

SUETONIUS *NERO* 41. 2 AND THE DATE OF HERON MECHANICUS OF ALEXANDRIA

Modern scholarship has provided two probable fixed dates (or at least *termini post quem*) and one probable *terminus ante quem* for Heron of Alexandria. I wish here to propose a third date, which tends to confirm the first two.

The probable *terminus ante quem* for Heron was established by Otto Neugebauer, who argued that Heron was independent of, and prior to, Ptolemy (fl. A.D. 127–48).¹ Fritz Krafft has more recently proposed a refinement of this *terminus*, suggesting that Heron was active before Marinus of Tyre (fl. A.D. 114).²

The first fixed date derives from Heron's *Mechanica* (3. 21), in which a new method of cutting female screw threads is described. Since Pliny (*HN* 18. 74 [317]) states that this method was discovered twenty-two years before he composed his *Natural History* (A.D. 77), Wilhelm Schmidt argued that the publication of the *Mechanica* should be dated to A.D. 55.³ Strictly, this argument is valid only if the screwcutter described by Heron was published for the first time in his *Mechanica* (which Heron does not claim) and if Pliny (and others) would have known about the method only through published works. Nonetheless, the simplest hypothesis would place invention and publication close together, so that A.D. 55 seems to be a probable *terminus post quem* for the composition of the *Mechanica*.

In addition, Neugebauer demonstrated conclusively that A.D. 62 is a *terminus post quem* for the *Dioptra*, in which Heron uses the lunar eclipse of that year (13 March) to determine the distance from Rome to Alexandria.⁴ Drachmann subsequently argued that Heron himself probably witnessed the eclipse; for if he were willing to use an old eclipse, he could have chosen one better suited to his purpose.⁵ Though this argument, viewed strictly, is uncertain (Heron did not choose a well-suited eclipse, but we do not know why), the hypothesis that Heron himself witnessed the eclipse seems to be the simplest.

1. *Über eine Methode zur Distanzbestimmung Alexandria-Rom bei Heron*, Kgl. Danske Videnskabernes Selskab, Historisk-filologiske Meddelelser, vol. 26.2 (Copenhagen, 1938), p. 22; amplified by A. G. Drachmann, *Ktesibios, Philon and Heron: A Study in Ancient Pneumatics*, Acta Historica Scientiarum Naturalium et Medicinalium, vol. 4 (Copenhagen, 1948), pp. 76–77, and id., "Heron and Ptolemaios," *Centaurus* 1 (1950): 117–31.

2. "Kunst und Natur: Die Heronische Frage und die Technik in der klassischen Antike," *A&A* 19 (1973): 1–19, esp. 16; on Marinus of Tyre, see F. Lasserre, "Marinos (2)," *Der kleine Pauly* 3 (1969): 1027–29, and N. G. Photinos, "Marinos von Tyros," *RE* Suppl. 12 (1970): 791–838.

3. See *Heron's von Alexandria Druckwerke und Automatentheater*, Heronis Opera Quae Supersunt Omnia, vol. 1 (Leipzig, 1899), pp. xix, xxii–xxiii; approved by A. G. Drachmann, *Ancient Oil Mills and Presses*, Kgl. Danske Videnskabernes Selskab, Archaeologisk-kunsthistorisk Meddelelser, vol. 1.1 (Copenhagen, 1932), pp. 125–28. See also the discussions by A. G. Drachmann, *The Mechanical Technology of Greek and Roman Antiquity* (Copenhagen–Madison–London, 1963), pp. 140, 205; Krafft, "Heronische Frage," p. 19, n. 55; and D. Sakalis, *Die Datierung Herons von Alexandria* (Cologne, 1972), pp. 4–5.

4. *Methode*, p. 23. See also the discussions by A. Rome, review of Neugebauer, *Methode*, in *AC* 7 (1938): 460–62; O. Neugebauer, *The Exact Sciences in Antiquity* (Providence, 1957), p. 178; and Drachmann, *Mechanical Technology*, pp. 9–10. G. J. Toomer reminds me that Neugebauer's *History of Ancient Mathematical Astronomy*, vol. 2 (Berlin and New York, 1975), pp. 845–48, is more accessible than his *Methode*.

5. Neugebauer, *Methode*, p. 23, noted the unsuitability; Drachmann, *Ancient Pneumatics*, pp. 76–77, thence inferred Heron's autopsy of the eclipse.

The eclipse must have been observed simultaneously in Rome and Alexandria to be used to determine the distance, and Heron could not have been in both places at once. An assistant or colleague must have observed the eclipse in one location, Heron in the other.⁶ This establishes a professional link between Heron and Rome in the early 60s.

Now, an anecdote at Suetonius *Nero* 41. 2 (and the parallel passage in Cassius Dio)⁷ may provide a *terminus ante quem* for Heron's *Pneumatica*. Nero regales *quosdam e primoribus viris* in A.D. 68 with a new type of water-organ: "per organa hydraulica novi et ignoti generis circumduxit, ostendensque singula, de ratione ac difficultate cuiusque disserens." This organ "of a new and unknown type" was very likely the work of Heron.⁸

Heron was the greatest practical mathematician of his age,⁹ and his pneumatic inventions, including new types of water-organ (cf. *Pneum.* 1. 42), were presumably the best available; no other known Mechanicus (roughly, "practical engineer") is dated to this era.¹⁰ The water-organ had been invented by Ctesibius around 260 B.C.,¹¹ so that to attract any attention Nero's model must have been a new design, as Suetonius declares it was. Would a new type of organ at this time have been Heron's work or that of an otherwise unattested inventor of organs contemporary with Heron? *Entia non sunt multiplicanda praeter necessitatem*.

The principal improvement claimed by Heron (*Pneum.* 1. 42) appears to be his placement of the pipes directly on the windbox (they would otherwise be connected to it by valved channels).¹² This would tend to make the sound louder (the airflow attainable at a given air pressure would increase without the impedance of the valved channels) and probably purer (noise would have been generated by the air flowing through the valves in the unimproved organ)—just the effects noted by Nero in the account of Dio. There were other differences in Heron's new organs: for instance, he seems to have introduced horn for the valve-springs where iron had been used previously;¹³ and I suspect that there were numerous similar improvements in technical details. Certainly Nero, who presumably was instructed by Heron or an assistant in Rome (we have noted

6. Noted by Rome, review of Neugebauer, p. 461. Menelaus of Alexandria also made observations at Rome (early in A.D. 98): Ptol. *Alm.* 6. 3; on Menelaus, see F. Sezgin, *Geschichte des arabischen Schrifttums*, vol. 5 (Leiden, 1974), pp. 158–64 (a reference I owe to G. J. Toomer).

7. 63. 26. 4 ad fin.: νύκτωρ ποτὲ τοὺς πρώτους τῶν βουλευτῶν καὶ τῶν ἱππέων ἐξαπίνης σπουδῇ, ὡς καὶ περὶ τῶν παρόντων τι κοινῶσιν σφίσι, μεταπέμψας "ἐξεύρηκα" ἔφη "πῶς ἡ ὑδραυλὶς" (αὐτὸ γὰρ τὸ ῥηθὲν γραφήσεται) "καὶ μείζον καὶ ἐμμελέστερον φθέγγεται." This is less precise and could refer to some method of playing or operating the organ; Suetonius makes it clear that the organ was a new type. I am more inclined to trust Suetonius' report that the organ was a new model than to restrict the novelty to some performance technique of Nero's such as Dio might imply.

8. The possibility is not noted in the two most recent commentaries on the passage, B. H. Warmington, *Suetonius: "Nero"* (Bristol, 1977), p. 109, and K. R. Bradley, *Suetonius' "Life of Nero": An Historical Commentary*, Collection Latomus 157 (Brussels, 1978), p. 254. I doubt that Seneca's neighbor the organ tuner has anything to do with Heron, since Seneca (*Epist.* 6. 56) says nothing about innovative designs; see J. M. May, "Seneca's Neighbour, The Organ Tuner," *CQ* 37 (1987): 240–43 (I am indebted to C. F. Konrad for drawing my attention to this article).

9. See T. L. Heath, *History of Greek Mathematics*, vol. 2 (London, 1921), pp. 307–8.

10. See Drachmann, *Mechanical Technology*, pp. 9–12: between Athenaeus *Mech.* (fl. 27 B.C.) and Pappus (fl. A.D. 295) there is only Heron.

11. See Drachmann, *Ancient Pneumatics*, pp. 3, 7.

12. *Ibid.*, pp. 7–8.

13. *Ibid.*, pp. 8–9.

Heron's professional link to Rome), thought so ("ostendensque singula, de ratione ac difficultate cuiusque disserens").

In sum, economy of hypothesis suggests that the organ demonstrated in A.D. 68 at Rome was Heron's; this in turn establishes A.D. 68 as a *terminus ante quem* for Heron's invention of the new model and thus suggests a rough date for the publication of his *Pneumatica*. This *terminus ante quem* is consistent with and tends to confirm the two *termini post quem*, A.D. 55 and 62, associated with the publication of Heron's *Mechanica* and *Dioptra*. At the very least, we seem to have another date in the long-disputed chronology of Heron of Alexandria.¹⁴

PAUL KEYSER
University of Colorado,
Boulder

14. This paper has benefited from critical readings by W. M. Calder III, George Huxley, C. F. Konrad, and an anonymous referee of *CP*.

THE FORTY THOUSAND CITIZENS OF EPHEBUS

In his sweeping critique of most of the methods used to estimate the populations of ancient cities, R. P. Duncan-Jones quotes the half-dozen surviving explicit ancient population figures, which in his view give a firmer base than the various methods of estimation, going back in many cases to Beloch's classic work on ancient demography.¹ Among them is a figure for Ephesus: "Ephesus had at least 40,000 male citizens, and thus a population probably no smaller than that of Pergamum, from the terms of a gift made in the second or early third century A.D."² As we shall see, Duncan-Jones' description of the nature of the evidence is not exact, but he follows a long tradition in accepting the figure of 40,000. The source of the figure is the interpretation of an inscription published by Josef Keil in 1930,³ which was apparently first brought into the service of demography by T. R. S. Broughton in his work on Roman Asia Minor in Tenney Frank's *Economic Survey of Ancient Rome*. Broughton wrote as follows: "At Ephesus Aurelius Barenus entertained (besides the magistrates) 40,000 citizens (*Jahresh.*, XXVI [1930], beibl., 57f., late II), a figure which proves that

1. *The Economy of the Roman Empire: Quantitative Studies* (Cambridge, 1974), pp. 259-62, esp. 260, n. 4. Beloch's *Die Bevölkerung der griechisch-römischen Welt* (Leipzig, 1886), though always cited, is more often a convenient target than a model.

2. "Pergamum in the second century A.D. had a free adult population of about 80,000, and about 40,000 slaves, implying a total population of about 180,000 including children," says Duncan-Jones (*Economy*, p. 261, n. 4), basing himself on Galen *De propriorum animi cuiuslibet affectuum dignotione et curatione* 5.49 Kuhn. What Galen actually says is that Pergamum had 40,000 citizens and equal numbers of women and slaves; he does not indicate that the 40,000 citizens are all adults, but the tenor of the passage suggests it. Galen, it must be noted, gives the numbers while emphasizing how many Pergamenes (all but fewer than thirty) are less wealthy than his addressee and urging him not to wish to be richest of all, and he claims no great precision: εἴπερ οὖν ἡμῖν οἱ πολῖται πρὸς τοὺς τετρακτισμυρίους εἰσὶν ὁμοῦ, ἔαν προσθῇς αὐτοῖς τὰς γυναῖκας καὶ τοὺς δούλους, εὐρήσεις σαυτὸν δάδεκα μυριάδων ἀνθρώπων οὐκ ἄρκούμενον εἶναι πλουσιώτερον.

3. "Vorläufiger Bericht über die Ausgrabungen in Ephesos," *JÖAI* 26 (1930), Beiblatt, p. 57.