable: both *stipites* were of equal thickness, but outside the outer *stipes* a wedge was placed in the hole; this would make it possible, if the wedge was removed, to move the *stipes* sideways, so that the drum could be taken down, without anyone having to squirm through the narrow subterranean passages.

The relative position of the *arbor* to the *stipites* is different in all three single presses. In one it is opposite the middle of the drum, in one it is somewhat on the side, and in one it opposite one of the *stipites*. In both the latter cases it is thus brought near one wall of the press room; the purpose probably is to get as much space free for treading the grapes as possible.

The two double presses consist of just two press rooms placed opposite to one another. In the one in Casa di Miri the *arbores* are placed directly opposite one another; but then the *stipites* are not. One pair is standing in a natural

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5 p. 90. **11** p. 90. **14** 469. **21** Rugg. 345, tab. xiv. **22** Rugg. 352, tab. xvii. **23** Rugg. 347, tab. xv. **28** Rugg. 333, tab. xii.

position, but one of the other pair has been placed so near the wall, that it has been necessary to cut out a niche in the wall behind it. It looks almost as if the two pairs of *stipites* had originally been standing right opposite one another; this was found unpractical, and then one pair, or perhaps only one *stipes,* was moved. It was moved towards the wall, partly so that the *prelum* should not take up more of the floor than necessary, partly because the rest of the space along the low wall was needed for the bringing in of the grapes. But why move it at all? Because the space between the two sets of *stipites* was only 5.3 m, so the two gangs would always get in the way of one another, unless the handspakes, *vectes,* could be placed at different ends of the two drums.

In Boscoreale the two pairs of *stipites* are directly opposite one another; but then the *arbores* are not. This seems to indicate that the rope from the *prelum* was made fast not to the middle of the drum, but towards one end; the holes for the handspakes then came at the other end. In this way the men using the presses would go clear of each other, since they worked at opposite ends of the two drums.

As to the height of the *stipites* we are without information. Still, it is a suggestive fact that the niche behind the *stipes* in the Stabiae press house was quite shallow till some 80 cm from the floor, and then suddenly was cut out to twice its depth. Its total height was some 130 cm. So the *stipes* was probably 125 cm high, and the drum was fastened about 100 cm from the floor, its pivot passing through the *stipes* and carrying a wedge on the other side.

The oil press in Boscoreale was made in a slightly differ-

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15 Mau 131 sqq., tab. iii; Pasqui 463 sqq., tab. xiv. **23** p. 90. **30** Mau 135.

ent fashion. There was an *ara,* 40 cm high, 2.0 m by 2.25 m broad and deep; the holes for the *arbor* and *stipites* were respectively behind it and before it. The distance from the *arbor* to the *stipites* is about 3 m; the distance of one *stipes* from the other 1.4 m. Here once more one *stipes* is narrow and one square: 32 cm by 25 cm; 32 cm square. The wall of the room is no more than 2.6 m from the *stipites,* which gives us a maximum for the length of the handspakes. In all other cases there is so much room for the handspakes — 5.3 m in Casa di Miri is the least — that it gives us no right to conclude anything.

The whole lay out of this oil press is so like that in one of the Stabiae villas, that Mau reasons, quite rightly, that that must have been an oil press too, though no signs of *stipites* or *arbor* have been found. Mau supposes that the pressing took place by means of weights placed upon the pulp. It is true that the description is not such as to allow any final conclusions. The press bed in question was placed in a corner of the room, it was 2.1 m by 2.4 m. We do not know whether it was raised or not, neither how much of the wall was found. But if it was raised, and if the wall was not too well preserved, it is possible, though there is no mention of such a thing, that there has been a hole in the wall behind it to take the end of the *prelum,* and that the whole thing was a lever and screw press. Right in front of the press bed, somewhat nearer the wall than the front of the *ara,* stood a round base of bricks, hitherto unexplained. It is standing exactly where I would expect the loose stone weight, and I suggest that it might be what was left of an *arca lapidum,* when all the woodwork had crumbled away. But it can never be more than a conjecture.

13 Rugg. 325 sqq., tab. x. Mau 136.

The Salona presses.

At Salona two presses were found, at Manastirine and Kapljuč; the latter has been described in detail and reconstructed by Brøndsted. It had an *ara* of stone, 0.4 m high, 1.5 m long and 1.34 m broad. Most of the top of the *ara* is taken up by a shallow depression, which leaves only a narrow ledge on every side, and which must have been meant to stay the foot of the *galeagra*. From the form of this depression Brøndsted has reconstructed a very plausible *galeagra*; it would fit Hero's first *galeagra* equally well. Inside this depression, touching its four sides, is the *canalis rotunda*. In the Manastirine *ara* there are four grooves for a *galeagra* inside the *canalis rotunda*; this is because the whole *ara* is round, so that there would be no room for the *galeagra* outside it. This can only mean that the grooves are a later addition, as they diminish considerably the space available for pressing. In the Kapljuč press the *canalis rotunda* has its outlet on the side towards the *stipites*; it is connected, by means of a stone gutter, with a square container, which again is connected with a large covered canal.

Behind the *ara* was found an overturned slab of stone, 1.03 m long by 0.47 m broad, having on its surface two shallow cuts, 0.22 m by 0.18 m, arranged symmetrically 0.4 m apart, with their long sides parallel to the short sides of the slab. A similar stone was found *in situ* at Manastirine, and here its place right behind the *ara* shows that it must have supported the *arbores*.

3.5 m from the *ara* two *stipites* of stone were found; 0.2 m thick, 0.62 m broad, sticking up about 1 m. On the

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2 Forschungen in Salona 2 : 9, fig, 4, Brøndsted fig. 103, p. 110.
4 103 sqq., fig. 95 sqq.

inner side each had a round hole, some 0.35 m in diameter, meant to take the drum, *sucula*. Their tops were rounded, and one of them was broken at the height of the hole.

Brøndsted has reconstructed this press with a pair of wooden *arbores*, like Cato's; as it was clear that they were unable to take the whole upthrust of the *prelum*, he has added a heavy weight, which is hung from the short end of the *prelum*, quoting Plinius's remark on the *arcae lapidum* as authority. In this Brøndsted is following Blümner's interpretation of Plinius; Blümner, who admits frankly that the text is not quite clear to him, takes the *arcae lapidum* to mean some sort of counterweight, placed at the short end of the *prelum* to pull it up again, when the pulp is to be replaced. The strongest argument against this interpretation is that the text is far more easily explained as referring to the loose weight of the screw and lever press; but against Brøndsted's use of it it may be argued that Plinius mentions the *arcae* only in connection with the screw press, so that there is no authority at all for connecting them with a drum and lever press. In fact, in Cato's press such a counterweight would have been no help; it would have been very much in the way. The press worked best when the *prelum* was as nearly horizontal as possible; this is clear, and it has been shown most neatly by the Herculanensians how the pressing had to be stopped now and then while the cross pieces above and below the short end of the *prelum* were adjusted. But during these adjustments the counterpoise would have been not only useless, but also very troublesome. But indeed if we make a rough estimate of the weights and forces in Brøndsted's press, we shall find that it is not only improbable, but

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8 18 : 317. **9** 348, note 1. **25** xxvii sqq. esp. xxix.

impossible. A *prelum* 30 cm thick and broad and 6 m long would weigh 486 kg, if it were made of oak. If the press bed were 1.5 m from the *arbores,* the *prelum* alone would press on it with a weight of 972 kg, and the upthrust on the *arbores* would be 486 kg. The *arbores* shown by Brøndsted, 0.3 m by 2.65 m, would, if they were made of oak, weigh only 430 kg together, or less than the upthrust of the *prelum* itself. It is true that there is a stone slab, on which they stand. But the two cuts in this slab are so shallow, that they cannot have held the *arbores* against any force directed straight upwards. The maximum of the pull on the *prelum* is determined by the weight of the *stipites*; if we pull too hard, we will draw them out of the ground. As we do not know their height, we do not get a very accurate estimate; putting it at 1.42 m, we find a weight of both together of 935 kg. This gives us a maximum weight on the press bed of 3740 kg, and an upthrust on the *arbores* of 2805 kg; add to this the weight of the *prelum,* 486 kg, and we reach the sum of 3291 kg as a maximum. I am not suggesting that this maximum was ever reached, or even intended to be reached; but I contend that a pair of *stipites* and a *prelum* capable of transmitting an upthrust of almost 3300 kg do not correspond very well with a pair of *arbores* weighing 430 kg. And thus the counterweight, instead of being merely meant to lift up the *prelum,* would have to take some seven eighths of the stress. So the functions of the counterweight and the *arbores* would be inverted, as the *arbores* would have to carry the counterweight, and the pressure would never be strong enough to bring the end of the *prelum* against the cross piece. Then why have *arbores* at all, and not just tie the end of the *prelum* to a heavy weight lying on the ground?

In Cato's press the walls and roof were built on to the *arbores* and *stipites* so as to give them weight enough; but the two Salona presses were built in the open, where this was not possible. I have already mentioned that the depressions in the base for the *arbores* seem too shallow to hold tightly a wooden post. In fact, the slab is not very much like Cato's *lapis pedicinus,* where there was a hole between the posts to be filled out with oak wood, and where the posts were made fast with lead. But it is very much like the base for two stone *arbores* found by Cowper in Tripolis. Fig. 29. And once we suppose that the *arbores* may have been made of stone, all the difficulties vanish. Supposing them to have been arranged symmetrically about the two depressions, we get the dimensions 0.47 m by 0.41 m; the tongue, *lingula,* of the *prelum* would then be 0.2 m thick. If these *arbores* were 3 m high, they would weigh together very nearly 2900 kg, thus forming quite a fair counterbalance to the *stipites.* So far I have dealt with maxima only. The actual forces will have been far smaller. The diameter of the hole for the drum is 0.37 m; the drum may have been some 0.45 to 0.5 m thick. Supposing the radius to have been 0.25 m, a man weighing 75 kg and using a handspake 2 m long would exert a pull on the rope of 600 kg, which would mean a pressure on the press bed of 2400 kg and an upthrust on the arbores of 1800 kg, all of it well within the power of the press. The fact that no stone *arbores* were found means nothing: they are not the only stonework missing. My reconstruction of the Kapljuč press is given in fig. 30.

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10 Fig. 35, p. 143.

Lever and screw presses.

Apart from the rather dubious oil press at Stabiae, I know of no lever and screw press from Italy; but in other parts of the Roman empire they have been found in great numbers. Bosanquet describes one from Praesos; the *ara* was round and portable, there was no *arbor*, only two holes in the wall for the *prelum*, after the manner of the Kalymnos press; something that may have been a weight-stone was found in the same room.

H. Swainson Cowper found in Tripolis a great number of remains of presses; though he took the *arae* to be altars and so had to suppose some religious significance in the stone *arbores*, and was altogether puzzled by the weight-stones, his clear descriptions and excellent photographs enabled Paton and Myres easily to recognize them for what they were. The *arae*, set flush with the ground, were from 2 to 2.6 m square; the canal in them was sometimes round, sometimes square. The *arbores* were in most cases monoliths set close together, ranging from 2 to 5 m in height, the distance between them being from 0.33 to 0.59 m. They were placed on foot stones; one of these, found alone, measures 1.8 m by 0.92 m. The depressions to take the tenons of the *arbores* were 0.60 m long and 0.5 m broad, set 0.5 m apart. In the *arbores* were holes to take the cross pieces; these holes were about 0.6 m apart, and from 0.13 to 0.18 m square. Either the holes pierced one *arbor* right through, and then went only half way through the other, or they were substituted by square cuts in the inner edge

5 Annual Brit. School Athens 1901/02 : 8 : 264—69. **10** The Hill of the Graces, Lond. 1897, 131 sqq. **15** Journ. Hellen. Stud. 1898 : 18 : 209 sqq., esp. p. 212.

of the *arbores*. Fig. 31. In some cases there were no real *arbores* at all, only a long, narrow, vertical opening in the solid wall; in that case there could be no through hole, only cuts in the edge, placed, naturally, in such a way that either the upper or the lower side of the cut came at the joint between two stones.

The weight-stones were about twice as long as they were broad, their thickness being somewhat smaller than their breadth. The dimensions vary from 1.6 m by 0.8 m by 0.65 m to 2.2 m by 1.15 m by 1.0 m. In either end they had a dove-tail shaped incision, some 0.2 to 0.3 m deep, the narrow parts being joined by a long, very narrow cut along the whole upper surface of the stone. The dove-tailed cuts must have been meant to take wooden sides, which must have carried a cross beam of wood, through which the screw passed. As there does not seem to have been any recess in the top of the stone to take the lower end of the screw, as in the weight-stones found in Lesbos, the wooden sides must have been long enough to allow the end of the screw, with a cross wedge, to go clear of the stone. The long, narrow cut I think was meant to take either a rope or an iron rod to keep together the sides; it would have far more effect if it was fastened below the surface of the stone. Fig. 32 shows my reconstruction of a weight and screw. The weight-stones have weighed from 830 to 2500 kg.

The presses were single in some cases, in other cases two together; in one case there was a long row of *arbores* with a common architrave. This recalls the press house found by GSELL in Algiers, where there were 6 presses, and the one described by SALADIN from Hendchir Choud-el-

18 PATON and MYRE's fig. 8, p. 216. **29** 2 : 29—31, tab. lxxv, lxxvi. **30** 125 sqq.

Battal, where there were also 6 presses; the *arbores* were 5 m high, and had slits in them instead of holes; above and below the slits there was a single hole; the one above being probably meant to take a cross piece to carry the block and tackle for raising the short end of the *prelum*, the one below to take another cross piece on which the end of the *prelum* could rest, if it had to go below the lower end of the slit. Masqueray mentions several press houses from Djebel Chechar, in Algiers.

In Val Catena, in Istria, a press house was found; here there were only the foot stones for the *arbores*. There were three of them, 2.2 m by 0.95 m, the depressions being 0.4 m square and 0.6 m apart.

The finding af *arbores* or traces of *arbores* shows that we are dealing with lever presses; the finding of weight-stones is a direct proof that they were screw presses. Where no weight-stones are found, the absence of any trace of *stipites* must be taken as proof that a screw was used.

Of direct screw presses none is known through the literature; but Professor Chr. Blinkenberg has kindly sent me a tracing of two stone press beds, found near a mill in the valley at Vallebona, near Seborga. See fig. 33. The press bed is 1 m square; the *canalis rotunda*, 7 cm broad, enclosed a circle of 0.5 m in diameter. Outside the *canalis*, touching it, was a square cut for the *galeagra*. This square cut, 0.64 m square, was not set in the middle of the bed, but somewhat at one side, leaving a ledge, some 7 cm broad, along three sides of the stone, while on the fourth side the ledge was 0.24 m. In the middle of the broad ledge was a square cut, to the whole depth of the stone, 20 cm deep by 14 broad;

8 Revue Africaine 1878 : 22 : 34, 38, 40. **10** Jahreshefte d. österr. arch. Inst. 18, Beiblatt col. 149 sqq., fig. 67, 68.

opposite it were two shallow cuts, near one another, some 10 cm deep, 3 cm apart, 5 cm broad. The outlet from the canal was on one of the other sides, to the right of the big cut. If this press bed is compared with my reconstruction of the *congeries* press, fig. 17, the likeness of the press beds is rather striking.

5. Cato's press house.

Cato's instructions on how to build a press house for four presses are given in the usual tantalizing Catonian way: we have lots of measurements and detailed explanation, but not the one thing needed to get a clear idea of its form: a general description or a ground plan.

The reconstruction has been attempted many times; by Meister in 1763 and Goiffon in 1771, before the Stabiae excavations; afterwards by the Herculanensians 1792, Th. Beck 1887 and now Hörle 1929. In all cases the lay out is almost the same. Cato gives the length of the house, 52′, and the breadth, 66′; in all cases the presses are arranged two and two parallel to the greatest dimension, facing each other across an open space in the middle; only in the placing of the four trapetes there is some difference: Meister, the Herculanensians and Beck place the presses in the middle and the trapetes on the sides; Goiffon places the presses on the sides and the trapetes in the middle; Hörle places the presses together on one side and the trapetes together at the other side. This placing of the presses is made in accordance with Cato's words: *torcularium si aedificare voles quadrinis vasis, uti contra ora sient*, and it is naturally corroborated by the findings at

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14 Meister fig. i, ii. Goiffon: Schn. tab. i, ii. **15** Herc. tab. iii. Schn. tab. vii. **16** Beck tab. xviii. Hörle fig. 1, 2, 3; p. 154, 156, 157. **28** 18 : 1.

Stabiae and Boscoreale. But Hörle has seen that it is not very effective; he admits that the two presses opposite one another could not be worked at the same time. And Schneider, who does not give any reconstruction of his own, prints the following warning, which I have taken as a motto for my work: "*Hoc tamen video, probe esse interpreti Catonis* "*cauendum, ne Stabiensis torcularii formam singulis Catoniani partibus accomodare conetur. Inde enim erroris periculum est manifestum.*" But of course the danger is greater still, if the findings at Stabiae and Boscoreale are wrongly interpreted. All writers on the subject seem to have taken it for granted, that these presses were symmetrically arranged opposite one another. As has been shown, they were not; both in Stabiae and Boscoreale care was taken that the two gangs should not collide when working. Also it is worth remembering that the Stabiae presses were quite different from Cato's: the uprights were fixed below the earth, while Cato's were weighed down with masonry from above; in Stabiae the whole floor was press bed, Cato builds a small press bed with a *canalis rotunda.* As to the condition: *uti contra ora sient,* it could be fulfilled in many ways beside the one of placing the presses in the most inconvenient way possible.

The press rooms at Stabiae were paved with great care, because they had to contain the grape juice on its way to the container. The construction of this pavement has been compared with Cato's instruction on how to make a *pavimentum,* and a great similarity had been found. Beck and Hörle go so far as to assume that Cato's *pavimentum* must have had the same function as the pavement in Stabiae, so they construct their presses on the same general

1 176. **6** 642, note e. **13** p. 89 sq. **28** Beck 431. **29** Hörle 160.

lines: the press floor stretches along the two sides of the room, with a low wall along one side; the *arbores* are within, the *stipites* without the press floor. As Cato has described in detail a small press bed, with a *canalis rotunda,* they have to place it in the middle of the fine pavement, where the *canalis rotunda* at any rate would seem to be quite superfluous, as the juice was allowed to run at large over the whole of the pavement. But if there are thus technical obstacles to this interpretation of the *pavimentum,* there is another obstacle in the text itself: Cato demands 30′ of *pavimentum* for two presses, and 20′ for the trapetes. But why on earth should the trapetes stand on a press floor? So the *pavimentum,* fine as it is, is no press floor at all, but is only meant for the workers to walk on.

The dimensions given by Cato for his press are as follows: *arbores* 2′ thick, 1′ apart; from *arbores* to *stipes* 16′; *stipites* 2′ thick; *prelum* 25′ long, including the tongue, 2.5′; the drum 9′ long without pivots. If we try to plot out this press, we will find a curious discrepancy. The distance from the back of the *arbores* to the front of the *stipites* is $2 + 16 + 2 = 20'$; the *prelum* is 25′ long, or 5′ longer than necessary. (Rather only 4.5′, as the 2.5′ of the *lingula* are taken up by the 2′ of the *arbores.*) As a piece of timber of these dimensions must have been very difficult to get, the more so the longer it had to be, it is quite incredible that Cato should have advised us to get it 4.5′ longer than necessary. See fig. 34. Beck admits the difficulty, and meets it in two ways. First, he adopts Goiffon's plan of placing the drum, not in between the *stipites,* but on a pair of brackets on their outside. The best thing there is to be said for this construction, apart from the fact that it brings

27 431, tab. xviii, fig. 12. **28** Schn. tab. ii.

down the surplus length of the *prelum*, is that it would make it easier to exchange the drum for another. That this was done is shown by Cato's list of spares, which includes a spare drum. But the construction is not convincing. The simple drag upwards of the drum is exchanged for a bending strain, which would stress the *stipites* and the whole press in a horizontal direction; the construction of the only press known which is in any way comparable to Cato's, that pictured on the wall of the house of the Vettii in Pompeji, is not made in this way, and, finally, it does not agree at all with Beck's own reconstruction of the press house. Beck's reconstruction shows a clear space from *stipes* to *stipes* of two opposite presses of 22′; by placing the drum 2′ in front of the stipites he reduces that space by twice two feet to 18′, which means that the worker using an 18′ handspake would be hampered by the drum of the opposite press. Beck's other explanation is that perhaps *lingula* did not mean the part of the *prelum* going in between the *arbores*, but the "tail" sticking out behind them; in this way he gains another couple of feet. This explanation, which is given with reservation, does not fit the text very well; but especially I fail to understand how the fact that there are about 5′ too much of the beam can be explained by placing these 5′ at the short end, where they would do no good at all.

There is another small difficulty in the text. Cato, when giving the distance from the *arbores*, says *ad stipitem primum*, and later on *ab stipite extremo ad parietem*. Some commentators translate "to the nearest part of the *stipites*" and "from the outside of the *stipites*;" but why should Cato write such a matter of course here, when he does not write it when speaking of the *arbores*, where it was just as much

3 12. **9** Blümner fig. 127, p. 347. **17** 431.

— or as little — needed? and above all: why the singular? Brøndsted admits straightaway that he does not understand it.

These two difficulties are solved at once, if we suppose that the drum was not placed at right angles to the *prelum*; then one *stipes* would be near and the other *stipes* farther from the *arbores*, and we would have the middle of the drum some 4′ further from the *arbores*, and thus the length of the *prelum* would be a fair fit. There is no technical objection to this arrangement; and in one of the Stabiae press rooms the *prelum* must have been placed at an oblique angle to the drum, since the *arbor* was just behind one of the *stipites*.

Fig. 35 shows my reconstruction of the press. The idea we get is this: The *arbores*, 2′ square, are standing 1′ apart; 16′ from them comes the first *stipes*, also 2′ square, or, perhaps, 2′ in diameter; 9′ from that comes the second *stipes*, of the same dimensions. The length of the drum and the thickness of the *stipites* together is 13′; if the *stipites* are standing on a line with the *arbores*, the parallel lines on their outsides will be 5′ apart, which makes the distance from the inner side of the near *stipes* to the outside of the far *stipes*, measured along the long axis of the press, 12′. This gives for the whole press 2 + 16 + 12 = 30′. The *arbores* are standing 2′ from the wall, and the distance from the far *stipes* to the wall which is behind the *arbores* of the opposite press is 20′; in all 2 + 30 + 20 = 52′ — which is the length of the Catonian press house. This seems to indicate that the presses were placed parallel to the length of the house, not the breadth; which incidentally explains why the shortest dimension is called the length, which is certainly unusual.

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2 106, note 5. **10** Rugg. tab. xv.

From the direction *pavimentum binis vasibus cum canalibus duobus P. XXX* I conclude that two and two presses had a strip of pavement in common for the workers with the handspakes; if the whole arrangement was symmetrical, two such presses occupied a space 52′ long by 33′ broad. That they were placed opposite one another is shown by the words *alteris vasis exadversum ab stipite extremo ad parietem qui pone arbores est,* where the *arbores* must mean those of the other press. As it will be seen from fig. 36, the *stipites* of the two presses are exactly opposite one another, but as the drums are sitting in oblique position, the *vectes* will go clear of each other altogether. The distance from one near *stipes* to the other far *stipes,* by a symmetrical arrangement, is exactly 22′, which agrees with Cato's words: *inter binos stipites vectibus locum P. XXII.*

Of the trapetes we know that they were standing to the right and left, outside the canal and near the farthest wall. In my reconstruction there is room for the trapetes, one to each press, near the wall that is farthest from the *arbores* of the press in question. As we are without information as to where the canal has to come, Cato's words in this respect are of little use to us; be we may assume that the canal did not necessarily run there.

Taking the text in detail, the first thing to be explained is the word *vas* as used by Cato. As he uses the distributive numbers with the plural throughout, it must be a *plurale tantum;* it cannot mean, as proposed by Meister, the *torcular* and the trapete together, as he distinguishes between *vasis* and *trapetibus* where he is speaking of the pavement; so *vasa, plurale tantum,* must mean a single torcular, with its *canalis rotunda, canalis* and *lacus.*

1 18 : 2. **7** 18 : 3. **15** 18 : 2. **27** 13.

The *arbores* have to be 2′ thick, that is, square, and 9′ high, inclusive of their tenons. Beck's objection to having them square because they would then fill out the whole of the *lapis pedicinus* is not convincing; the tenons, *cardines,* which entered the holes in the *lapis pedicinus,* of course were narrower than the *arbores* themselves. The foundation for the *arbores* must be 5′ deep, with stones in it; the foot stone itself 5′ long, 2.5′ broad, 1.5′ thick. In this stone there is made a hole for two tenons; when the *arbores* have been placed there, the middle of the hole is filled out with oak, and lead is poured round it to make it fast. Meister shows a very ingenious foot stone with undercut holes for the tenons; see fig. 37. There can be no proof that it was like that, but it is in itself a pleasing solution. Far less convincing is Hörle's interpretation. Starting from the supposition that the foundation has to keep down the *arbores,* he places the stone slab at the bottom of the five feet deep excavation, and places on it two strong cross pieces of wood to take the tenons of the *arbores.* Round these, which form the *pedicinus,* the rest of the *fundamentum* is placed, and on top of it comes the *pavimentum* or press floor. The difference in height between the *stipites* and *arbores* is explained by the fact the *stipites* had no *pedicinus* to stand on. This interpretation does not fit the text very well. In the first place, it goes against the order of the things mentioned by Cato. But Cato can always be relied on to give things in their right order. When he says *fundamenta . . . lapides . . . forum . . . foramen,* he does not mean that the *lapides* should come after the *forum* and the *foramen.* Also *ibi foramen* coming after *totum forum longum* can only mean that the *foramen* is to be made into the *forum.* The

2 431. **11** 18, fig. 1. **15** 161 sqq., fig. 4. **27** 18 : 3—4.

explanation of the *foramen* also seems a little strained. If Hörle's *pedicinus* had to resist the upthrust on the *arbores,* its length would be a determining factor as to its worth. And then we are to believe that Cato says nothing of the length except that holes must be dug for it. And he does not even say holes, he says a hole. Also it is very doubtful if a small digging out at the side of a hole could have been called *foramen.* Hörle's explanation of the word *pedicinus* is not very clear, either. The word is found here only, so it is up to the interpreter to find an explanation that really fits it in both places. Meister explains *pedicini* by *cardines;* this is all right as far as it goes, but does not explain the singular: *ibi arbores pedicino in lapide statuito.* It is better, I think, to take *pedicinus* as an adjective, first to be supplied with *cardines,* next time to *lapide.* According to Hörle it means first the single cross pieces, and then them both together.

But also technically Hörle's construction is unsound. If a big stone slab was placed at the bottom of the hole, right away, it would be sure to set and warp the whole construction above it. The pavement is necessary to bear the stone, not vice versa. Also, if the upthrust is to be taken by the foot of the press, it seems most unpractical to put in a stone all of one piece, weighing about 1000 kg, and then use it to carry a weight and nothing else. The logical sequence is the one given by Cato: first the foundation for the stone, then the stone, then the *arbores* caught by their tenons in the hole in the stone. And then comes the argument from the use of lead. Lead is not used to fasten wood to wood. Any carpenter worthy of that name, in Cato's days or now, should be able to fit together Hörle's *pedi-*

cinus in such a way that no drop of lead could come in between the wooden sides. But it is impossible to make smooth wood fit the rough-hewn stone hole; so there it is necessary to pour in lead to make a tight fit. The use of lead is direct proof that something, wood or iron, had to be fixed to stone. As further proof I may refer to the way in which the *stipites* were placed: first foundation, then a stone slab, 2.5′ by 2.5′ by 1.5′, then the *stipes*. As the *stipites* were 9′ apart, they could not have a common foot stone; they get exactly one half of what the *arbores* have. This square stone would not allow of any *pedicinus,* nor was it necessary, as the *stipites* were not exposed to more than one fourth of the strain.

The top of the *arbores* is formed into a tenon 6″ long; then a head piece of oak is placed above it. This head piece has the function of keeping the tops together at the right distance; also, probably, to carry the beam that was placed on top of the press.

The long slits in the *arbores* have to be 3.5′ long and 6″ broad. The words *ab solo foramen primum P. I S* I take to mean that the lower end of the slit should come 1.5′ from the floor. Some interpreters suppose that they refer to a hole for a cross piece to keep the *arbores* together, and seek an analogy from the *arbores* at Hendchir Choud-el-Battal. But those *arbores* were meant for a screw and lever press, they were made of stone and 5 m high; they can furnish no analogy to CATO's *arbores* for a lever and drum press, which were made of wood and 3 m high. Also a cross piece in this place was altogether superfluous, as the feet of the *arbores* were kept together by a solid stone slab.

So far CATO has described an oil press only; if it has

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20 18:2. **22** BECK 431; BRØNDSTED 105, note 2. **24** p. 97.

to be used for wine, it must be modified. *In vasa vinaria stipites arboresque binis pedibus altiores facito, supra foramina arborum, pedem quaeque uti absiet, unae fibulae locum facito.* "In the wine presses make the *arbores* and *stipites* "two feet higher, and above the slits in the *arbores* make "room for one *fibula* . . ." The words *pedem quaeque uti absiet* seem to be corrupt; Keil explain it: "*ut una quaeque* "*arbor pedem absit ab altera.*" The *fibula* then must be something that keeps the *arbores* in their places. This agrees with Hörle's explanation, which will be discussed below; and it agrees with W. Sachur's explanation of the word in Vitruvius: he explain the *fibula* as a short, strong plank with two clamps on it, meant for keeping two pieces of timber together. While I have no objection to Sackur's explanation in Vitruvius, I do not think that it fits Cato's text. Cato mentions in his check list: *constibilis* (or *confibulas*) *ligneas, qui arbores conprimat, si dishiascent, et cuneos VI.* This looks more like the thing. But he also mentions 40 *fibulae,* and it is incredible that he should have needed 8 clamps for each press. Beck explains the *fibulae* as iron rings fixed on the *arbores* and *stipites.* This is impossible, for if they were fixed on the timber, there was no need to check them in the list. According to Hörle this *fibula* is a piece of wood, going through the *arbores,* and carrying a a wedge at one end. Its function is to keep the *arbores* apart at their upper end, and so he discards for the wine press the *capitulum robustum* and the whole elaborate superstructure of balks and beams: "Man kann sich leicht vor- "stellen, dass für eine einzelne Kelter die den ganzen "Kelterboden überspannenden Längsbalken, die 'Ober- "schwellen', als unwirtschaftlich empfunden und beiseite

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11 42 sqq. **16** 12. **20** 430. **23** 173, fig. 6 p. 174.

"gelassen wurden." If it was possible in the wine press by fixing a 15 cm by 15 cm wooden *fibula* of 1.5 m's length to supersede a piece of timber 60 cm by 30 cm, and 10 m long, I should deem it exceedingly "unwirtschaftlich" not to do the same thing in the oil press. Once more, Hörle's supposition that Cato's press was anchored to the ground like the Stabiae presses has led him astray. But either way the dilemma here is inevitable: if the superstructure was necessary to the oil press, it was so to the wine press; if it could be spared in the wine press, it was superfluous in the oil press. But if the *capitulum robustum* was in place, Hörle's *fibula* is superfluous. So we are still as far as ever from knowing what sort of thing a *fibula* was.

Cato's intention in making the uprights of the wine press two feet higher is clear: the *pes* was more bulky than the *sampsa,* so the capacity of the press had to be enlarged upwards. For this purpose it was not enough to raise the height of the uprights, the slits also had to be longer. This seems obvious. But Cato does not say so; he says: "make "room above the slits for one *fibula*." If we suppose that the *fibulae* were the cross pieces to be put into the slits, the meaning at once grows clear. This explanation seems very satisfactory. The cross pieces were loose, they were quite necessary, there had to be several of them for every press, they form the only unknown item of the check list with a number large enough for the purpose. Cato's instruction would then mean that the slits have to keep their original size, but that a hole should be made for one *fibula* above them, and the words *pedem quaeque uti absiet* must refer to the distance of the *fibula* from the top of the slits. The intention of this arrangement I take to be to make it possible to use the same press for wine and for oil, or rather, to make it possible to use it for wine without spoiling it as an oil press, as the too long series of *fibulae* would be troublesome and waste time.

The *stipites* also were 2′ thick, either square or round; they were 1′ higher than the *arbores,* probably because they had to be fastened sideways to the beam above the press. Their foundation has been described already.

The drum, *sucula,* was 9′ long, exclusive of the pivots, in the middle it had the *porculus* which must be some sort of clamp on which to fasten the rope. There were 6 holes made through it for the handspakes, thus making 12 openings in all. The idea that there were only six openings is quite rightly rejected by Hörle: six holes would put the handspakes 60° apart; when one handspake touched the earth, the end of the next would be almost its full length above the floor; as some of them were 18′ long, it would be manifestly impossible to work them. The holes, according to Cato, were one half foot square. Hörle, however, dividing the text in another way, makes the *fibula* of the wine press one half foot square, and leaves us with no information about the size of the holes. He may be right, but there is no reason to think that the *fibula* should be other than an ordinary one, which was 6″ thick; and the size of the holes, 15 cm square, agrees quite well with the dimensions of the longest handspakes; it could hardly be less since it was 18′ or 6 m long and had to take the weight of the worker, say 75 kg, at its outer end. From this follows that the drum can hardly have been less than 2′ in diameter; the pivots being 1′ to suit the *stipites.* Cato's instructions on how to place the holes in the drum run: "Make the first hole you make one foot from the pivot; space the

4 18 : 2. **7** p. 107. **8** 18 : 2; 19 : 1, 2. **13** 175. **18** 174. **30** 19 : 1.

"others as justly as you can." As the clamp had to be in the middle, there would be three holes on either side; if they were spaced one half foot apart, they would leave 3′ free in the middle.

The rope for the press was twisted of leather thongs, 8 ox-hides being used for one rope. The finished rope was 55′ or 51′ long according to the size of the press. Beck and Hörle have both described how this long rope was used: it was formed into a closed ring, which was laid double; this double ring went over the *prelum* and then from both sides of the *prelum* to the drum. In the wine presses the *prelum* was 1′ higher than in the oil presses; that a rope 4′ longer was then required shows that the rope came down 4 times. In this way we understand that 3′ were necessary in the drum for the windings of the rope; for as the distance travelled by the end of the *prelum* cannot have exceeded 6′, one single revolution of the drum must be enough, as its circumference was a little over 6′. As to the clamp, *porculus*, Cato says first that it should be in the middle of the drum; then he adds that the middle should be sought by sighting towards the middle of the space between the *arbores*, so that the *prelum* may be placed in the middle of the press.

About the *prelum* we know that it had to be 25′ long; the tongue, *lingula*, 2.5′. Both Beck and Hörle assert that it was 2′ thick; I have not been able to find any statement to that effect in Cato. All that I know is that its inner end was more than 1′ thick, since it had to be cut down to fit in between the *arbores;* it seems very probable that it tapered towards the other end, as there was no necessity

5 135 : 3—4; 63. **7** 428. **8** 181. **19** 19 : 2. **24** 18 : 2. **31** Beck 425; Hörle 181.

for having it 2′ thick there. The *lingula* should be measured off from the middle of the *prelum;* it should be given a play of one inch.

For the handspakes, *vectes,* three dimensions are given: 18′, 16′, 15′. The longer the handspake, the greater the pressure; but as long as 15′ were enough, no one wanted to use one of 18′. But why have them both of 15′ and 16′? It is as if we get a glimpse of something very different from the modern, well-considered way of doing things. I suggest that each batch of pulp had to undergo three successive pressings, and that three sizes of handspakes were used for them. For five presses Cato prescribes 40 handspakes, or 8 to each press; or perhaps rather 6 to each press, with 10 in reserve for them all. Cato mentions also three sets of *remissarii,* 12′, 10′ and 8′ long. Hörle explains them most convincingly as handspakes used for lifting the *prelum,* which was done by means of the drum and a rope running over a tackle; their different size he explains by supposing that they were used also to stop the drum, after the fashion of Hero's *περόναι.* This seems to me all right as far as it goes. But here I may call attention to Professor Boëthius's description of how the press was worked. It was necessary to lower the *prelum* very carefully, so as not to get the juice squirting all over the place. The name *remissarii* may allude to this function more than to the function of lifting the *prelum.* But it is a matter of very little moment. These *remissarii* are not mentioned by that name in the check list. If we are to include them in the *vectes,* we will not get a whole set for each press. But as the check list is, perhaps, Cato's own check list of his actual belongings, it may mean that Cato did not use the drum for lifting the *prelum* at all,

4 19:2. **12** 12. **15** 176. **20** p. 66. **21** App. 1.

but used his 10 tackles instead. He knows both ways, if we take *rotas* c. 3:6 to mean the drums used for lifting, as seems probable. When he tells us to take 8 sheaves in the upper and 6 in the lower block, the text must be corrupt; no man with any practical experience in the use of tackles could write that.

The superstructure of the press has puzzled all commentators, and they all disagree about how it was arranged. I do not think that I can solve that riddle, but I think that I can point out exactly why it cannot be solved.

The text runs: c. 18:5. *insuper arbores stipitesque trabem planam inponito latam P. II, crassam P. I, longam P. XXXVII, vel duplices indito, si solidas non habebis. sub eas trabes inter canalis et parietes extremos, ubi trapeti stent, trabeculam pedum XXIII S inponito sesquipedalem, aut binas pro singulis eo supponito. in iis trabeculis trabes, quae insuper arbores stipites stant, conlocato: in iis tignis parietes extruito iungitoque materiae, uti oneris satis habeat.* And then, c. 18:8: *si trabes minores facere voles, canalis extra columnam expolito. si ita feceris, trabes P. XXII longae opus erunt.*

The intention of this construction is clear enough: neither the *arbores* nor the *stipites* were in themselves able to withstand the full force of the press; they had to be reinforced by being joined to the walls in such a way that the whole construction was heavy enough. But how the beams were placed is a question that has been solved by each commentator in his own way. MEISTER puts one broad beam across the tops of two sets of *arbores*, and another across the *stipites*; the shorter balks he puts across from beam to beam, along the length of the press. GOIFFON places the broad beams along the length of the presses, two to

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27 Fig. i. **30** SCHN. tab. i.

each press; as they are 74′ together, while the press house is only 66′, he uses the surplus for a nice, big joint over the middle of the press house. The Herculanensians, fig. 38, put the broad beams across from *arbor* to *arbor*, and then place the balks under them, in the same direction, spanning from the inner *stipes* of each press to the wall. Beck follows Meister, and Hörle has a somewhat similar construction; only, because of his asymmetrical placing of the trapetes, he needs only one balk for each two presses, the balk coming right over the wall that separates the presses from the trapetes.

The Danish doctor of medicine, Jens Bang, who has written a paper on the press house, in the Videnskabers-Selskabs Skrivter for 1803 og 1804, p. 181—196, feels the difficulties to be unsurmountable; he calmly declares that there is no room for four presses within the limits of the press house, and so reconstructs it with only two presses in it. His paper has been deservedly disregarded by most authors; I quote it only to illustrate the very real difficulties of the question. In the placing of the balks and beams he follows Meister.

In trying to get some light on the problem of this superstructure, I should like to call attention to a fact that seems to have been overlooked by most of the commentators. Cato prescribes expressly a headpiece of oak, *capitulum robustum*, to be put across the tops of the *arbores*. This seems to me to indicate most clearly that the broad beams went along the press, not across it. If the tops of the *arbores* were imbedded in a beam, 2′ by 1′, with masonry atop of it, there would seem to be little need of an extra *capitulum*. The singular *trabem latam* I take to mean that there had

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3 Tab. iii, Schn. tab. vii. **6** Tab. xviii, fig. 12. **7** Fig. 1, p. 154.

to be only one broad beam for each press; being 2′ broad it would be broad enough for the *stipites* to be fastened to it from either side. Such a construction was of course out of the question in presses as reconstructed by MEISTER and the others, as the long beam would be in the way of the handspakes; GOIFFON solves the question by so arranging the drum that the handspakes are worked backwards, along the side of the press, quite out of keeping with the text (but then he translates *vectibus* by "vehicles"); if the drum was not at right angles to the *prelum*, there is no difficulty on that score.

So far everything is plain; the great length of the beams would give the *stipites*, which were not fastened to a *lapis pedicinus*, a proper share of the weight. But when it comes to the *trabeculae sesquipedales* the difficulties begin. Let us notice first that these *trabeculae* were really stronger than the *trabes*, having a cross section of 2.25 square feet against the 2 square feet of the *trabes*. The text runs: c. 18:5. *sub eas trabes inter canalis et parietes extremos, ubi trapeti stent, trabeculam pedum XXIII S inponito sesquipedalem, aut binas pro singulis eo supponito. 6. in iis trabeculis trabes, quae insuper arbores stipites stant, conlocato: in iis tignis parietes extruito iungitoque materiae, uti oneris satis habeat . . .* c. 18:8. *si trabes minores facere voles, canalis extra columnam expolito. si ita feceris, trabes P. XXII longae opus erunt.*

The instruction c. 18:6 is clear enough: "Let the beams "that lie on top of the *arbores* and *stipites* rest on these "balks." The function of the *trabeculae* is to carry the *trabes*, or rather, to support their outer end, since the *arbores* and *stipites* could be depended upon to do their

7 SCHN. tab. ii. **10** SCHN. 666.

share of supporting. The free end of the *trabs* would come some 37′ from the wall behind the *arbores*, and some 5′ from the outer *stipes;* its distance from the parallel wall would be some 4′. But if this is clear, the preceding sentence is most certainly not. As it stands, it gives as the place for the *trabeculae* "between the canals and the far walls"; but the canals are in the floor, while the *trabeculae* are 8′ up in the air. But also the form of the sentence is queer. *sub eas trabes . . . trabeculam . . . inponito: inponito* — in what? And why the repetition: *sub eas trabes . . . in iis trabeculis trabes . . . conlocato?* Further on, c. 18:8, a *columna* is mentioned as a part of the construction; where is it, and why is it not mentioned here? From the words *canalis extra columnam expolito* it may be concluded that the *columna* in the original construction is outside the canals, which can only mean — between the canals and the far walls. All this seems to indicate that the text here is incomplete, that the thing that has to come between the canals and the far walls is not the *trabeculae,* but the *columna;* but then it seems probable, too, that *sub eas trabes* must refer to a *columna,* since otherwise we do not get a support for one end of the *trabecula.* It is hardly possible to reconstruct the text with any absolute exactness, but the sense will have been: *sub eas trabes ⟨et⟩ inter canalis et parietes extremos, ubi trapeti stent, ⟨columnas exstruito; insuper columnas⟩ trabeculam pedum XXIII S inponito sesquipedalem aut binas pro singulis eo supponito. in iis trabeculis trabes, quae insuper arbores stipites stant, conlocato, . . .* If this is right, the direction of the *trabeculae,* see fig. 36, must have been, as it should be, roughly parallel to that of the *vectes,* since there must have been far more room above the *vectes* than 8′. If we assume that there was no roof on that part of the building, the reason for the *pavimentum* is clear: if this part was not paved, it would soon be trampled to a mire. The canal, which came from the *canalis rotunda,* would then have followed the same oblique line, coming in the edge of the *pavimentum.* In the two presses standing near the walls I take it that short spars were laid from the wall to the beam above the press, and then the wall built up all along the beam; on the *trabecula* also a wall was erected, and then a roof laid from that over the trapetes. For the two presses in the middle of the press house the two walls may have been connected in the middle.

There remains to be explained the directions c. 18:8 *si trabes minores facere voles, canalis extra columnam expolito. si ita feceris, trabes p. XXII longae opus erunt.* It seems most natural to take the *trabes* to mean the balks above the press; but it is soon found that it is impossible. By no stretch of fancy can a beam of 22′ be placed over a press with a *prelum* of 25′; also it is unthinkable that Cato should demand a beam 37′ long, and then, later on, tell us offhand that 22′ will do, if we make a slight correction in the plan. Also the length of the beam determines the weight of the wall to be built upon it. But it is hardly possible that that could be reduced by 40 $^{0}/_{0}$ in this offhand fashion. So it must be the *trabeculae,* not the *trabes,* that can be reduced; and it is clear that if we shift the *columna* by letting the canal come outside it, we can gain a few feet. It is not much, from 23.5′ to 22′, but worth taking, since Cato himself hints that a balk of 23.5′ may not be available, but may have to be made in two parts.

The press bed, *ara,* had to rest on a foundation 5′ deep, and 6′ broad (square?); the *ara* itself was 4.5′ across; whether it was square or round is not mentioned. Neither does Cato mention its height over the floor; but since the lower end of the slits in the *arbores* came only 1.5′ from the floor, the press bed cannot have been very high. This agrees with the findings in Salona. From the *ara* Cato goes on to speak of the rest of the pavement, which is natural, since the *canalis* formed part of it and had to be connected with the *canalis rotunda*. Brøndsted's press at Salona seems to show that the juice was made to flow quite a long way from the press to the container; if my conjecture about the *columna* is right, we know that the canal started from the side of the *ara;* the words c. 17:2 *pavimentum binis vasis cum canalibus duobus P. XXX* show that the canal came in the *pavimentum*, but the single dimension, 30′, is hardly enough to give us a clear idea of the lay out. On my ground plan, fig. 36, there is a strip of pavement, 30′ broad, in common to the two presses, but it has a queer, lozenge shape. The container, *lacus*, could come near the trapete; but how exactly it was arranged must remain unsolved.

The press lid, *orbis olearius*, should be 4′ broad, that is, in diameter, and 6″ thick. It should be joined with Phoenician joints, whatever that is; as the *orbis* is broad and flat, it must be some way of joining boards lengthways, some sort of groove and feather arrangement. But this was not enough: over and above oaken *subscudes* have to be added, *subscudes iligneas adindito. Subscus* means a sort of double dovetail, which must have been fitted in between the boards to keep them together. *eas ubi confixeris, clavis corneis occludito.* This cannot mean that the *subscudes* had to be fixed by means of nails, for that is absurd; so it probably means that the oaken *subscudes* must not come into contact with the oil, therefore the holes must be closed by

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4 Brøndsted fig. 96, p. 104. **7** 105.

stoppers of cornel wood. Then tree *catenae* have to be put on. Beck has explained them, rightly, I believe, as three pieces of timber placed across the *orbis*. As they will not come into contact with the oil, they can be fixed with iron nails. *eas catenas cum orbi clavis ferreis corrigito.* The verb is rather peculiar; if it is not simply a corruption of *coniungito*, it means that the *orbis* should be made straight by being fixed to the *catenae* with iron nails, but the text really says that the *catenae* are to be made straight together with the *orbis* by means of iron nails, which seems a queer way of putting it. The *orbis* should be made of elm or cornel wood; if you have both, put them in alternately. As the wood of the *orbis* came into contact with the oil, it must be some sort of wood that did not harm the flavour of the oil. If the second sentence does not simply mean: if you have to use both, better use them alternately, we get here another glimpse of some old superstition. Fig. 39 shows my reconstruction of the *orbis*.

The *orbis* was placed under the *prelum* on the top of the *sampsa*, which was probably placed in baskets, *fiscinae*. In the relief in the British Museum the *orbis* is lashed to the *prelum* with ropes. From the fact that only an *orbis olearius* is mentioned, Hörle concludes that no *orbis* was used for pressing wine. The argument seems to me most inconclusive. Cato is describing oil presses all the time; he mentions the wine press as an afterthought; most probably the same sort of *orbis*, or the very same *orbis*, was used for wine. At any rate the *orbis* fits the size of the *ara*, so that any attempt at pressing without it would result in pressing less pulp in each pressing.

Whether Cato has known the way of pressing with a rope

21 Brøndsted fig. 102, p. 108. **23** 172 sq.

round the pulp, as mentioned by Hero and described by Brøndsted from Dalmatia, I cannot say. The way in which the pulp is guarded seems to be subject to great variations from one locality to another, even to this day. At any rate, Brøndsted's attempt to explain the *funis torculus* as the rope to be wound round the pulp is not convincing; partly because Beck's explanation seems so much better, partly because such an enormous strength was not required for this purpose, and lastly because it would hardly be long enough. If the heap of pulp was as broad as the *orbis*, 4′, its circumference would be $4\pi'$, or 12.6′; the *funis torculus* could reach only four times round it. But since they can press wine pulp in Bosco Tre Case without anything round it, it is not very easy to be sure of Cato's way, in the absence of direct evidence.

If we want to know the force of Cato's press, we have to begin at the outer end. The longest handspakes were 18′ long; supposing the drum to be 2′ in diameter, and the handspakes to have gone into the hole 1′, we find that a man weighing 75 kg would exert a pull on the rope equal to 18 times 75 kg or 1350 kg. To this is added the weight of the rope. It was made of 8 oxhides; a tanned oxhide will weigh about 16 kg; 8 hides 128 kg. Supposing that about half of the rope was on the drum, we get 64 kg to add to the 1350 kg, or 1414 kg in all. Assuming the *prelum* to have, as in the Salona press, a leverage of 1:4, we get 5656 kg for the weight on the *ara*. To this must be added the weight of the *prelum*. Assuming, to get a maximum, that the *prelum* was 2′ square all over, as supposed by several commentators, and 25′ long, we find a net weight of some 2320 kg. This is centred in the centre of gravitation, and so presses

2 107; cf. p. 61. **5** 107 sq. **7** p. 111. **13** cf. App. 1.

on the *ara* with twice its weight, or 4640 kg. Add to this the pressure from the drum, and we get a total of 10.296 kg. Three quarters of this weight represent the upthrust on the *arbores*; that will be 7722 kg. The *lapis pedicinus* weighed about 1000 kg; the rest of the upthrust had to be taken by the masonry above.

APPENDIX 1: THE ART OF PRESSING

Professor, dr. A. Boëthius, director of the Swedish Archaeological Institute in Rome, has sent me the following description of the working of a screw and lever press, and has kindly allowed me to include it in my paper.

The press in question is standing in Bosco Tre Case, and belongs to Professor Carotenuto, of Naples. The owner showed Professor Boëthius how it was worked, with the aid of an old *colono*, who has worked the press when it was in actual use some 30 years ago. Fig. 40. The letters in the description refer to fig. 41, which is a diagram made from a drawing by Professor Boëthius.

The art of pressing wine.

By Axel Boëthius.

First the pulp is heaped up at a certain point in the basin, between v and x. For this special ability is required: *un buon colono*.

Next (I) the filling l is knocked out, when the trunk a—b on account of the weight of the root a, slowly, so that the wine does not squirt too much, is lowered towards f and rests on the covering planks of the stack o and p. The block r—q is lifted towards t. The pressure is upwards towards t, downwards towards the covering planks o and p.

II. In this position the filling k is easily knocked out. The trunk is free and is kept in position only by the pressure on the planks o and p and the counter-pressure downwards from t by the cross block q—r.

III. The increased room m is filled with wedges.

IV. The procedure is reverted: the block q—r is screwed down so that a pressure arises downwards, towards u, from the block q—r, balanced by a pressure upwards towards e at the point h by the filling m. Through this pressure and counter-pressure the trunk is pressed against the planks o—p. This pressure is contrived in the antique wine press in the Villa Item only through the turning by hand on the drum that corresponds to the screw t—u (the block &c.). Not so in Professor Carotenuto's press and the other presses in Bosco Tre Case! By the turning of the screw t—u (to force down the cross block r—q) the stone is lifted. When it is screwed as far as necessary, the whole press is standing under a formidable tension, with the whole weight of the stone the cross plank q—r presses down the trunk a—b. With a corresponding weight a—b weights upon the covering planks of the stack, o—p, and upwards upon the locking filling m at the point h. It is self evident how strong the construction above h must be.

V. When the press is brought into this state it is left: the stone keeps up the pressure and sinks slowly down into its hole.

VI. The cross plank r—q is lifted once more, the root a sinks, the trunk a—b, resting on the covering planks of the stack, o—p, is raised by the end b as high as permitted by the cross beam q—r. The direction of the pressure is upwards towards t, (that is, towards the cross beam r—q) and downwards at the other end on account of the weight of the root a. The trunk is carried by the covering planks of the wine stack.

VII. In this position the filling m is taken out.

VIII. The filling k is replaced, whereupon

IX. the cross beam r—q is once more screwed down. The trunk no longer reaches the covering planks of the wine stack, o—p, but is intercepted by the wedges, which fill out k and are put in as high as made possible by the sloping position of the trunk a—b with its lowest point at the root a and its highest point at b. Next

X. the root is lifted by renewed screwing of q—r downwards, and the filling l can be put in again, and the cross beam q—r can be dispensed with, if it is wished. The trunk rests on the wedges k and l, that is on points i and j, (the initial position). This procedure is repeated thrice for every wine stack. Between each time the sides of the wine stack are cut smooth with a special axe, so that the outer pulp, which has had lesser pressure than the rest, is cut away, and the rest of the pressed husks and ribs is formed as a sort of die on which the just mentioned, cut off, less pressed part of the stack is placed. The altar becomes solid and hard as a big block, much harder than a bale of straw or hay and may be lifted like a hewing block. For each of the three pressings more wedges may be placed at m. The Villa dei misteri has three wedges, which indicates that they have used here the three repetitions common in Bosco Tre Case.

APPENDIX 2: PLINIUS 18:317 AND THE DATE OF THE SCREW PRESS

I had hoped that it would have been possible to avoid the tangled "Heronian question" altogether; but it cannot be done. To anyone comparing Hero's presses with Plinius's history of the press, it is clear that we have here a *terminus post quem* for the dating of Hero, as has been pointed out by W. Schmidt. But those who through other arguments have come to the conclusion that Hero wrote before the beginning of our era, have sought to explain away this *terminus*.

First, they argue, Plinius is obscure, and so cannot be accepted as evidence one way or another. The only obscurity I have found is in the use of the word *malo* in stead of *arbori*, as explained; and even that is not very obscure, and it certainly has no bearing on the question of the direct screw press.

Next, they hint that there is no certainty that Plinius's direct, one screw press is identical with Hero's. The two presses are different only in as much as Hero is describing a small, portable press, while Plinius is speaking of a large, fixed press, as shown by the *congeries*; but the principle, that the power of the screw is used directly for pressing, without the aid of any lever, is the same. That Plinius uses

6 Hero vol. 1, Einl. xix.

the word *prelum* in connection with the direct screw press is without any weight in this connection, as I have tried to show.

The last argument is that anyway Plinius is most unreliable as to dates, so we need not trust a date in Plinius if we have reason to believe it to be false: even if Hero's date is not finally established, the mention of screw presses in Vitruvius is enough to disprove Plinius's statement.

Vitruvius writes, 6:6:3, *ipsum autem torcular, si non cocleis torquetur sed vectibus et prelo premitur, ne minus longum pedes xl constituatur.* Here the screw press, *cocleis,* is opposed to the lever and drum press, *prelo et vectibus;* if Vitruvius was contrasting the lever and drum press with the lever and screw press, his date, 25—23 b. C., might be squeezed to some sort of agreement with Plinius's *intra c annos,* written 77 a. D. But if we take it that Vitruvius is speaking of direct screw presses, then either Plinius is wrong — or Vitruvius's date is false.

But Vitruvius's date is by no means finally established. Schanz upholds the early date, it is true, and so does Krohn; but it is a suggestive fact that Krohn has had to correct Vitruvius's text twice in the face of all the mss. to get an awkward place smoothed over — without, it seems to me, the least success. W. Sachur's attempt to show that Athenaeus has copied Vitruvius, not vice versa, is exceedingly unconvincing.

As to the trustworthiness of Plinius, R. Meier writes: *Audiendo fortasse vel legendo nescio unde acceperat* (Plinius) *eo fere anno illud nescio quo loco in usum venisse atque hoc nuntio fretus contendit ipso eo anno esse inventum;* then he

22 10:13:8. **25** 86 sqq. **28** 31.

quotes MÜNZER and cites an instance from KALKMANN, who shows how PLINIUS dates the painter TIMOMACHUS at the time of CAESAR, though he belonged to a much earlier period.

It is established beyond doubt that PLINIUS was very careless in his use of his sources; but still I shall require most convincing evidence before I believe that PLINIUS made a silly mistake of a hundred years or so in his statement about the direct screw press. We have confirming evidence, hitherto overlooked, in HERO's Mechanics: while the presses may be taken to illustrate different points of the theoretical mechanics, the *galeagra* cannot come under this heading, however we twist it; the only plausible reason for including the *galeagra* here is that it was new and therefore interesting, But that fixes the invention of the *galeagra* to time of the invention of the direct screw press, as has been shown. But PLINIUS says of the *galeagra*, without any connection with the date of the screw press, that it has been invented "recently" (*Nuper*). So we have to believe once more that he merely read we know not where, that it had been introduced at that time, we know not where, and jumped to the conclusion . . . But did he? To us the press is only a small part of an obscure subject among many in the Roman antiquities; to PLINIUS it was part of his daily life. And he does not tell us that it was changed beyond recognition at a remote date, which he must needs have had from some book; he tells us that this revolution in its principle had come 22 years ago — not only during his life time, but when he was already a man. He was the owner of large estates, and the question of repairing or renewing presses must have cropped up year after year all his life. If the

1 30 MÜNZER 119 sqq. KALKMANN 223. **17** 15 : 5.

direct screw press had been in use for a hundred years when he wrote his book, it is unthinkable that he should not have met it, and still more unthinkable that he should not have noticed it. I may call attention to the fact that while he writes of the screw and lever press, which was invented before his time: *intra C annos,* a rather vague expression, he says of the direct screw press: *intra XXII hos annos.* Is it too fanciful to suppose that he wrote from actual, personal experience?

LITERATURE

BECK. TH. BECK: Historische Notizen. IV. CATO DER AELTERE. (Der Civilingenieur. 1887 : 33 : 418—438. Taf. XVIII.)

R. BILLIARD: La vigne dans l'antiquité. 1913.

BLÜMNER. HUGO BLÜMNER: Technologie und Terminologie der Gewerbe und Künste bei Griechen und Römern. 1. Bd. 2. Aufl. 1912.

R. C. BOSANQUET: Excavations at Praesos. (Annual of the British School at Athens 1901/02 : 8 : 231—270.)

BRØNDSTED. JOHANNES BRØNDSTED: Recherches à Salone I. 1928.

G. A. BOECKLER: Hauß- und Feld-Schule. 1678.

CARRA DE VAUX. Journal Asiatique 1893: 9 : 1—2. (Edition of HERO's Mechanics with translation.)

A. A. CARUANA: American Journal of Archaeology 1888 : 4 : 453.

CATO. M. PORCI CATONIS de agri cultura liber rec. HENRICUS KEIL. Lps. 1882.

COLUMELLA. Scriptorum rei rusticae veterum latinorum. Tomus 2, illustravit Io. GOTTLOB SCHNEIDER. Lps. 1794.

H. S. COWPER: The Hill of the Graces. 1897.

R. EGGER: Forschungen in Salona. 2. 1926.

F. PH. FLORINUS: Oeconomus prudens et legalis. Nürnb. 1750.

ANTON GNIRS: Forschungen über antiken Villenbauen in Südistrien. (Jahreshefte der österreichischen archeol. Institut. 1915 : 18, Beiblatt. col. 99—164.)

GOIFFON. Saboureux de la Bonnetrie: Traduction d'anciens ouvrages latines relatifs à l'agriculture. 1783. Tome 1 : 197—216. (In the copy in the Royal Library the plates are missing, so I have quoted GOIFFON exclusively from SCHNEIDER's work.)

STÉPHANE GSELL: Les monuments antiques de l'Algérie. 1—2. 1901.

Herc. Antichità di Ercolano. Tomo VIII. 1792.

Hero. Heronis Alexandrini Opera quae supersunt omnia. 1—5 1899 - 1914. Quotations without volume no. are from vol 2:1; Herons von Alexandria Mechanik und Katoptrik, hrsg. und übers. von L. Nix und W. Schmidt. 1900.

Friedrich Hultsch: Griechische und römische Metrologie. 2. Bearb. 1882.

Hörle. Joseph Hörle: Catos Hausbücher. Paderborn 1929. (Studien zur Geschichte und Kultur des Altertums 15:3/4.)

A. Kalkmann: Quellen der Kunstgeschichte d. Plinius. 1898.

Keil. Henricus Keil: Commentarius in Catonis de agri cultura librum. 1894.

Krohn See: Vitruvius.

La Vega. Descrizione del ritrovamente e ristaurazione di un antico Molino da Olio. (Memoria sulla economia olearia antica, e moderna, Napoli 1783, p. 53—71, tab. i—iii.)

E. Masqueray: Le Djebel Chechar. (Revue africaine 1878: 22:26 sqq.)

Fr. Matz u. F. v. Duhn: Antike Bildwerke in Rom. 1—3. 1881—82.

Mau. A. Mau in Römische Mitteilungen 1896:11:135 sqq.

A. Mau: Pompeji in Leben und Kunst. 2. Aufl. 1908.

Rudolph Meier: De Heronis aetate. Diss. Lpz. 1905.

Meister. Albertus Ludov. Frieder. Meister: De torculario Catonis vasis quadrinis. Goett. 1763.

F. Münzer: Beiträge zur Quellenkritik der Naturgeschichte des Plinius. 1897.

Albert Neuburger: Die Technik des Altertums. 1919.

Carsten Niebuhr: Reisebeschreibung nach Arabien und andern umliegenden Ländern. 1. Bd. Copenh. 1774.

Nix. See: Hero.

Magda H. Ohnefalsch-Richter: Griechische Sitten und Gebräuche auf Cypern. 1913.

A. Pasqui. La villa Pompeiana della Pisanella presso Boscoreale. (Monumenti antichi pubbl. d. Accad. dei Lincei 1897:7: 397—554.)

W. R. Paton, J. L. Myres: On some Karian and Hellenic oil-presses. (Journal of Hellenic Studies 1898:18:209 sqq.)

Plinius. Naturalis historiae libri XXXVII ed. C. Mayhoff. Lpz. 1875—1906.

RUGG. M. RUGGIERO: Degli Scavi di Stabia dal 1749 al 1782. Napoli 1881.

W. SACKUR: Vitruv und die Poliorketiker. 1925.

HENRI SALADIN: Rapport sur la mission faite en Tunisie de nov. 1882 à avr. 1883. (Archives des missions scientifiques ... 3. Sér. 1887 : 13 : 1—225.)

W. SCHMIDT See: HERO.

SCHN. Scriptorum rei rusticae veterum latinorum Tomus 1 ... illustravit IO. GOTTLOB SCHNEIDER. 1794. (The quotations are from the commentary, which has its own pagination.)

PAULUS WEISE: Quaestionum Catoniarum capita V. Diss. Goettingen 1886.

VITRUVII de Architectura libri X edidit F. KROHN. 1912.

MEASURES

1. Cato.

pes, foot, 29.5 cm; containing 16 *digiti*, inches, à 1.8 cm.

2. Hero.

ذراع, *πῆχυς*, ell, 46.24 cm; containing 1.5 *πόδες*, 2 *σπιθαμαί* or 6 *παλαισταί*.

قدم, *πούς*, foot, 30.8 cm; containing 4 *παλαισταί*.

شبر, *σπιθαμή*, span, 23.12 cm; containing 3 *παλαισταί*.

شبر, *παλαιστή*, hand's breadth, 7.71 cm.

قنطار, *τάλαντον*, talent, 26.20 kg.

3. Sundry.

Palmo Neapolitano, 26.3 cm; containing 12 onzie à 2.19 cm.

English foot, 30.48 cm; containing 12 inches of 2.54 cm.

ILLUSTRATIONS

LIST OF ILLUSTRATIONS

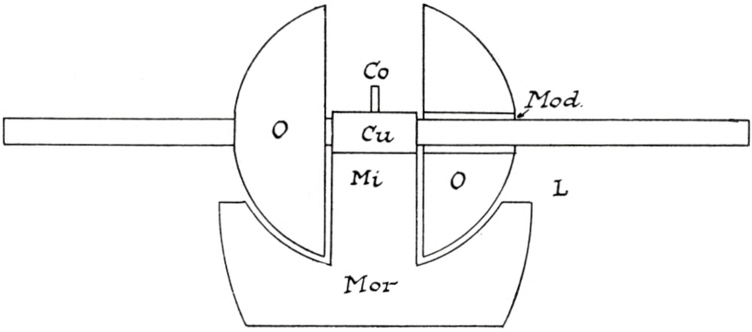


Fig. 1. Catonis II.

Fig. 1 illustrates the text p. 8; it shows the general shape of the Catonian trapete. *Mor* is the *mortarium,* or stone cup, which is shown in a cut, with *Mi,* the *miliarium,* in the middle. *O—O* are the *orbes,* one of which is shown in a cut, to show the wooden bush, *modiolus, Mod,* and the way it is threaded on the *cupa, Cu. Co* is the *columella,* or iron pin; *L* the *labrum.*

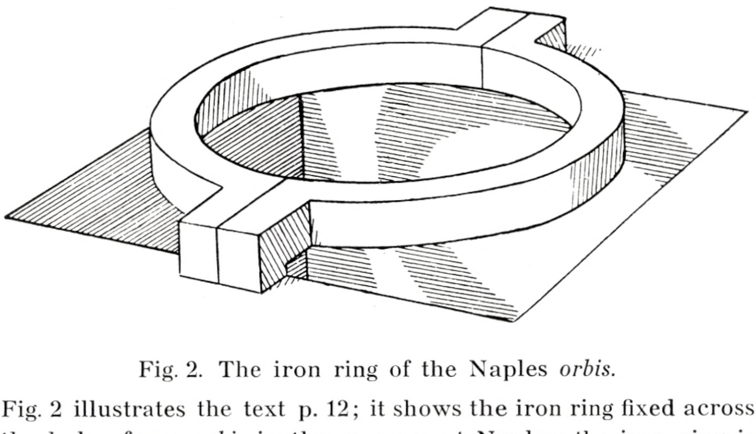


Fig. 2. The iron ring of the Naples *orbis.*

Fig. 2 illustrates the text p. 12; it shows the iron ring fixed across the hole of one *orbis* in the museum at Naples; the iron ring is mentioned by La Vega p. 55.

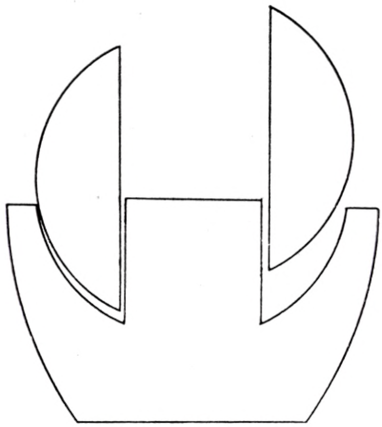


Fig. 3. The Naples trapete. 1:20.

Fig. 3 illustrates the text p. 12; it shows a cut through the Naples trapete with its *orbes*. On the left the *orbis* is placed so that its lower edge is one inch from the bottom; its inner side is seen to be too near the *miliarium* and its outer side too near the *labrum*. On the right the *orbis* is so placed that its flat side is one inch from the *miliarium* and its curved side one inch from the *labrum*; its edge is far above the bottom. It is clear from this figure that the *orbes* do not belong with the *mortarium*.

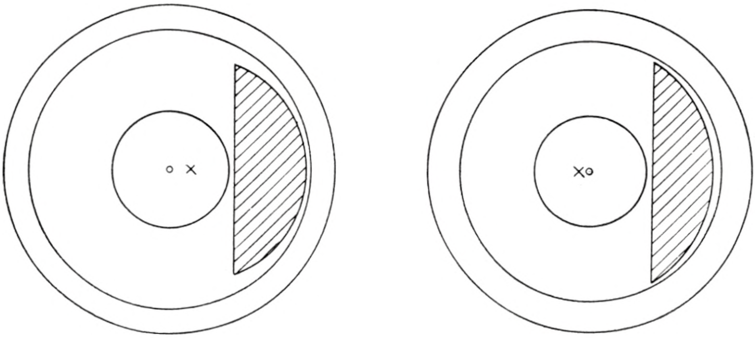


Fig. 4. Comparison between Catonis II and the Pompeji trapete.

Fig. 4 illustrates the text p. 13—15; it shows for comparison Catonis II and the Pompeji trapete, both seen from above, with one *orbis* in each; the *orbis* is shown in a horizontal cut at the height of the *labrum*. The centre of the *mortarium* is marked o, the centre of the *orbis* is marked x in both figures.

In the Catonian trapete the centre of the *orbis* is nearer to the *orbis*; the edges of the latter curve away from the *labrum*, and the olives can be crushed both between the *orbis* and the *miliarium* and between the *orbis* and the *labrum*. In the Pompeji trapete the centre of the *orbis* falls on the far side of the centre of the *miliarium*; the meridian of the *orbis* are further away from the *labrum* than are its edges, and no crushing could be done at this point. This shows that the *orbes* do not belong with this *mortarium*.

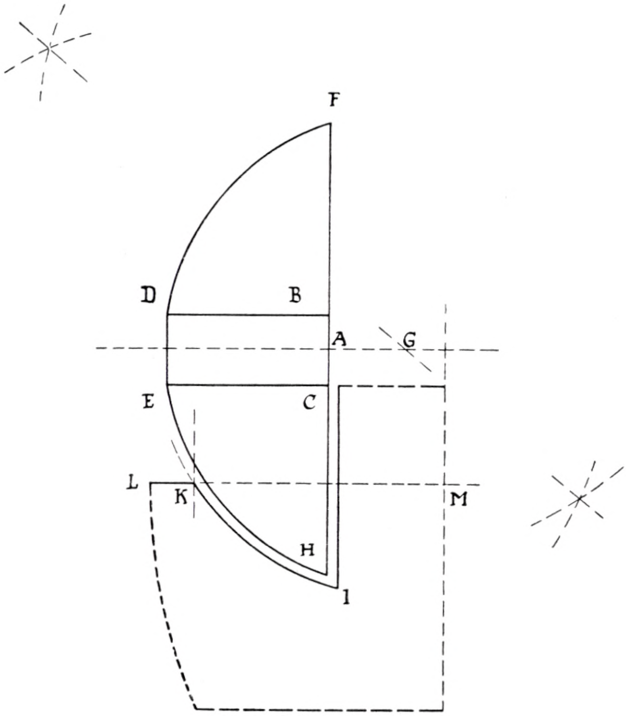


Fig. 5. The construction of a trapete.

Fig. 5 illustrates the text p. 18; it shows how a Catonian trapete is reconstructed on paper from the figures given by Cato, as explained in detail p. 18.

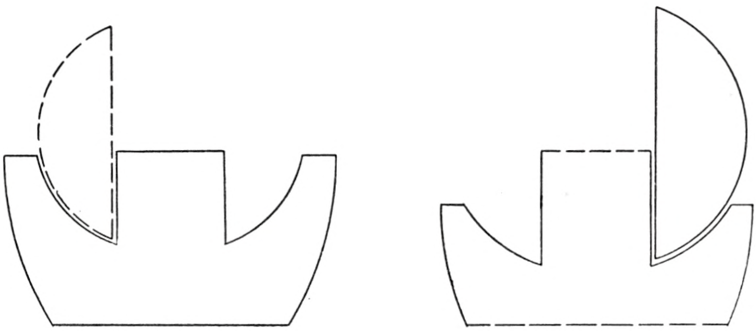


Fig. 6. The old and the new trapete compared.

Fig. 6 illustrates the text p. 19; it shows on the left the Pompeji trapete with one *orbis*, on the right the 3. Catonian trapete. The difference in the form of the *mortarium* is easily seen. The *orbis* of the Pompeji trapete is shown in dotted lines because it does not exist; the top of the *miliarium* and the bottom of the *mortarium* of the Catonian trapete likewise, as they are not known to us through Cato's text.

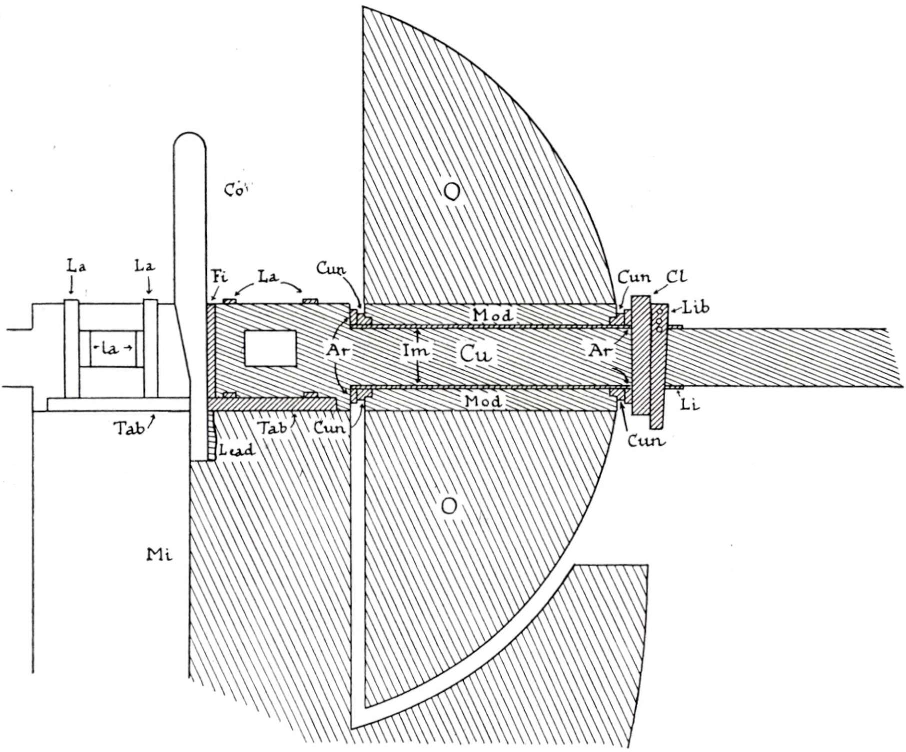


Fig. 7. Detail of the Catonian trapete.

Fig. 7 illustrates the text p. 25 sqq. It shows the *miliarium*, one *orbis* and part of the *cupa* and *mortarium* of a Catonian trapete. The whole right side, including the *orbis*, is shown in a vertical cut.

Ar *armilla*, or washer.
Cl *clavus*, or bolt.
Co *columella*.
Cu *cupa*.
Cun *cunica*.
Fi *fistula ferrea*; the iron tube round the *columella*.
Im *imbrices*; the half cylindrical, iron mountings on the *cupa*.
La *laminae*; iron bands round the *cupa*.
la *laminae pollulae*; iron plates lining the holes through the *cupa*.
Li *librarium*; the iron muff through which the bolt and wedge pass.
Lib *librator*; the adjusting wedge.
Mi *miliarium*.
Mod *modiolus*.
O *orbis*.
Tab *tabula ferrea*.

The holes in the *librator* or adjusting wedge are meant to take a cross bolt, to keep the wedge from working its way down during the crushing and so jamming the *orbis*.

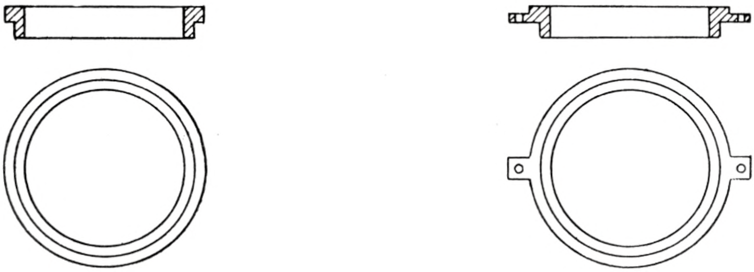


Fig. 8. *Cunica.*

Fig. 8 illustrates the text p. 27—28; it shows on the left an old-fashioned *cunica* without the double lip; it would be apt to fall out, if the wood of the *modiolus* shrank. On the right is shown CATO's improved *cunica* with its double lip, through which the nails could be driven to hold it to the end of the *modiolus*.

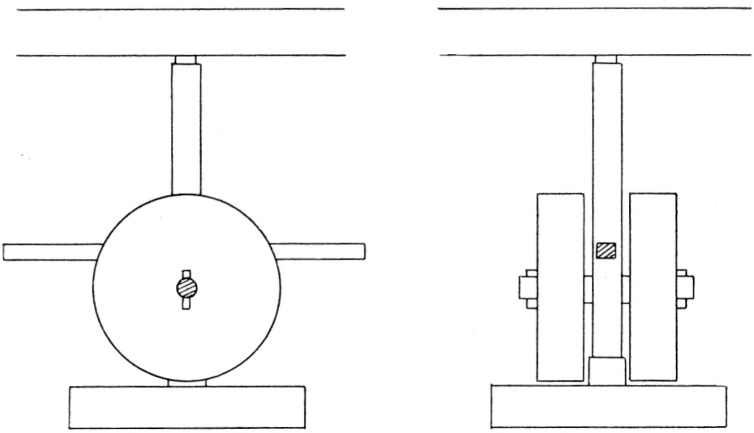


Fig. 9. The *mola olearia.*

Fig. 9 illustrates the text p. 42; it shows COLUMELLA's *mola olearia* as reconstructed by the author. I have left out the ledge guarding the horizontal grinding surface to emphasize the fact that the mill stones were carried by the short cross piece and did not rest on the surface, since they could be adjusted to fit the size of the berries. The adjustment could be made either where the cross piece goes through the upright timber, or where the pivot of the upright enters the short *miliarium*.

Fig. 10. The Rondanini relief.

Fig. 10 illustrates the text p. 42 and 68, where it is described in detail. The illustration is made from a photograph sent me by the present owner of the Palazzo Rondanini, Count Sanseverino. Compare fig. 22.

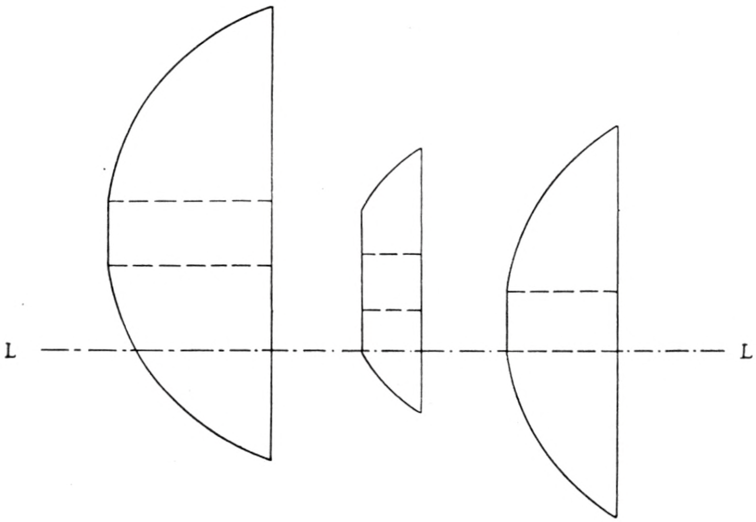


Fig. 11. The three *orbes* compared.

Fig. 11 illustrates the text p. 46; it shows for comparison the three different forms of *orbes*. On the left the Catonian *orbis*, with the big, superfluous curve above the *labrum*; in the middle the Nauplion *orbis*, where the superfluous part has been cut off, and on the right the Pompeji *orbis* with once more the full curve, but narrow, so that the whole curve could be used. *L* denotes the height of the *labrum* in all three cases.

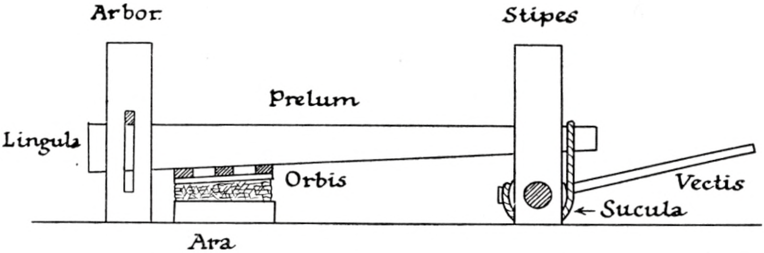


Fig. 12. Lever and drum press. Plinius's 1. press.

Fig. 12 illustrates the text p. 50; it shows the old lever and drum press; the Latin names of the single parts are given. The press beam, *prelum*, was drawn down by means of a rope, which went round a drum, *sucula*, which was turned by means of handspakes, *vectes*. The posts carrying the drum are called *stipites*, the posts behind the press bed, *ara*, are called *arbores*. *Lingula* is the part of the *prelum* that goes between the *arbores*. *Orbis* is the lid laid on the pulp to be pressed.

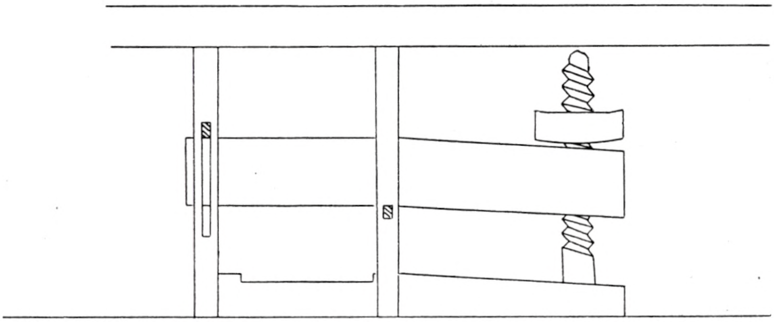


Fig. 13. The Fenis press.

Fig. 13 illustrates the text p. 54; it is drawn from a photograph sent me by Professor Boëthius. It shows in actual existence Brøndsted's reconstruction of Plinius's first lever and screw press. The screw nut is not round, but a piece of wood twice as long as broad. The loose nut does not agree with Plinius's words: *adfixa arbori stella*; so I do not recognize this as Plinius's press; cf. fig. 14.

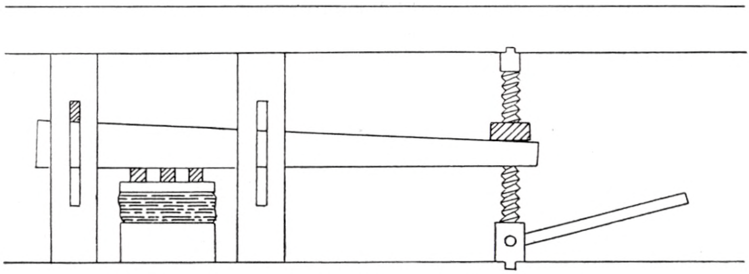


Fig. 14. Plinius's first lever and screw press.

Fig. 14 illustrates the text p. 54; it shows my own reconstruction of Plinius's first lever and screw press. When the screw is turned, the screw nut takes the *prelum* down or up; either the hole in the *prelum* is oblong, or the end of the *prelum* is forked, and the screw nut placed across the fork. Whether the screw is pivoted in the roof, or only in an undercut hole in the floor, I cannot say; both ways are possible.

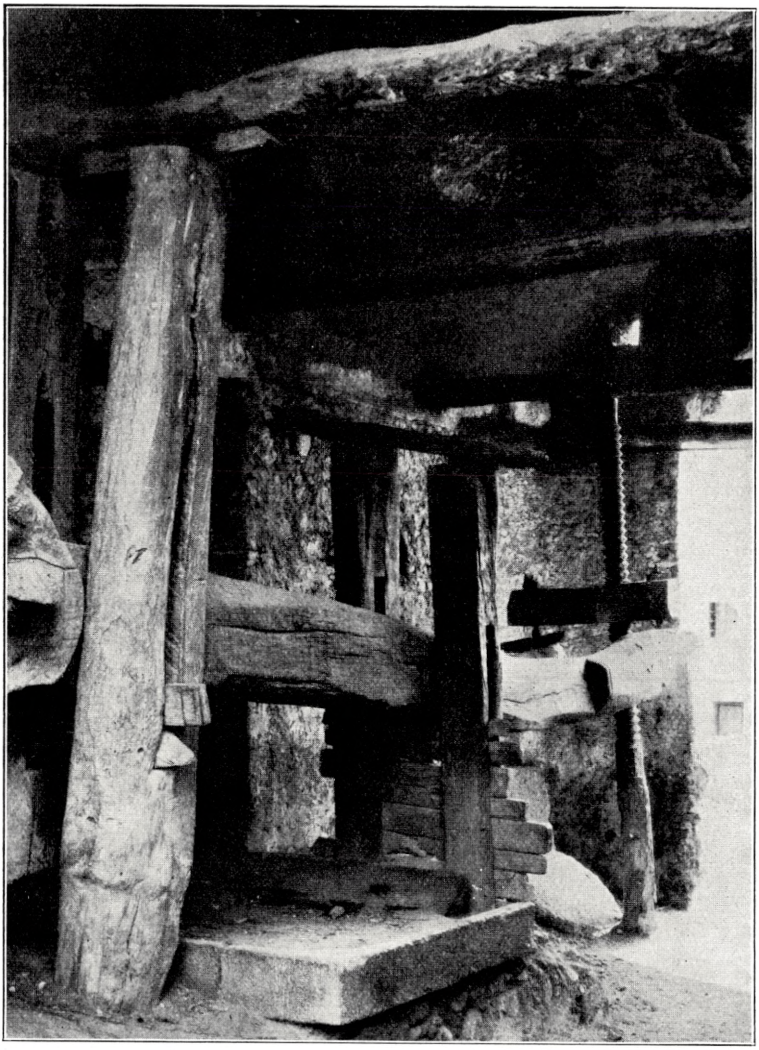


Fig. 15. A press from Bosco Tre Case.

Fig. 15 illustrates the text p. 56; it is a reproduction of a photograph by Professor A. Boëthius, which shows an old press found in Bosco Tre Case, where it was still used about 30 years ago. Its construction is very much like that of Plinius's 2. screw press, see fig. 16. The lower end of the screw is not fastened to the floor, but to a loose stone, which goes into a hole in the floor. For a diagram of a press of the same sort see fig. 41.

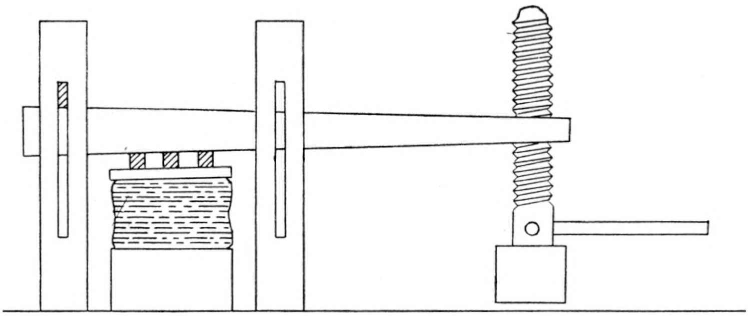


Fig. 16. Plinius's second lever and screw press.

Fig. 16 illustrates the text p. 56; it shows Plinius's second lever and screw press, with a hanging stone weight. The construction is essentially the same as in Kalymnos press, the Praesos press, Niebuhr's press from Egypt, and the Bosco Tre Case presses pictured in figs. 15, 40 and 41. How it is worked is described in appendix 1, p. 122 sqq.

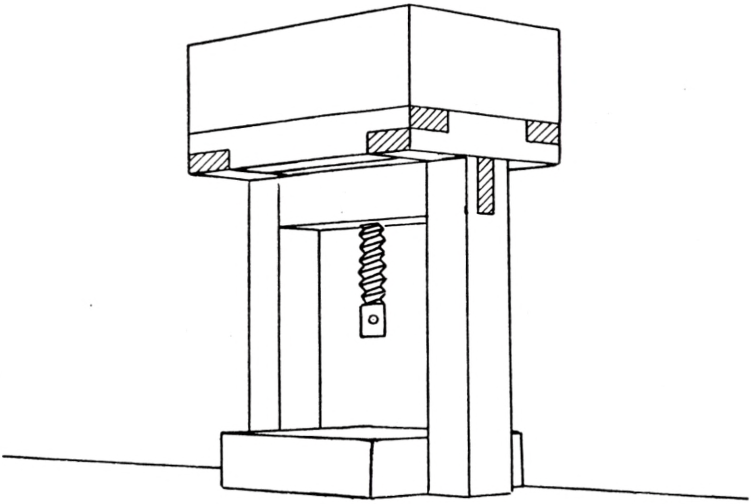


Fig. 17. The *congeries* press.

Fig. 17 illustrates the text p. 58; it shows the author's reconstruction of the press with the *congeries* mentioned by PLINIUS. The press bed is built close to a wall, where once the end of the *prelum* could be put into a hole. When it was made into a direct screw press, the *congeries* was built above the *prelum*, through which the screw goes, in order to give it sufficient backing. The screw is turned by means of handspakes put into the holes in lower end; it might also have been reconstructed with a *stella* above the *prelum*, in which case the *congeries* had to be raised above the *prelum*.

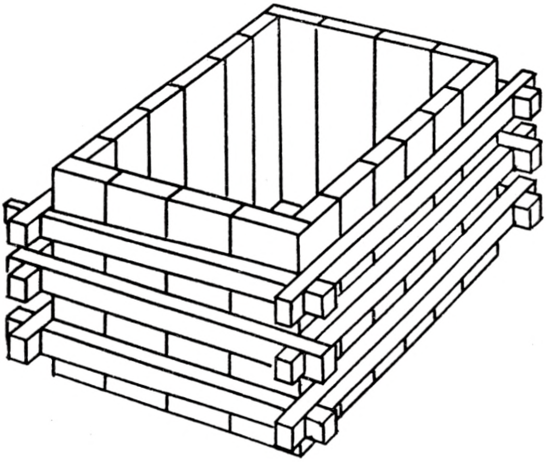


Fig. 18. Hero's second *galeagra*.

Fig. 18 illustrates the text p. 61; it shows Hero's second *galeagra*. It consists of four walls of thin boards, standing upright, with three horizontal cross pieces to each wall; the ends of the cross pieces are cut to half their thickness, so that they interlock and keep the whole thing together.

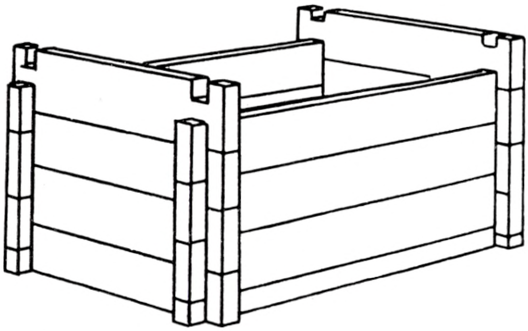


Fig. 19. Hero's first *galeagra*.

Fig. 19 illustrates the text p. 62; it shows Hero' first *galeagra*. It consists of boards on edge, all of them having cuts above and below, near their ends, so that they all interlock to form a rigid construction; as the pressing went on, the upper boards could be removed two and two, so that the *prelum* could come down all the way.

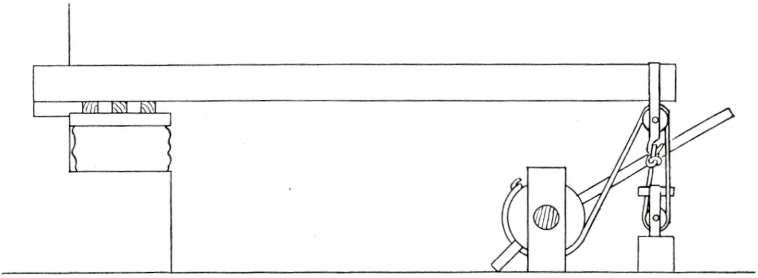


Fig. 20. HERO's lever and drum press with hanging stone weight.

Fig. 20 illustrates the text p. 63—67; it shows HERO's lever and drum press with hanging stone weight. When the drum is turned by means of the handspakes, the stone is lifted; it is then made fast to the *prelum*, while the drum is kept from turning backwards by mean of the short περόνη, which rests against the floor.

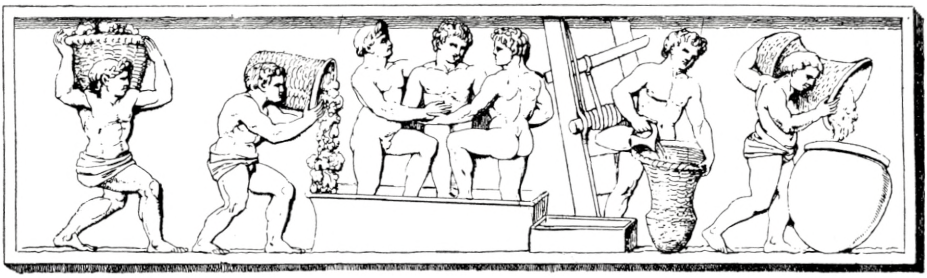
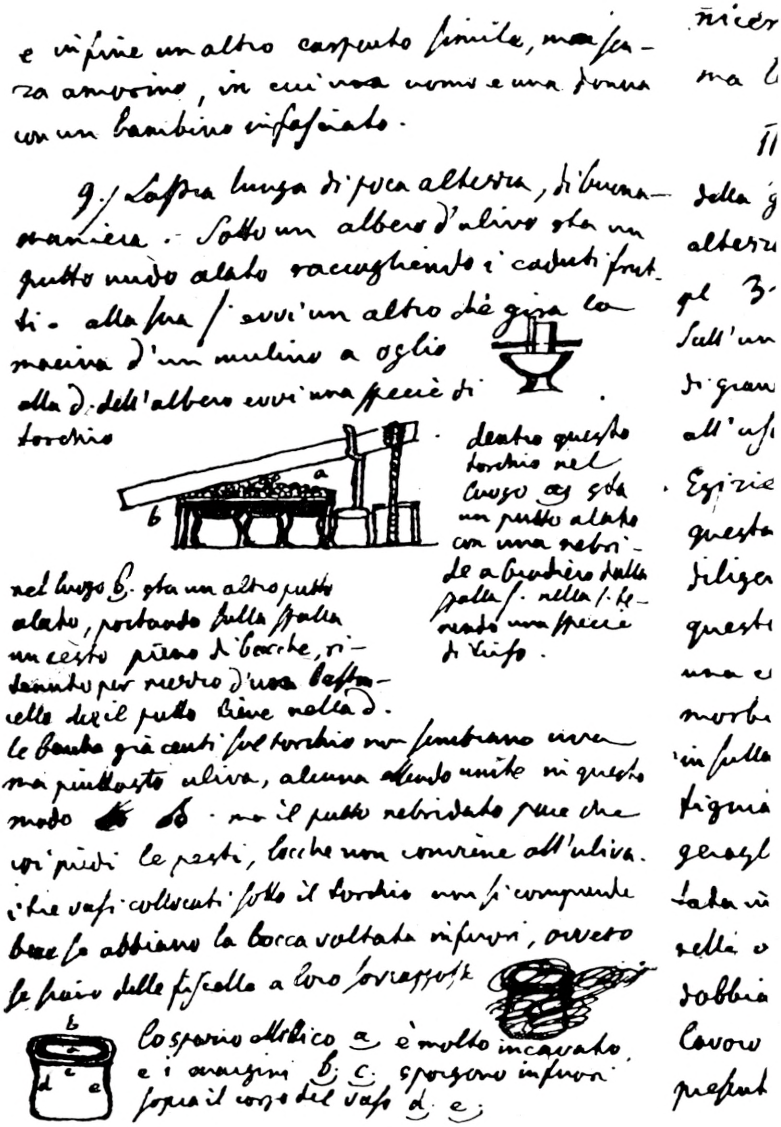


Fig. 21. The Villa Albani relief.

Fig. 21 illustrates the text p. 67; it shows a reproduction of the engraving, pl. xxvi, of G. ZOËGA: Li bassirilievi antichi di Roma. On it are seen a pair of *stipites* holding a drum, which seems to be fastened on their outside by an iron band; between the *stipites* the end of the *prelum* protrudes; a rope is tied to it, and goes down to the drum, on which it is wound in many coils. Another rope is seen coming up from the drum; it reaches the shadow above the *prelum*. Below the drum, behind the knee of the figure standing in front of the press, a square block is seen; this is probably the weight-stone. As explained in the text, the course of the rope is not clear.


e in fine un altro carpento simile, ma senza amorino, in cui vanno uomo e una donna con un bambino in fasciato.

9./ Lastra lunga di poca altezza, di buona maniera. Sotto un albero d'olivo sta un putto nudo alato raccogliendo i caduti frutti. alla sin./ evvi un altro che gira la macina d'un mulino a oglio

alla d. dell'albero evvi una specie di torchio

dentro questo torchio nel luogo a. sta un putto alato con una nebride a traverso della spalla/. nella /. tenendo una specie di tirso.

nel luogo b. sta un altro putto alato, portando sulla spalla un cesto pieno di bacche, rilevando per mezzo d'una bastoncello dove il putto beve nella d.

le bacche già cadenti sul torchio non sembrano uva ma piuttosto oliva, alcune stando unite in questo modo — ma il putto nebridato preme che coi piedi le pesti, lo che non conviene all'oliva.

i tre vasi collocati sotto il torchio non si comprende bene se abbiano la bocca voltata in fuori, ovvero se siano delle fiscelle a loro sovrapposte

Lo sporto Attico a è molto incavato, e i margini b. c. sporgono in fuori sopra il corpo del vaso d. e.

Fig. 22. Facsimile of a page in G. Zoëga's Apparatus ad Bassirilievi.

Fig. 22 illustrates the text p. 69; it shows a facsimile of a page of G. Zoëga's Apparatus ad Bassirilievi, Ny kgl. Saml. Fol. 357^{b}, vii, pag. 184^{d}; it represents part of his notes from the Museo Kircheriano. The text, which describes a relief very similar to that of Pal. Rondanini, cf. fig. 10, runs:

9.) Lastra lunga di poca altezza, di buona maniere. Sotto un albero d'ulivo sta un putto nudo alato raccogliendo i caduti frutti. alla sua s(inistra) evvi un altro che gira la macina d'un mulino a oglio alla d.(estra) dell'albero evvi una specie di torchio.

dentro questo torchio nel luogo *a* sta un putto alato con una nebride a brochiero (?) dalla spalla s.(inistra). nella s.(inistra) tenendo una specie di tirso.

nel luogo *b* sta un altro putto alato, portando sulla spalla un cesto pieno di bacche, ritenuto per mezzo d'uno bastoncello che il putto tiene nella d.

le bacche giacenti sul torchio non sembrano uve ma piuttosto uliva, alcuna essendo unite in questo modo  ma il putto nebridato pare che coi piedi le pesti, lacche non conviene all'uliva. i tre vasi collocati sotto il torchio non si comprende bene se abbiano la bocca voltata infuori, ovvero se siano delle fiscelle a loro sovrapposte.

lo spazio ellittico *a* è molto incavato, e i margini *b. c.* sporgono infuori sopra il corpo del vaso *d. e.*

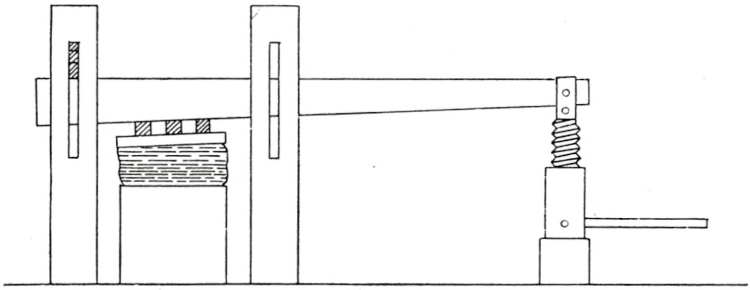


Fig. 23. Hero's lever and screw press.

Fig. 23 illustrates the text p. 70; it shows Hero's lever and screw press with hanging stone weight. The principle is the same as that of Plinius's second lever and screw press, see fig. 16, but the arrangement is different: the screw is fastened to the *prelum*, the weight is fastened to the screw nut, which is very long. When the screw nut is turned, it swallows the screw. The joint between the *prelum* and the screw is mere conjecture; unfortunately Hero's text here is unintelligible. For details see fig. 24.

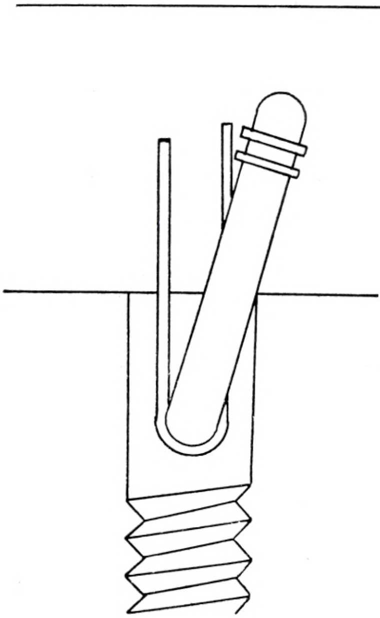


Fig. 24. Detail of the screw of HERO's lever and screw press.

Fig. 24 illustrates the text p. 70—72; it shows the author's reconstruction of the way in which the screw of HERO's lever and screw press is fixed to the "brick". A hole is drilled through the top of the screw stick, an iron axle is put through this hole, and is bent upwards and fastened to the brick. Long iron cramps are nailed to the brick, and support the axle by their curved part. The text is so confused that this reconstruction is very far from being certain.

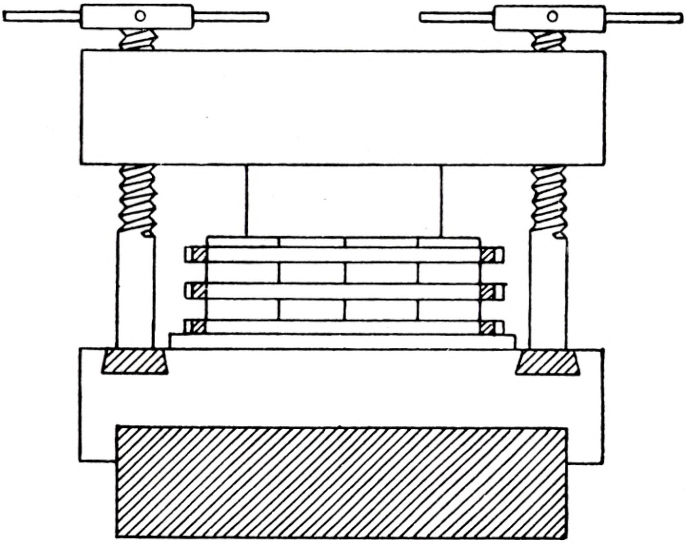


Fig. 25. Hero's twin screw direct press with his second *galeagra*.

Fig. 25 illustrates the text p. 57 and 73 sqq.; it shows Hero's twin screw direct press. The female screws are contrived in the *prelum* itself; when the screws are turned, down comes the *prelum*. The feet of the screws are undercut, and two boards, sliding in dove-tailed grooves in the press bed, catch the grooves of the feet to keep them down, but allowing them to turn; for details see fig. 26. As to the second *galeagra* see fig. 18.

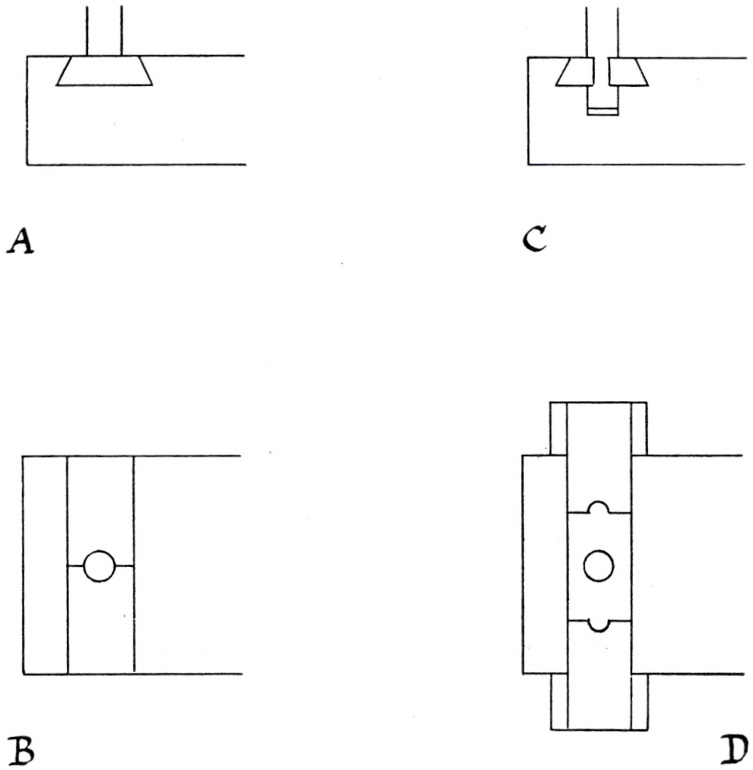


Fig. 26. Detail of HERO's twin screw direct press.

Fig. 26 illustrates the text p. 72 and 74; it shows how the foot of the screw of HERO's twin screw direct press was fastened to the table. *A* shows the end of the table seen from the front, with the screw foot and the dove-tail shaped cross piece in their places; *B* shows the same seen from above. *C* shows the same as *A*, but seen in a cut, to show the way in which the foot of the screw is grooved; *D* shows the same as *B*; only the cross pieces have been drawn out to show the narrow incision in their ends.

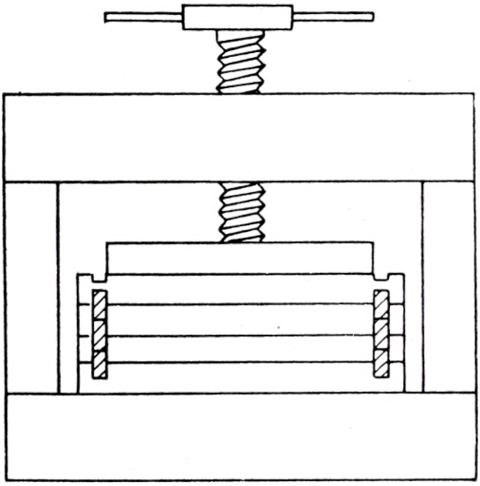


Fig. 27. Hero's one screw direct press with his first *galeagra*.
Fig. 27 illustrates the text p. 57 and 76 sq.; it shows Hero's one screw direct press; the female screw is contrived in the *prelum*, which stays in its place, while the screw presses down on the press lid. The principle is the same as in Plinius's direct screw press, only Hero's press is portable, while Plinius's press is fixed; cf. fig. 17. As to the first *galeagra*, cf. fig. 19.

Fig. 28 illustrates the text p. 77 sqq.; it shows Hero's screw cutter. *A* shows the screw with the hole for handles above and the smooth peg below; below that is the peg seen from below; the two diagonals are drawn in, and the cross line; on the figure above are seen the two lines drawn on the peg. *B* shows the screw peg with the canal cut into it, and the iron cutter and wedge in position; below is seen the peg seen from below; one third is cut off, and the canal is cut into the rest. *C* shows the screw cutter in function. The screw is put into a hole in a plank, with five small pegs driven in to form a provisional screw thread; the plank is clamped to the plank into which the female screw has to be cut; the lower end of the wedge is sticking out below. Below that is the same arrangement seen from below.

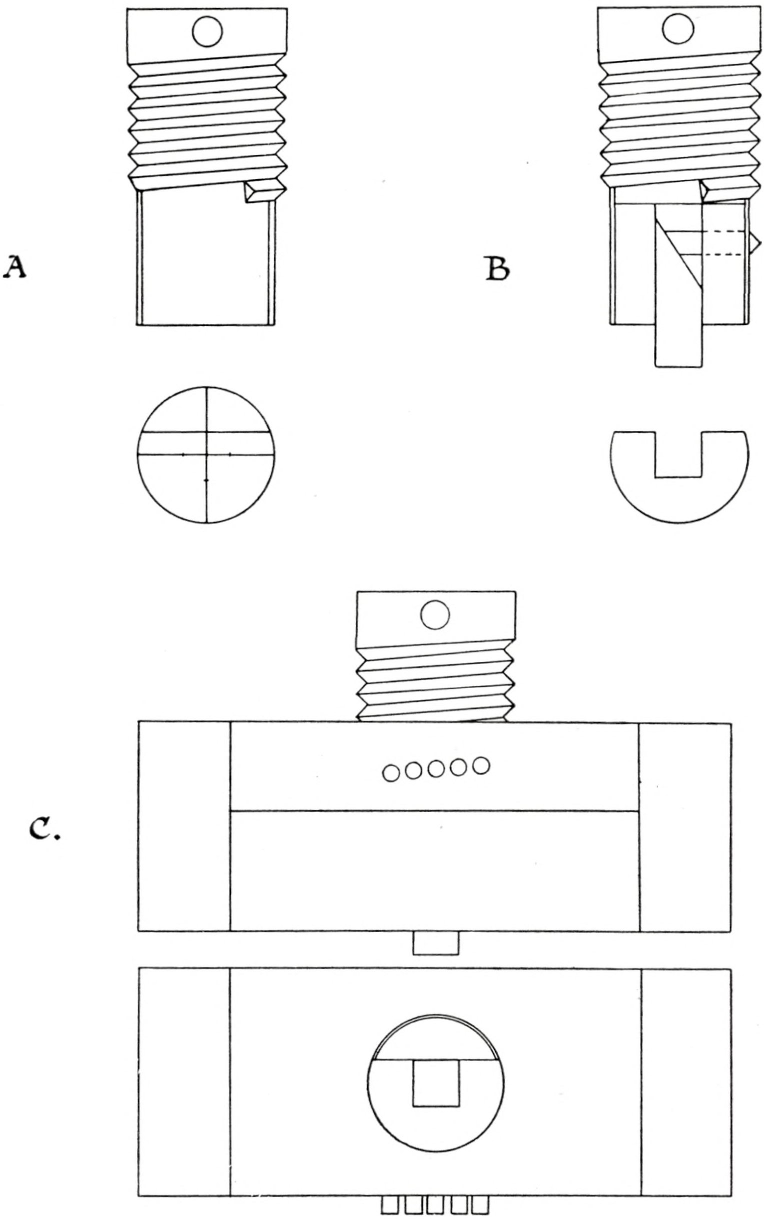


Fig. 28. Hero's screw cutter.

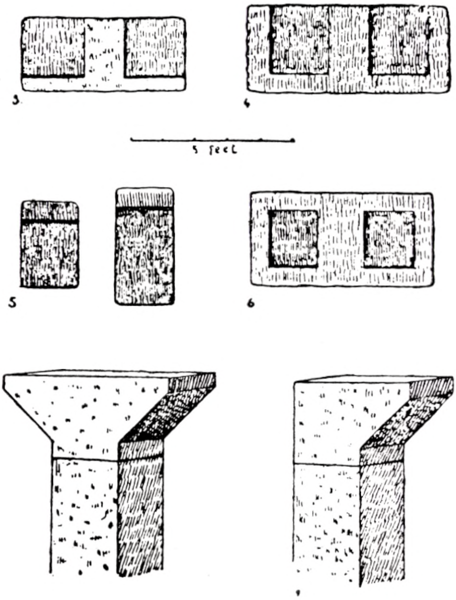


Fig. 29. Footing Stone for stone *arbores.*

Fig. 29 illustrates the text p. 95; it is reproduced from H. S. Cowper: The Hill of the Graces, 1897, fig. 35, p. 143; its no. 6 shows the usual form of a footing stone for a pair of stone *arbores.* It is so like the stone slab from Brøndsted's press at Kapljuč, cf. his fig. 96, p. 104, that I do not hesitate to assert that that was meant for a set of stone *arbores,* too.

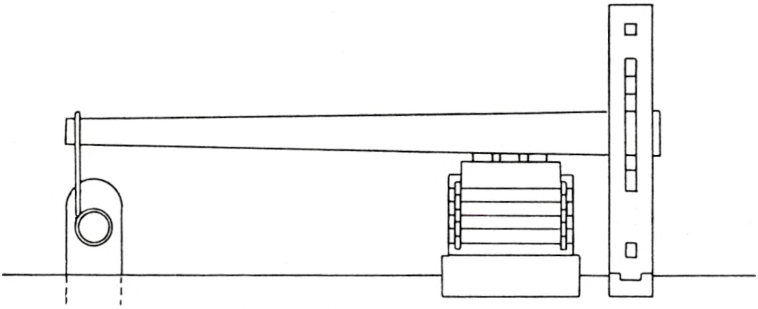


Fig. 30. The Salona press.

Fig. 30 illustrates the text p. 95; it shows the author's reconstruction of the press found at Kapljuč, near Salona, by Brøndsted; it is copied from Brøndsted's fig. 96, p. 104, the only difference being that the *arbores* are of stone. On the press bed is shown Hero's first *galeagra*, as it would fit the *ara*.

Fig. 31. Stone *arbores* from Tripolis.

Fig. 31 illustrates the text p. 96; it is reproduced from H. S. Cowper: The Hill of the Graces, 1897, fig. 80, p. 260, and shows a pair of stone *arbores* for a lever and screw press. The square cuts are meant to take the cross pieces under which the short end of the *prelum* was inserted.

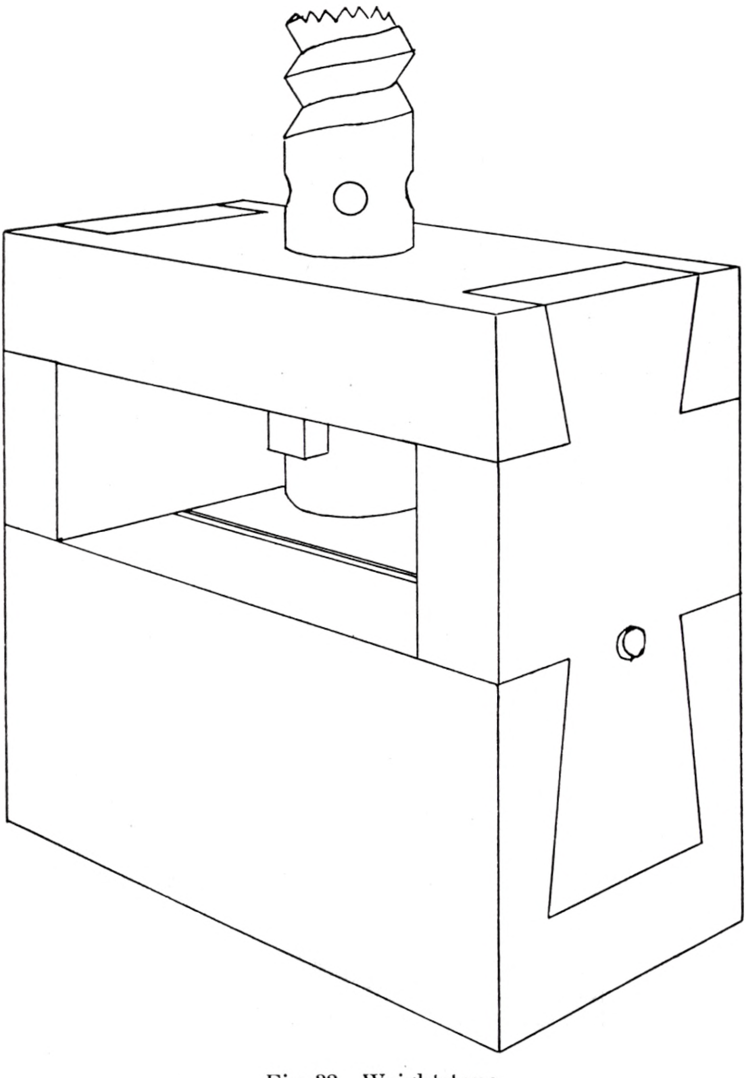


Fig. 32. Weightstone.

Fig. 32 illustrates the text p. 97; it shows one of the Tripolis weightstones mounted. Into the dove-tail cuts in the ends of the stone are fitted wooden sides to carry the wooden cross piece, through which the screw goes. An iron rod passing along the groove at the top of the stone keeps the sides together; a necessary precaution in a very dry climate.

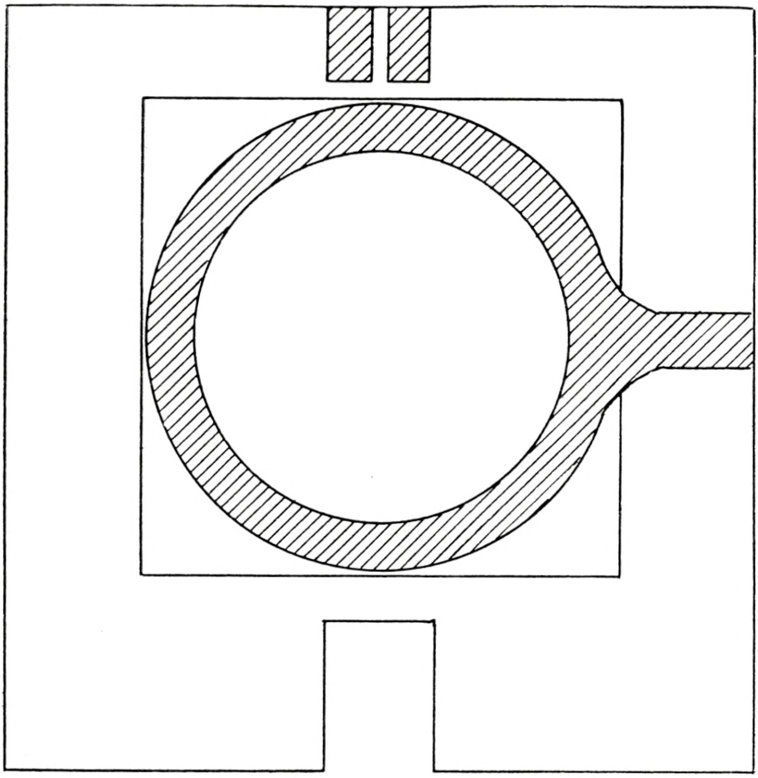


Fig. 33. The Vallebona *ara.* 1 : 10.

Fig. 33 illustrates the text p. 98; it is made from a sketch by Professor CHR. BLINKENBERG. It shows an *ara,* found in Vallebona, near Seborga; it has a *canalis rotunda* and a square depression for the *galeagra.* The two cuts at the sides indicate that it has been used for a direct screw press; if with or without *congeries* cannot be seen. A similar *ara* was found near by.

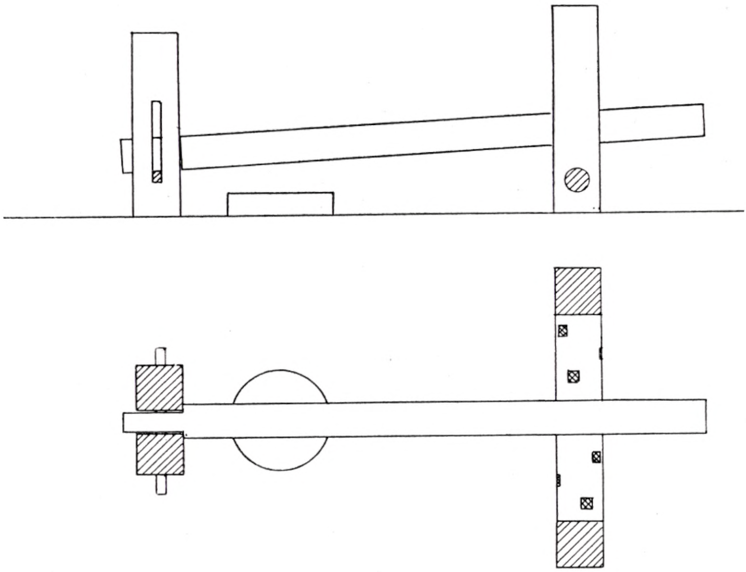


Fig. 34. Cato's press as it is usually reconstructed.

Fig. 34 illustrates the text p. 101; it shows Cato's press as it is usually reconstructed. It is easily seen that the last four feet of the *prelum* are superfluous, and the author refuses to believe that the press looked like this. Fig. 35 shows the author's reconstruction, which is more likely and more consistent with the text.

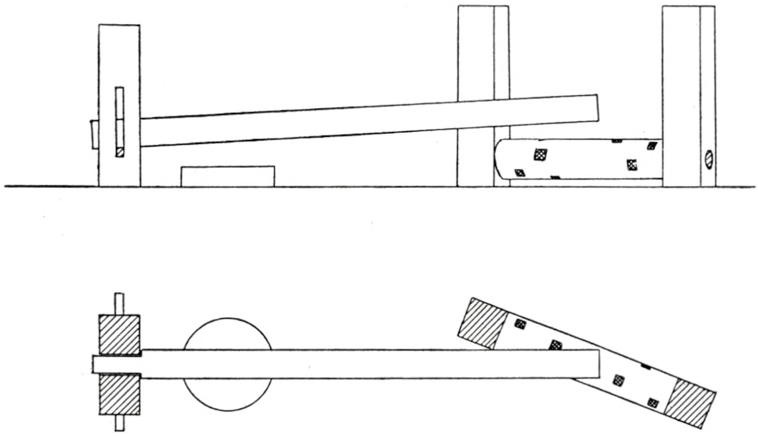


Fig. 35. CATO's press as reconstructed by the author.

Fig. 35 illustrates the text p. 103; it shows the author's reconstruction of CATO's press. If the drum is slewed round, as shown, one *stipes* becomes the "near" *stipes*, and the other the "far" *stipes*, and the whole length of the *prelum* is utilised. The *stipites* are shown square; they may have been round, as in the painting in the House of the Vettii.

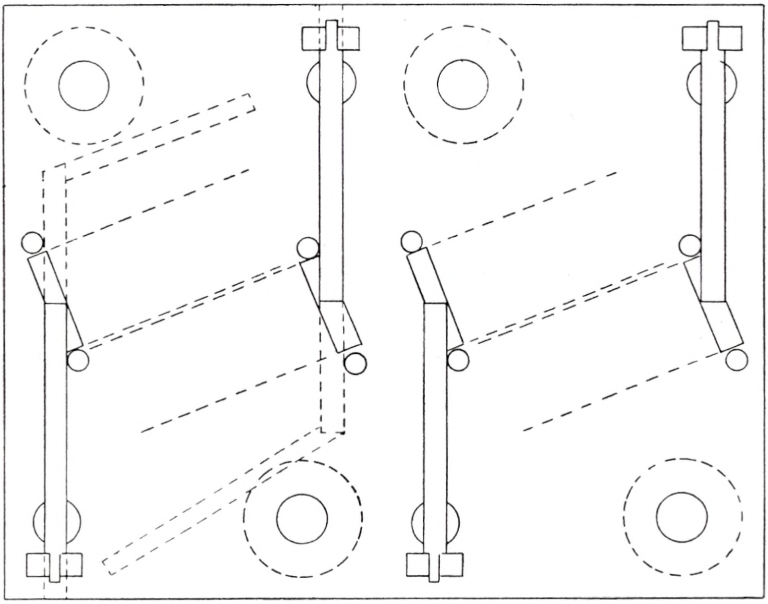


Fig. 36. Cato's press house, as reconstructed by the author.

Fig. 36 illustrates the text p. 114 sqq.; it shows a ground plan of Cato's press house as reconstructed by the author. The four presses are standing two and two opposite each other; the four trapetes are indicated by circles; the dotted circle shows the space covered by the *cupa* when rotated. In the left half of the plan the *trabes* above the presses are shown in dotted lines; to the press in the middle has been added the outline of a long *trabecula*; to the one at the wall a short *trabecula*. The dotted lines at right angles to the drums indicate the space necessary for the handspakes.

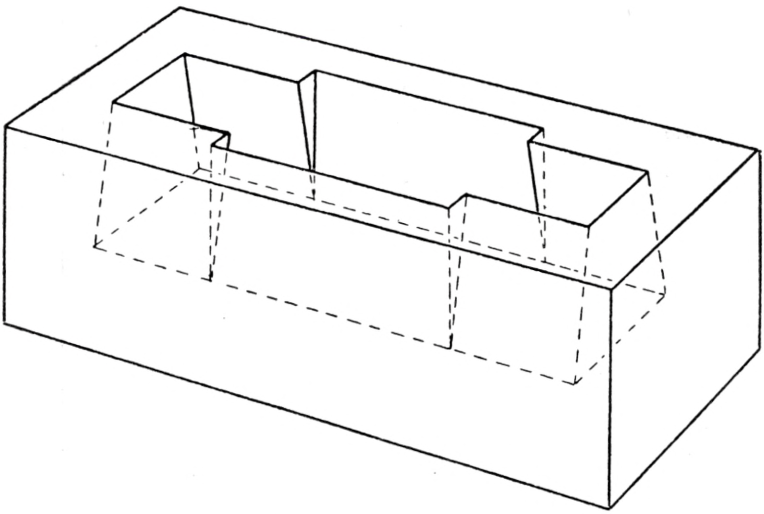


Fig. 37. MEISTER's *pedicinus.*

Fig. 37 illustrates the text p. 105; it shows CATO's *pedicinus* as reconstructed by MEISTER. The two ends of the hole are undercut to take the swallow-tail at the foot of the *arbores*; the hole in the middle is just large enough for the next *arbor* to be put in, when the first is in position. If then the space in the middle is filled out with an oaken block, the whole construction is very solid indeed.

It cannot be proved that the *pedicinus* was like this, but it is a probable and pleasing solution.

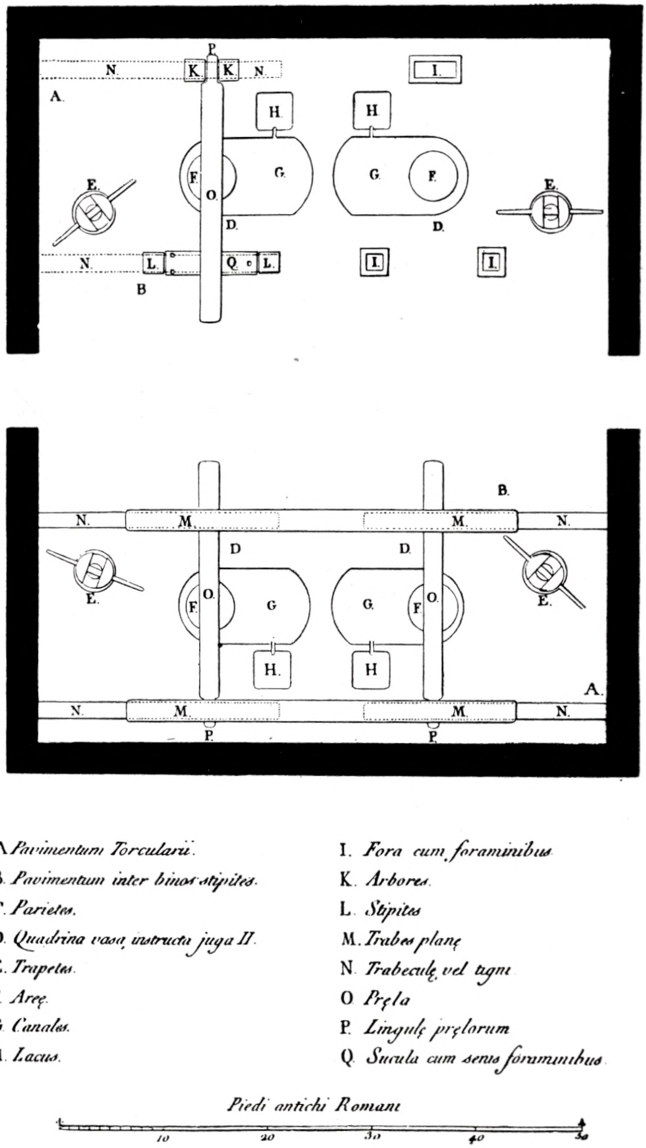


Fig. 38. Cato's press house reconstructed by the Herculanensian academy.

Fig. 38 illustrates the text p. 104; it is a reproduction of tab. III of the Antichità di Ercolano, vol. 8, and shows Cato's press house as reconstructed by the Herculanensian academy. The disproportional length of the *prela* is very evident.

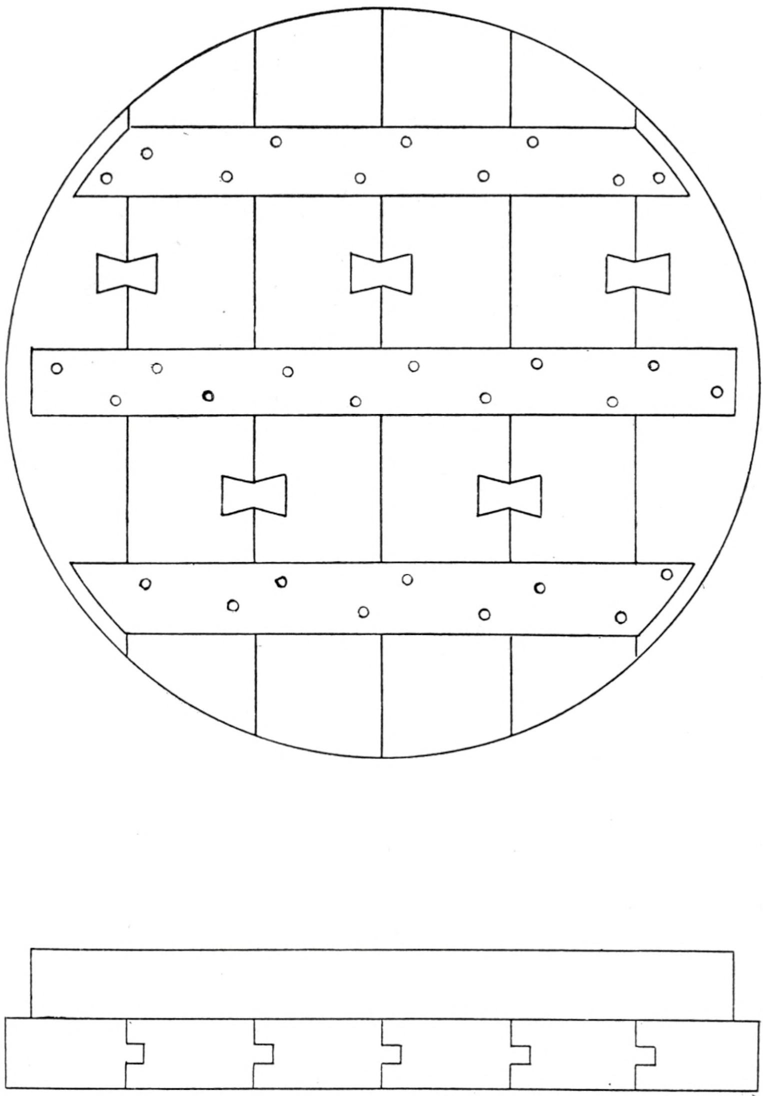


Fig. 39. *Orbis olearius.*

Fig. 39 illustrates the text p. 119; it shows the author's reconstruction of CATO's *orbis olearius.* The feather and groove joint shown below is supposed to represent the *coagmenta Punicana,* but there is no proof that it was not made in some other way. The double dove-tails are the *subscudes*; the cross pieces are the three *catenae.*

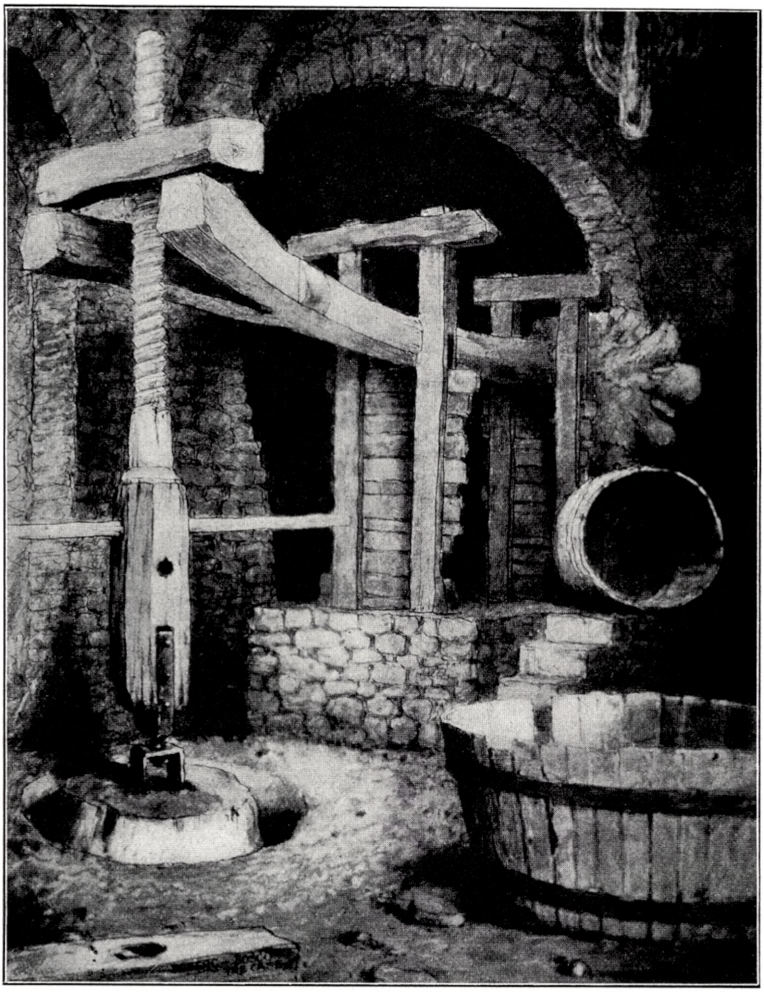


Fig. 40. The Bosco Tre Case press. Drawing.

Fig. 40 illustrates the text p. 56 and 122; it is reproduced from a drawing in water colours by F. Boberg, kindly sent me by the Swedish Archaeological Institute at Rome. It shows the Bosco Tre Case press described in App. 1. Cf. figs. 41 and 15.

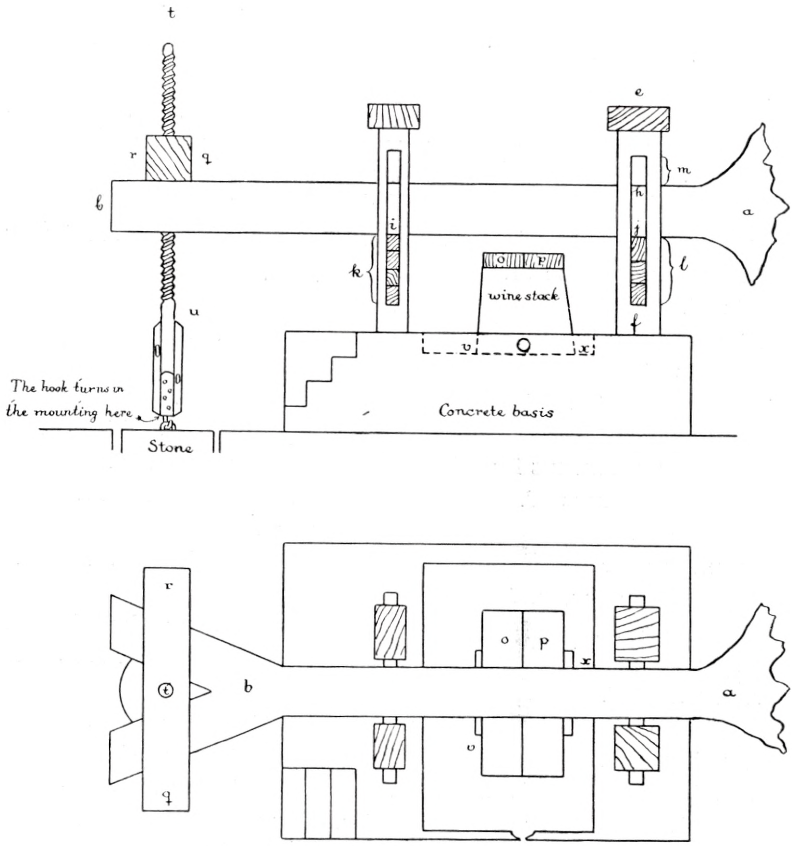


Fig. 41. The Bosco Tre Case press.

Fig. 41 illustrates the text p. 122 sqq.; it is a diagram made from a sketch sent me by Professor Boëthius as an illustration to his description of how the press was worked. The letters in the figure are explained in the text.

INDEX 1. — GENERAL INDEX

INDEX 2 — GREEK WORDS

INDEX 3 — ARABIC WORDS

CONTENTS

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