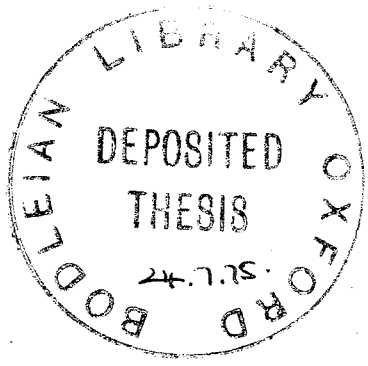
G R E E K W E I G H I N G

by

C.H. Grayson



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G R E E K W E I G H I N G

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CHAPTERS VI- IX

CONCLUSION

chapter six

THE GREEK ATTITUDE TO WEIGHING

- καὶ μὴν πόθεν Πλούτων γ' ἂν ὠνομάζετο,
εἰ μὴ τὰ βέλτιστ' ἔλαχεν; ἢν δέ σοι φράσω,
ὅσῳ τὰ κάτω κρείττω 'στὶν ὧν ὁ Ζεὺς ἔχει·
ὅταν γὰρ ἱστῇς, τοῦ ταλάντου τὸ ῥέπον
κάτω βαδίζει, τὸ δὲ κενὸν πρὸς τὸν Δία.

(Aristophanes fr. 488. 1-5)

Introductory

The balance and its operation figure prominently in Greek literature. For the most part reference is indirect: in allegory, metaphor or simile. Pictorial representations also are more frequently related to the allegorical balance (and only group C of those collected above directly pictures actual weighing). It is important to make use of these sources of evidence to make up for the lack of more direct descriptions of Greek weighing. Furthermore the completely general contexts of metaphor and vocabulary might come closer to a truer picture of Greek weighing than the particular specialism of a certain trade. Both general and particular are part of the overall question of how Greeks weighed, but the danger is to infer the general from the little specific direct evidence. This is of specialised areas (as coin manufacture) or of specialist machines (such as the bismar in [Arist.] Mech. §20).

In the latter parts of this chapter I shall consider under separate headings allegory, metaphor, language and similes. The distinctions between these categories are rarely clear-cut; a great deal of overlap and possible misappropriation has been inevitable. The method followed can be justified in the wider context. Isolation of a series of allegorical contexts for the balance enables more direct contact to be made with pictorial representations; further the allegorical contexts, being more formally established in myth and religion, are thereby less indicative of the conscious experience of those writing about them (or drawing them). Metaphors are rather better such indications in the largely poetic literary contexts in which they can be found; language (or the vocabulary of weighing) is a more attenuated form of metaphor and so again is rather less indicative of a writer's awareness of the metaphor. Thus we can speak (and indeed read) of "redressing the balance" without consciously picturing the operation. Metaphors can lose their content, and language its richness. Nevertheless the original force of the metaphor (or word) is implied by its later use, however attenuated, and it is not to be ignored in the general historical context of Greek weighing considered here. The simile on the other hand remains continually direct evidence of the writer's imagination, and so of his experience, when he mentions a balance or weighing.

There is need for a more basic justification for the procedure adopted in this chapter, arguing towards practice from largely-literary metaphor or simile. It could be objected in the first place that metaphors lose their content and that point I hope to have countered above; secondly there is the danger that metaphors etc. are selective. Thus, of the many processes of forging, the saying "strike while the iron is hot" picks out only one; "cold steel" draws attention to another; "fiery furnace" has a literary (rather than actual) ancestry ... . However it should prove possible by considering the relative frequency of such metaphors etc., and of other metaphors etc. related to them, to determine which belonged to an active, rather than passive, imagination[1], and which represented what was thought to be the central aspect of the activity (forging or weighing). The consistency with which the Greeks emphasise the tilted beam as opposed to the level beam approaches the point of being an argument for this being what the Greeks thought was the central aspect of (reason for) weighing.

A third objection could be the possibility of literary borrowings from outside the culture under investigation (as "fiery furnace" above; but also compare "weighed in the balance and found wanting")[2]. Fortunately the Greeks were far less vulnerable to such borrowing than the historical English. Some may very well have occurred (especially by Orphicism from Egypt); if it has permeated general literary society it would surely have been more detectable than it is: though if it is at all detectable, I do not think it need be irrelevant for such a study as this.

This is because, against a fourth objection that this approach is blind to the possibility of development and change, I have been most concerned to note incompatibilities and variations in the sense of metaphors and words used. These are in fact remarkably few in the period from Homer down into the fourth, and even third, centuries B.C. Even if it be suspected that out of date metaphors etc. can retain their currency (as "strike while the iron is hot"), it is very much the case that an actively-developing literature will readily fashion new ones: the weighing scene in Aristophanes Ranae probably overstepped the mark in this respect (τυροπωλησαι, ἐριοπωλικως, μεταγωγειν all needed scholiast's glosses and failed to pass into literary tradition) and compare such modern metaphors, well beyond the reach of Gibbon, "we're not on the same wave length", "He's run out of steam" (though approaching obsolescence), "spare-part surgery" etc.

While I have attempted as wide a coverage of literature as possible, it proved unnecessary to document the aspects indicated by metaphors etc. as fully as might have been possible. I have further restricted comment, especially in the section on vocabulary, to the more interesting examples. The full range of sources covered is indicated by the lists of ch. I.1.(3).

Two further areas of indirect evidence are presented here in advance of the general survey of allegory, metaphor etc.: first, ancient theory of weighing; second, that of weight. These illustrate how closely language and metaphor etc. reflected theory. Throughout a remarkably consistent picture of the balance emerges. One question, to be pursued in a later chapter, is to what extent this consistency not only first reflected but later restricted the development of Greek weighing machines and techniques.

The aspects of the balance indicated by this indirect evidence are briefly reviewed in a concluding section at the end of the chapter.

1. Theoretical accounts of weighing and the balance

No systematic treatise on weighing or on the operation of the balance has survived. Although titles of lost works, as Archimedes' περι ζυγων, might allow the possibility of their having once existed, it seems likely that these are no less mathematical than extant works.[3] Nevertheless the subject of weighing, the theory of the balance, and a few observations on its practice, do appear incidentally in a number of treatises (or scattered fragments of them) on more general mathematical or semi-mechanical subjects. These references will be seen to offer some qualification of the overall picture of Greek attitudes to weighing: first, the balance appears as an instrument that balances, or equates, by being level; and second, theoretical treatment of the balance does not necessarily assume as basic the equal-arm, central-pivot type, but tends to regard this as a special case in the more general mechanical problem of variable-length levers.

The significance of these two points is however considerably reduced by the late dates of the writings themselves and by the theoretical contexts in which the balance appears. This will be shown by a brief survey of the relevant material. At the same time I shall note evidence of practical weighing experience, and in particular of the types of weighing machine implied. Though more relevant for subjects outside the present chapter (thus balance design ch.I and point of weighing ch.VIII), it is convenient to include these matters here.

The most important treatise to be considered is also probably the earliest. The work on Mechanics in the Aristotelian corpus was probably written in the early third century B.C. by an Alexandrian scholar, possibly Straton.[4] In a general discussion of the lever and the circle (or wheel), several references are made to the balance. These indicate only a limited awareness of the theory of equal-arm balances, but also reflect practical considerations of its use (and more interestingly its misuse). A single-arm balance type is described in detail from actual observation of its use in a practical commercial context. This is typical of the writer's fundamentally negative

approach: inferences are made from observed characteristics of balances, but no modifications in design are suggested or pursued.

Comparison of the balance to the lever is correct, even if the expressions "inverted lever" (μοχλὸν ἀνεστραμμένον. 20.854a 9-10) and "beam with its cord below" (κάτωθεν ἔχον τὸ σπαρτίον. 3.850a 3-5) that continue this comparison are somewhat quaint. That a larger lever will move a given weight more easily, whence the principle of the steelyard, is illustrated straightforwardly by the special meat-scales described in §20 (853 b 25-54 a 15 and also cf. §3. 850 a 35 εἰς ἄνισα διῃρημενον of the lever). Otherwise the principle is noted behind the fraudulent methods used to adapt supposed equal-arm balances, that are discussed in the conclusion of §1 (at 849 b 35).

The description of this fraud seems adequate. By offsetting the point of suspension from true centre and by, at the same time, weighting one arm, the purple-dye sellers deceive. The writer is however either elliptic here or does not understand the principle for such deceit. As the scales most likely would be checked by prospective buyers when unloaded, one imagines that the deceit would not be apparent in this situation. They would therefore increasingly underweigh (i.e. indicate less than true weight of) the load added to the pan suspended from the weighted arm. Yet the writer makes out that sellers wanted the beam to incline to this weighted side (πρὸς ὃ βούλονται ῥέπειν ποιοῦντες), which is the very reverse. In fact this attribution of motive surely derives from a superficial understanding of the mechanical principles involved: it is not simply a matter of one half of the beam being heavier (which would indeed incline the way described here).

A similar lack of understanding can be seen in the general discussion of "why large balances are more accurate than small" to which the purple-dye sellers are somewhat implausibly attached (§1.848 b 1 - 849 b 34). The writer admirably shows that a given angular displacement of a balance beam is more easily observed (quicker movement: θαττον) the greater the beam's length. In fact his data are more relevantly the perception of movement: which incidentally reveals the absence of pointers on the balances he has experienced. And secondly, neither explanation nor data relate to the basic question asked initially of accuracy (ἀκριβέστερα) - small movements might be ἀδηλα but they still occur. Perhaps we should be satisfied with "observable sensitivity" while adding, thirdly, that no allowances are made in the argument of this section for design errors, in particular for either air-disturbance or for friction.

There is some evidence that the writer of the Mechanics was aware of friction in another context. §11 (852 a 29-37) argues that rollers are better than carts for moving heavy weights, because of the friction in the latter case between cart-wheel and axle: διότι ἐπὶ τῶν σκυτάλων οὐδεμίαν ἔχει πρόσκοφιν, τὸ δὲ ἐπὶ τῶν ἁμαξῶν τὸν ἄξονα, καὶ προσκόπτει αὐτῷ. This concept could be relevant to the immediately preceding problem: "why is it easier (διὰ τί ῥᾷον ... κινεῖται τὸ ζυγόν) to move an [unloaded] heavy beam, than one which is [loaded] light?", (§10. 852 a 23ff.). The solution is partly a recognition of inertia, "weight is more difficult to move in any direction". Yet the ambiguity should be recognised: inertia (of the heavier beam) should make the effect of applying a certain force less immediate, but the beam will nevertheless move, its sensitivity only being reduced with loading if a further factor of "friction" is involved.[6] The phrases in the problem here, ῥᾷον, δυσκινητον etc., seem to apply more to movement at all, than to its speed.[7] The passage can therefore stand as evidence for the performance of Greek balances,[8] and it is clear that "friction" (or pivot resistance) was not realised to be as significant a cause of inaccuracy as it appears to have been.

The other sections relevant to the balance are more impressive. The detailed description of the "bismar", one-pan balance with variable suspension points, §20, has been already discussed above in ch.I. It contains no serious misconceptions, though it is noticeable that the writer has constant recourse to the presumably more familiar two-pan balance (as also to the lever). Weighing with the "bismar" is described as measuremental and involves the levelling of the balance beam: for example 854 a 1ff. ὥστε γιγνώσκειν, ὅταν ὀρθὴ ἡ φαλαγξ ἦ, ἀπο ποιου σπαρτιου ποσον βαρος ἐχει ἡ πλαστιγξ. Such implications cannot be drawn from the other references to the balance in this treatise which concentrate upon its behaviour.

§2 (850 a 3-29) concerns indeed the behaviour of two sorts of balance-beam suspensions. The writer correctly explains the stability of a beam suspended from a point above its centre of gravity, and the instability of that supported from below. That he was arguing from the observed behaviour of actual balances is very clear from his statement that the beam supported from below would stay where it was depressed and not swing back to level. In fact a simple lever would continue turning till it fell off its pivot, and a balance-beam until it became one of the stable sort (after revolving through 180°) if it could move thus freely. A suspension cord tied around the

beam would in the case of the Greek balance here being described prevent such movement (though an axle suspension could, ordinarily, permit movement through 90°, and, if modified, the full 180°). Yet more important however is the fact that this cord was nevertheless slack enough to allow the writer to observe even the difference he does.[9] I have already noted that this passage indicates that both sorts of beam suspension were in use for actual balances in the third century B.C.

Of Euclid (Alexandria: floruit c. 300 B.C.) little can now be retrieved, although the indications are that he wrote quite extensively on balances and weighing. An Arabic text entitled "Euclid on the balance" shows if genuine[10] that Euclid was interested in the horizontal position of the properly-balanced beam (though no pointer seems mentioned for the careful observation of this in practice); the text is also concerned with the equality of arm-length of two-pan balances and pursues the ratios of variable pivot points. This is also found in two further works attributed to Euclid: "On the light and heavy" and "On weights". But there is no indication in any of this that the subject was anything but theoretical mathematics. No examples of practical balance-types survive; or of the application of the theory to single-pan steelyards.

Whether Archimedes of Syracuse (280's-212 B.C.) was really excited by weighing machines, and was inspired by the Charistion into remarking something along the lines of "give me a place to stand and I shall move the earth", has already been discussed and doubted.[11] The general impression, derived from extant works by this mathematical genius, is that he did not really take seriously the mechanical problems tradition has associated with him.[12] Nevertheless there are scattered references in these works, and also in one or two later writers, that show clearly that Archimedes by the later third century B.C. had considerable understanding of some aspects of the theory of weighing.

First, he was interested in leverage, and investigated the relationship between distance and weight in terms of a balance. Compare the postulates at the start to Equilibr. I and the later propositions in I.6-7.[13] Heron of Alexandria cites Archimedes' lost work "On the lever" for an argument showing that position of pan-suspension was more important than simply

centralised beam suspension of a balance; and Archimedes, again from Heron, seems to have shown the importance of the regularity of a balance-beam.[15] Though the theory involved here is clearly that of single-pan balances with counter-weights, it is interesting to note that there is no evidence that Archimedes was thinking in practice of other than badly-designed two-pan balances.

This seems to hold, secondly, for the use of the principle of the balance in Archimedes' mechanical method for determining the centre of gravity of various figures. See, for example, Method. 2 (for a sphere) καὶ νοείσθω ζυγὸς ὁ ΓΘ, μέσον δὲ αὐτοῦ τὸ Α (ΓΑ being a diameter of the sphere, extended to Θ). The two-pan balance was, as already noted for [Arist.] Mech., a useful illustration (thirdly) of circular motion. That Archimedes used this is again indicated by Heron.[16]

There remains of course (fourthly) Archimedes' celebrated work on specific gravity. The tradition of Hieron's wreath, somewhat surprisingly, begins with Vitruvius (IX Praef. 9-12). A later, and theoretically very different, account is contained in the Latin didactic poem Carmen de ponderibus.[17] In this version the items were measured immersed in water, and calculations made from the differences in these measured weights; modern scholars have improved on this with the reconstruction of sophisticated balances.[18] Vitruvius' account however involves measurement only of the volume of water displaced; the weights are all equal (both the false wreath and its gold and silver reproductions). Dijksterhuis[17] is surely right in rejecting the unlikely authority of the later version, even though it would bring Archimedes closer to the origins of hydrostatics. Similarly, in On Floating Bodies I.5, items said to be weighed in fluids are apparently only compared with each other (equal, or different). There is no indication here that he considered using other than the normal two-pan balance and the only evidence elsewhere in Archimedes is the story of the Charistion.

A fifth comment can however be made here that Archimedes did use the balance to register equal or similar weight. There is evidence that he may even have regarded the point of weighing as to achieve balance with a level beam: he is credited with a work, now lost, called Περι ζυγων or Περι ἰσορροπιων;[19] ἰσορροπος (and ἰσορρεπειν) appear to have meant for Archimedes this position of balance (e.g. Equilibr. I postulates 1 and 2) just as noted for the writer of [Arist.] Mech. and for Euclid.

Vitruvius, writing under Augustus, had naturally a more practical approach. Though he introduced the balance in the now familiar theoretical context of discussion of circular and linear traction, his examples were more direct: at X.iii.4 a detailed description of the Roman steelyard, single-pan with movable counterweight on a marked beam [id autem ex trutinis, quae staterae dicuntur, licet considerare]; and at X.iii.7 the importance of balancing weights carried on poles in the very middle of such poles so that the weight carried is equally divided [maxima pondera ... exanimantur per ipsa media contra phalangarum ...]. There is no reference to the two-pan balance for this latter case; and even the further example, of oxen-yokes, is more closely related to the principle of non-central balances [X.iii.8].

Several examples given by Heron (Alexandria: floruit c. A.D. 62) do however indicate the use of the two-pan balance, and in making no reference to varieties of single-pan machines may serve to underline my suspicion of the general conservatism of the Greek world. The references in Heron to Archimedes have already been noted; no authority is cited for two other problems discussed by Heron at Mech. II.34.C (p.176) and K (p.182). These read very much like the discussions of the Aristotelian corpus both Problems and Mech.; in both Heron's problems the balance is introduced as part of the solution rather than actually being the problem itself; in both two-pan balances are implied.

At Mech. II.34.C the example contrasts two weighing operations. Three minai are balanced, each in one pan of a two-pan balance; to one side 1/2 mina is then added: the pan sinks violently [?]. Secondly ten minai are balanced in each pan; 1/2 mina is again added to one side, but the pan seems only to sink a little [?]. Heron's explanation is that in the first instance a greater (relatively) weight was added than in the second, and that therefore in the second its addition had less effect. This explanation is inadequate for either of the possible phenomena with which the problem is properly concerned. I have been unable to check the Arabic, and the two German versions available[20] confuse the vital issue of whether it is a matter of speed of inclination that varies or simply the fact or extent of such inclination. The proper answer to this problem is inertia, which alone cannot involve a difference in ultimate degree of inclination at rest. The second problem at

Mech. II.34.K seems to involve "friction" (or resistance to torque at point of pivot) increasing with loading. Given the design of Greek balances, especially with suspension cord tied round the beam, the increased resistance from increased load, is likely to be the factor operative here. For a similar problem of interpretation see above [Arist.] Mech. 852 a 23 ff., also Appendix B. The second example is however more important in showing that Heron's balances were basically stable, in that he speaks of their horizontal position as "natural".

These references to weighing derive, as noted above, from basically mechanical or mathematical treatises. Why was no special study written on the balance? One possible reason is that the balance was too commonplace, and it was simply to help understanding that Archimedes introduced such similes into his method as noted above [Method. 2]. Another reason is that Greeks lacked sufficient awareness of other factors (such as inertia, friction and wind interference) to realise their relevance to the balance. Yet they were puzzled by phenomena resulting from such factors (Heron Mech. II.34.C especially); so perhaps we can suggest, thirdly, that they lacked motivation to pursue such puzzles and resolve them; and that the design of Greek weighing machines was sufficient for the purposes to which they were put. Others, however, apart from those Greeks who wrote on theory and with the exception of Archimedes if he built a Charistion, did make modifications. A fifth explanation may therefore lie in the typical resistance of cultured Greeks to practical matters. This makes it very difficult for us to infer from their silence on details of balance design that no Greeks were concerned in such design, or in improving it. I hope however to show below a way of partially resolving this deadlock.

A related problem that arises from the Greek theory considered in this section is why such theoretical writing begins as late as the third century B.C. It is possible that earlier Greek scientists had been concerned with weighing, as with other forms of measuring. Already in the late fifth century such practical investigations were condemned by writers who were not involved in them, such as the slurs of Eur. Ion 1137-9 against οἱ σοφοί, and the joke problem of Ar. Nub. 144f :-

ἀνήρετ' ἄρτι Χαιρεφῶντα Σωκράτης
φύλλαν ὁπόσους ἅλλοιτο τοὺς αὑτῆς πόδας

Socrates in this play was associated with such practical pursuits; is it impossible that they really concerned the elusive historical figure?[21] Later in the fourth century Aristotle is perhaps the clearest example of a practical experimenter: but by the time he came to weighing, doubts can be cast over whether he actually carried out any experiment at all.[22] The medical profession equally were concerned to standardise measures, and were positively involved in weighing.[23] None of these possible contexts have however yielded any known writing on the design, theory, or use of weighing. I think it fair to use this silence to underline the fact that the theoretical writings of the third century B.C. onwards that refer to the balance, were not inspired by the balance, or practical questions in general, but by a development in the direction of theoretical mathematics. Here we should of course distinguish the secondary writers, like Vitruvius, who were more concerned with practical matters.

Nevertheless this survey has established indirect evidence of a definite changed attitude to weighing by the third century B.C. Implied by all the writers considered, is the use of the balance to balance and the fact that this is achieved by a horizontal beam. The general theory of the balance appears to have been modified in the third century B.C. from being based on the simple equal-arm balance to generalised lever-theory which could include both equal-arm balances and variations on the unequal ratios of arms. The former is indicated by [Arist.] Mech. while the later, possibly investigated theoretically by Euclid, was assumed by Archimedes. This observation would seem to imply a growing awareness of, or familiarity with, other balances than the equal-arm type in the third century B.C. But it should be remembered that single-pan balances existed in the late fifth century[24] and were described also by [Arist.] Mech. at the start of the third century; and further that the usual sort of balance used by Greek theoreticians continued to be the two-pan sort (both Archimedes and Heron) despite their more advanced, theoretical positions.

In one or two cases it is indicated that the balance could be used to measure. Thus [Arist.] Mech. 854 a 1ff.; also Vitruvius X.iii.4, whose account of how Archimedes solved the problem of Hieron's wreath involves only measurement of volume. The weighing of items immersed in fluids which is described in Archimedes' On Floating Bodies was as said above, only to note whether lighter / equal to / or heavier than, the fluid. This looks like

returning us to the more basic, practical, use of the balance of earlier Greeks.

Beyond this certain observations on the types and performance of Greek balances have been noted. These are pursued in detail in other chapters.[25] They are certainly the greatest gain from such treatises as [Arist.] Mech. or Heron's Mech. These writers, though understanding the general theory of leverage, were oblivious of such factors as inertia, friction, air interference, or inclination registerment. Most significantly it is clear that developments had been made to balances for practical contexts (for meat or purple-dye selling) independent of theory and possibly ahead of it. None of the theoretical writers suggest improvements to design (such as the pointer), they simply describe one such modification (the "bismar" [Arist.] Mech.), or marvel at another (Archimedes' reaction to the Charistion ?). Several they misunderstand or misinterpret.

2. The Greek concept of weight: the light and the heavy

2. (1) Metaphors

A very common metaphor throughout Greek literature is the heaviness of misfortune or the load of serious matters and the complementary levity of trivia or lightness of happiness: Alcman 37a βαρυδαιμων πολις; Aesch. Pers. 437 δις ἀντισηκωσαι, Eum. 780 βαρυκοτος; Soph. fr.757 της ἀναγκης οὐδεν ἐμβριθεστερον and the whole scene in Ar. Ran. where phrases by Euripides and Aeschylus are weighed against each other.[26] However, although these phrases occasionally occur in contexts which include the use of the balance (as Ar. cited and Soph. El. 120 λυπης ἀντιρροπον ἀχθος), it is not directly from the use of the balance that the metaphor is derived but from more basic concepts of lightness and heaviness. The idea of fortunes, heavy when disastrous or light when felicitous, goes contrary to what I shall show to be the use of the balance to represent fortunes,[27] where both good and bad have weights, the heavier the good the better. The contradiction that exists is parallel to that described in Ar. fr.488 (cited at the heading to this chapter).

However, there is here the clear dichotomy of light/heavy in terms of up and down even if not in a directly comparative (i.e. conjoined) sense. This is the necessary experience of weighing with a two-pan balance (not spring-type where all goes down that has weight) and of being interested in the positions of the pans simply and not the actual weights of the objects weighed. It may be difficult to establish the derivation of ideas of light and heavy from the use of the balance, but even if it was clear how this might be done,[28] the result is not as significant as the question of how closely related was the idea of weight with the use of scales in the historical periods with which I am concerned. With a discussion of the philosophical and scientific theories of weight, I hope to show that the dichotomy of light/heavy is fundamental to the Greek attitude towards weight and that this attitude is based on, and severely limited by, the experience of the use of nothing other than the two-pan balance.

2. (2) The Presocratics

To extricate a theory of weight from the Presocratics is not an easy matter. This is not so much a result of the fragmentary nature of the evidence, awkward though this be, as of the conceptual approach of the philosophers themselves. With no distinction between the sort of existence actual objects have and the qualities they possess, or statements about them, explanation of the physical world necessarily had to include explanation of experience of this world. With access only available through sense-perception, it was in terms of sense-perception that the explanations were expressed whether or not a particular theory subscribed to the immediate validity of sense-perception itself. In other words, the kinds of things we now classify as qualities (formal or relational) were in the main taken by the Presocratics as fundamentals themselves. Of course there were exceptions, and notably the atomism of Democritus, but the greater number of these early physicists treated qualities of things on a level at least equal to the things themselves. Given an object, therefore, several things could be said of it - round, hard, hot, heavy ... - and with no existential difference between, say, the heaviness of the object and the object itself, it is not difficult to see how these qualities themselves appeared more basic. They could be applied to more than the one object, and so appeared closer to the explanation of the physical world than mere objects. In so far as a coherent and logical explanation was the aim, it is easy to understand the attraction of grouping together certain pairs of opposite qualities, and it is in this context, along with hot/cold, hard/soft, etc., that the concept of weight first appears, in terms of light/heavy. Despite one or two attempts to allow for the relative nature of weight, it was still in terms of this dichotomy that Plato inherited the concept.[29]

To Anaximander, in the first half of the sixth century, can probably be attributed the first isolation of these opposites, PP.123 mentions the hot and the cold. The detailed theory that reached Aristotle (PP.120) may be the result of later Peripatetic additions,[30] but Anaximenes' attempt to reduce the number to a single pair, μανοτης and πυκνοτης (PP.146 again hot and cold), shows that, by the later part of the sixth century at least, the group of the opposites was recognised. Heraclitus, who takes us into the fifth century, seems to have accepted opposites while at the same time being aware of the continua the extremes of which some of them at least represented: fr.126

the hot and cold continuum; fr.57 night and day; and, in general, the well-known fr.60 ὁδὸς ἄνω κάτω μία καὶ ὠυτή (PP.203). Unfortunately for our purposes Heraclitus was more interested in explaining change (or explaining as change) and he does not pursue the actual relationships between these opposites. Pythagoras also was possibly aware of there being a continuum between the musical opposites of high and low notes, but chose to emphasise the numerical nature of the subdivisions and extend these, rather than the idea of a continuum.[31] In fact opposites retained a central position in Pythagoreanism[32] and no satisfactory explanation of qualitative distinctions resulted.[33]

Parmenides had a profound effect on the development of these ideas, but not directly. As regards sensible opposites, he saw a difference between the objects of reason and those of sense perception (τα νοητα and τα αἰσθητα) and distinguished the former as only real (τα ὀντα) from the latter (simply δοξα). There are difficulties in understanding what validity he meant to attach to his long description of the "unreal" world of sense-perception, especially after his vehement repudiation of all that "is not" and the cryptic introduction to the description itself, κοσμον ἐμων ἐπεων ἀπατηλον (fr.8 l.52 in PP.353). He gives in fact a somewhat traditional, mechanistic account of the world reduced to two basic opposites, light and darkness,[34] and individual details and testimonia indicate that it is seriously meant as Parmedides' own version. A solution seems to lie in the introduction's problematic:

... μορφας γαρ κατεθεντο δυο γνωμας ὀνομαζειν
των μιαν οὐ χρεων ἐστιν - ἐν ᾧ πεπλανημενοι εἰσιν ...

Parmenides has already indicated that properly only one of a pair of opposites exists, the other "is not" and so is ἀνωνυμον and ἀνοητον (fr.8 l.17 in PP.347). But having followed Kirk and Raven thus far, I am not happy with their explanation that Parmenides is expressing awareness of a difference between the logical incompatibility of opposite qualities and their actual self-implication in sensation.[35] This explanation begs the question of recognition of the opposites' being relative terms, and I can find no justification for this until late in Plato's analysis of the problem.[36] Instead I imagine Parmenides to be simply giving an account of τα αἰσθητα in terms of such αἰσθησις. Perception suggests pairs of opposites where only one should properly be said to be/exist (των μιαν οὐ χρεων ἐστιν). When one remembers that for Parmenides ἐστιν is an ultimate, persisting existence (fr.8 ll.4, 6), it is possible to make sense of his departing from true eternal reality to describe for a moment the here-and-now, temporary world of perception.

Parmenides was in fact I think more interested with the ὀν and μη ὀν issue, and it was left to Plato to tackle the relation of it to αἰσθησις. This was to raise the problem of (incompatible) opposites to a metalinguistic level and will be discussed more fully below when I reach Plato. Meanwhile three further contributions were made to the development of the concept of weight that I shall briefly summarise here. All are attempts at accounting for the sensible world.

Firstly there was the traditional, revivalist approach of Anaxagoras who suggested that everything contained a bit of everything (PP.508, 509). With matter infinitely divisible and composed of all varieties of substances, qualities, shapes etc. that constantly changed their admixture in any particular object (PP.497), this was a development of Heraclitus and approached close to atomism. But Anaxagoras drew no distinction it seems between opposites, such as light and heavy, and actual substances. Such fragments as fr.8 (PP.513) which seem to imply awareness of the continuum from hot to cold etc. do not in fact mean more than that there is a little bit of cold, heavy etc. in hot, light etc. things.

The first real attempt to knock qualities from their traditional basic position in physical theory can probably be attributed to Democritus' atomism. Though the chance approximation to modern theory is universally applauded, the break made from earlier constructions of the physical world out of qualities or even substances (perhaps no more than standing for a group of qualities) is much more important. The way was cleared for an approach to a theory of weight that did not have to consider lightness and heaviness as autonomous entities or counter the linguistic problems raised by Parmenides. Democritus, however, does not seem to have made use of this opportunity. Though his atoms differed in shape and size, there is some doubt as to whether they also had, and differed in, weight. Aristotle (de gen. et corr. 326a9, PP.572) and Theophrastus (de sensu 61, PP.573) agree that they vary in weight as a result of their size, whereas Aetius (1.3.18 in PP.574) explicitly states that Epicurus added βαρος as a third primary quality to Democritus' pair, μεγεθος and σχημα.[37] I cannot follow Kirk and Raven's commentary on this question, but Aetius' subsequent comment (1.12.6, also in PP.574) Δημοκριτος τα πρωτα φησι σωματα ... βαρος μεν οὐκ ἐχειν, κινεισθαι δε κατ' ἀλληλοτυπιαν ἐν τῳ ἀπειρῳ seems to me to suggest that the βαρος he is mentioning is a βαρος that accounts for a certain atomic movement. The theory of primeval, universal downward-fall and the subsequent clinamen is almost certainly Epicurean[38] and requires a special

theory of weight related to downward and uniform motion. There is no reason to suppose that Democritus postulated this, especially when we have Aetius' evidence for Epicurus' being responsible. Equally there is no reason to suppose that Democritus did not think that his atoms had some kind of weight (indeed how else could they differ in weight - according to their size, or how could objects in the world be light and heavy composed of nothing other than atoms and weightless void ?). What I find interesting however is the way this quality of Democritus' atoms is expressed. They have μεγεθος and σχημα, but are βαρυτερον according to their ὑπεροχη [μεγεθους] (Aristotle) or βαρυ και κουφον τω μεγεθει διαιρει Δημοκριτος (Theophr.)[39]. Lighter or heavier, we are no nearer a concept of absolute weight.

Not much need here be said about Protagoras, whose subjectivism came as a somewhat sceptical rejoinder to Parmenides' exposition of τα αἰσθητα. "Man is the measure" can be taken as the assertion that each man's experience on any one occasion is as valid as another's, and brings us back, with the question of truth and reality, closer to the subsequent development of Greek philosophy. Atomism was for the moment a dead end. Little is in fact known of Protagoras' doctrines except as they appear in Plato, and it is impossible to tell to what extent Plato has there adapted them to suit his own purposes. I incline to the view that the detailed exposition is almost entirely Plato's: for one thing, more than one version is presented, and, for another, these versions are specially tailored to Plato's subject. I shall therefore treat the views of the Protagoras when I come to examine Plato's own contribution. Mention of the general Protagorean thesis is however in place in this survey of the Presocratic philosophers in that it illustrates the continuity from Parmenides of the linguistic context in which such physical concepts as light and heavy were considered. The promising alternative on a purely physical level offered by atomism failed partly no doubt because it simply avoided the fashionable philosophical problems that were becoming increasingly linguistic, but equally that light and heavy were not extricated from these problems, is indicative that no real thought had been devoted to the development of an account of absolute weight. To the end of the fifth century lightness and heaviness survived as independent concepts, related as opposites or even comparatives but still distinct. This will be of significance in considering the practice of weighing down to the time of Plato and Aristotle.

2. (3) Plato and the "one and the many" problem

(a) Plato inherited light and heavy along with the whole class of similar incompatible predicates (hot/cold, big/small, good/bad, pleasant/painful, ... true/false, ... is/is not), and the problems associated with them are central to many of his dialogues. The generic name "the one and the many" applied to the group is a little vague, and I shall begin by citing a statement of the problem in Rep. 524a:

> ἀναγκαιον ἐν τοις τοιουτοις αὐτην ψυχην ἀπορειν, τι ποτε σημαινει αὐτη ἡ αἰσθησις το σκληρον εἰπερ το αὐτο και μαλακον λεγει, και ἡ του κουφου και ἡ του βαρους τι το κουφον και το βαρυ εἰ το τε βαρυ κουφον και το κουφον βαρυ σημαινει;

That Plato can give it such a central position here in the education of the philosopher-king, but later refer to it as παιδαριωδη (Philebus 14d τα δεδημευμενα των θαυμαστων περι το ἑν και τα πολλα), must warn us against a consistent account. A second caveat should be the primarily philosophical contexts to be considered, and a third is the difficulty of isolating what Plato understood as the problem. I do not however intend to get too involved in this, and, if the interpretations I offer do not satisfy, I hope that at any rate they are clear enough to indicate the areas from which my conclusions are drawn. Fourthly I am assuming from the frequent occasions of light/heavy as exemplifying the problem of the one and the many that it can be supposed still to be implied as an example when not explicitly mentioned. This assumption is justified in general for my purposes as these rely mainly on the explicit references. At a later stage in his treatment of the problem Plato may have dropped the light/heavy pair; this development will be discussed more fully in the second part of what follows.

Although later involved in the question of meaning and truth, the "one and the many" as a philosophical issue in Plato is grounded on predication, identity and existence. It could be said to arise from a failure to distinguish expressions performing these three functions, and from a consequent attempt to make such a statement as "x is φ" do all three at once (i.e. "x is φ", "x equals φ", and "x is")[40]. What makes Plato so difficult is that it is not always clear which of the three he is distinguishing and which confusing.

(b) Let us take first the puzzle as it appears in Phaedo 102b ff.: Σιμμιαν Σωκρατους φης μειζω εἰναι, Φαιδωνος δε ἐλαττω ... οὐτως ἀρα ὁ Σιμμιας ἐπωνυμιαν ἐχει σμικρος τε και μεγας εἰναι. The problem is basically that of predication, and Plato ("Socrates") gives here his clearest account of his solution in terms of participation in the Forms. This explanation is retained in the Republic where light and heavy, as already mentioned (Rep. 524a), are included alongside the central example, great and small, which is what we found in the Phaedo. The Republic discussion, that runs in all from 523e to 524e, and that of the Phaedo have both reduced what would appear to be clear relative terms[41] to absolutes. This reduction is not simply to make the paradox more attractive, it is intended as a simplification leading to Plato's explanation of the more basic "x is heavy".[42] This is not seen as a relation between x and weight, but as a relation between x and heaviness. X partakes of the Form Heaviness by receiving it into itself and thereby "is heavy" (Phaedo 102e ὡσπερ ἐγω δεξαμενος και ὑπομεινας την σμικροτητα και ἐτι ὢν ὁσπερ εἰμι οὐτος ὁ αὐτος σμικρος εἰμι). The same is true for "x is light".[43]

The main implications of this explanation are twofold. Firstly, that weight was seen as two independent concepts (Platonic Forms) Lightness and Heaviness,[44] and not as a single concept such as could be measured in absolute terms on a single scale. Hot and cold, hard and soft, pleasure and pain etc. similarly, though opposites, are not so by definition, but are in the first place independent entities: hot differing from hard as much as, in the same way as, it differs from cold. Secondly, that this whole picture of participation in the Forms, never wholly abandoned by Plato,[45] is not simply metalinguistic but is meant as an actual description of reality, and in fact the Forms are more "real" than objects of the everyday world.[46] Even though the motivation for the theory may have been philosophical, the result is a physical model that in the matter of weight is based on lightness and heaviness. Only with the distinction between relative (complement-hungry) and non-relative predicates, in the Sophist,[47] and the argument of the Parmenides, that the relations are between objects in the actual world and not Forms,[48] is this picture affected. But the distinction between the "is" of predication and that of existence, implied by these later arguments, serves to remove the picture from any relevance to the real world and the discussion ceases to be of relevance to this chapter.[49]

I should add here that this view of weight in terms of distinct and opposed lightness and heaviness is attributed by Plato to two other attempts at explanation of the "one and the many" problem, namely those he gives to Heraclitus and οἱ ῥεοντες and to Protagoras, when he discusses the problem in the Theaitetus.[50] Οἱ ῥεοντες simply point to the paradox and say it shows everything is changing, that x has changed itself from being heavy in "x is heavier than y" to being light in "x is lighter than z". This is a mechanistic view of physical reality, not a theory of predication; and equally Protagoras' "heavy for me, light for you", with its total denial of objective reality, is concerned with the world as it is.[51] Again that world admits no explanation of lightness in terms of heaviness, but is constructed to preserve the possibility of the dichotomy. Although Plato disposes of both these theories in this dialogue, his reasons are concerned with the problem of distinguishing between knowledge and true/false belief and do not include criticism of the distinct identity of the concepts light and heavy. The problem therefore remained, as Plato acknowledged, one of objects' apparently changing from one thing to another, the change being all the more remarkable when this second thing was its opposite.[52]

(c) A second aspect of the puzzle of the "one and the many" can be illustrated by the dilemma in the Sophist of hunting down the sophist himself. This is first done by a series of dichotomies until he is finally pinned down to being concerned with φαντασττικη, the making of images of what is not the case. The discussion which develops and occupies the central part of the dialogue is to explain how there can be images of what is not the case, how false statements can be meaningful, or more simply τετολμηκεν ὁ λογος οὑτος ὑποθεσθαι το μη ὀν εἰναι (237a). I think it right to see this as yet another version of the "one and the many" problem, as it arises in part from considering existence as a predicate just as the relational predicate "is heavy".

The problems related to incompatible predicates already discussed above have been dismissed by Plato now as not really serious philosophical issues (παιδαριωδη Philebus 14d). This is not that a solution has been found, but that Plato has realised that other, more important, problems underlie the superficial contradictions of the earlier puzzles. Sophist 237b refers to these earlier puzzles but suggests a new direction μη τοινυν ἐριδος ἑνεκα μηδε παιδιας. This I think is generated by the negation implicit in the opposites of the earlier "one and the many" problem, and the isolation of

the ὄν and μη ὄν pair of opposites confirms this particular interest. If so, Plato is concerned here in the Sophist only with the problem of negation (and, as a result, with that of meaningful falsehood), and confusions or terminological difficulties over existence and "is the case" are irrelevant.[53] Importance can therefore be attached to Plato's avoidance of Antisthenes' position that all statements are identity statements (ϑοι νην ὀφιμαϑεσι 251ab) which capitalised on the Greek love for antithesis in demanding that something said not to be "a" must nevertheless be something, namely "~a" or "b". Plato's earlier solution had been to explain "x is φ" by "x partakes in the Form Φ" and he used opposites for negation. In the Sophist he still adheres to this explanation, but modifies negation with the introduction of middle terms το αὐτον and το ἑτερον. The example given of great and small (257bc) recalls the earlier Phaedo passage where the same pair is used. The implications, however, of "x partakes in a Form other than Φ" are vague, but analysis of the theory shows that it only works for incompatibles. Given positive Forms:-

$$\sim\phi x \equiv (\exists \varphi)(x \text{ partakes of } \Phi . \cdot \Phi \text{ is in no sense part of } \Psi)$$

but if negative Forms are to be assumed, so that:-

$$\sim\phi x \equiv \quad , x \text{ partakes of Form } (\sim\Psi),$$

their existence is unattested and an explanation of "~φ" (for example το μη βαρυ) would seem to reduce to the ἑτερον concept again and so incur the earlier criticism. The rather inadequate definition of negation in the Sophist shows how little Plato has moved in this dialogue in fact from his earlier positions, and with what small a class of statements (incompatibles) he is concerned.

The major change from his earlier position and the aspect of the problem first discussed is that Plato is no longer talking about the world as it is, but about statements about the world. The arguments are therefore less relevant than they were for the way Plato in fact regarded this real world. He does not however seem to have greatly altered his position. Participation in the Forms remains, but with the introduction of το ἑτερον the simple opposites are no longer self-implicating, logically, in statements; "x is not heavy" need not imply "x is light" but simply "x is other than heavy".[54] This was necessary in order to establish a foothold for truth and meaning, and it cannot be thought of as affecting the real world. Plato was correctly restricting the claim made by a statement of the form "x is not heavy" in considering the truth of such a claim, and thereby escaping the problem of saying what something, that was not, was.[55] There is nothing here to counter

the conclusions drawn earlier and nothing incompatible with them.[56] Moreover the identity statement issue and the question of mutually implicating opposites, though not followed by Plato, is precisely that posed in the traditional "one and the many" problem, and shows the wide support given it still. Finally it seems that Plato's theory of negation only fits such incompatibles as constituted the "one and the many" problem, and as incompatibles they remain.

Up to this point I have assumed the inclusion of light and heavy in the class of incompatibles under discussion. If this was the case, then in Plato's analysis of the "one and the many" problem no advance was made either towards seeing light and heavy as relative terms or towards connecting them to any overall continuum of absolute weight. As far as this side of Plato's contribution is concerned, lightness and heaviness remain distinct entities. The reality of the Forms would be his indication that this was how he viewed the real world. This is an important and useful conclusion to reach in any case, but it must be admitted that the assumption made at the outset may not be entirely justified for the later dialogues. In the whole of the Sophist, although small/large, one/many, hot/cold are cited in examples, there is no reference as far as I can see, to light/heavy. The same is true of Theaitetus, the Parmenides, and the Politicus, all late dialogues. The question of whether this omission is significant is raised by the fact that there appears in the Timaeus (as the result of a physical model) a clear change from the old view of an absolute dichotomy between light and heavy that is known to have been held by Plato when he wrote the Phaedo and Republic at least. Opinion however varies on the date of the Timaeus. Those who place it in the last group of Plato's writings, with the Laws and Critias,[57] enable my assumption to stand; and the omission, if not then simply chance, can be explained on the grounds that Plato's immediate concern in these dialogues was to settle the problems of the ὄν/μὴ ὄν pair that were basic to the whole class of opposites.

Owen however has argued an earlier date for the Timaeus, assigning it to Plato's middle period and pointing out significant developments from it to the Sophist.[58] This vitiates my assumption, but, as the following discussion of the Timaeus passage will show, the change from an absolute dichotomy between light and heavy that it made goes no further than a recognition of relativity and is primarily concerned with a physical explanation

of light and heavy. To a large extent therefore what has been said of the linguistic treatment of opposites in the Theaitetus and Sophist still holds for the light and the heavy, inasmuch as they are opposites, and the question of my assumption is not really important. Despite the introduction of "otherness", opposites, as I have already said, still remain independent concepts even if their interrelation had been weakened by the removal of self-implication. "X is not heavy" is shown by the Sophist not to imply "x is light".

This last is a most significant result for our purposes as it means, theoretically at least, that one can speak of something being heavy without at one and the same time implying that it is not light. This long overdue departure from the experience of two-scale balances (where the heavy side implies the light) had nonetheless brought Plato no closer to a concept of absolute weight even though it removed one major obstacle. It was an advance made on an entirely linguistic level (the absence of references to light and heavy could now be cited to support this); the more practical approach of the Timaeus is in striking contrast and must now be considered in detail.

2. (4) Plato's revised physical view in the Timaeus

In a long section dealing with the physical basis of sensation (Timaeus 61c - 68d), Plato describes first the tactile sensations, in which group are included pleasure and pain, and then those of taste, smell, sound and colour. It is a completely physical context and contrasts strongly with the linguistic philosophy of the passages already examined in this chapter. The same pairs however recur (in the tactile section) - hot/cold (61d - 62b), hard/soft (62b-c), light/heavy (62c - 63e), and pleasure/pain (64 - 65b). These pairs are noted as opposites (thus το ἐναντιον 62a), but the important point is that they are all, with the exception of light/heavy, defined independently of each other. Thus hot, for example, is sharp and cuts the body while cold compresses and contracts it, this contraction causing trembling. Pain is the violent disturbance of the natural state, pleasure the return to it. In other words, the world reflects very positively the independent existence of these concepts, and it is just this independence that I have shown to underlie Plato's philosophical work on words referring to the real world. Light/heavy however are not so described.

Although the opposites light/heavy are listed with the other pairs, the description that follows is very different and can for the first time be called a physical description of weight. Plato first relates light/heavy to up/down.[59] It is a mistake however, he argues, to think of the world as in fact divided into up and down, for it is spherical and it would be silly to look for an up- or a down-part in a sphere, as a man walking round the sphere also shows.[60] Plato then explains how the pairs up/down and light/heavy occur both in fact and in verbal usage (ὁθεν δε ὠνομασθη ταυτα και ἐν οἱς ὀντα εἰθισμεθα διαιρουμενοι λεγειν 63a). He imagines someone taking a balance and going to weigh differing amounts of the universal fire. At the place where the fire is these amounts are put into the pans which are then moved forcefully away to air. Each piece of fire strains to get back, and, as the greater has more force, it counteracts the pull of the other και το μεν πολυ βαρυ και κατω φερομενον κληθηναι, το δε σμικρον ἐλαφρον και ἀνω. The same thing, Plato says, happens with us in real life, διισταμενοι[61] earth or related matter (γεωδη γενη ... και γην ἐνιοτε αὐτην), we call the greater "heavy" and the lesser "light" (το δε σμικροτερον ῥᾳον του μειζονος βιαζομενος εἰς το ἀνομοιον προτερον συνεπεται· κουφον οὐν αὐτο προσειρηκαμεν, και τον τοπον εἰς ὀν βιαζομεθα, ἀνω, το δ' ἐναντιον τουτοις παθος βαρυ και κατω, 63d). The conclusion of 63e4-7 restates this, retaining the balance context in φερομενον and the μεν/δε of down-and-heavy/up-and-light, but also extending the principle, "tendency towards kindred aggregate", to all things (ἡ μεν προς το συγγενες ὁδος ἑκαστοις οὐσα).[62]

The importance of this passage justifies the detailed description I have given of it. Instead of being incompatible absolutes, light and heavy are here explained as entirely relative. To recognise a "tendency of matter to move towards its kindred aggregate" is the first step towards a concept of weight. It is not however yet to isolate the concept sufficiently to order amounts of differing substances, nor is it a recognition in any way of absolute weight. Theophrastus refers to this definition of heavy by Plato (de Sensu 88) Ἐτι δε το βαρυ και κουφον οὐχ ἁπλως ἀλλ' ἐπι των γεωδων ἀφωρισε. τουτων γαρ δοκει το μεν βαρυ χαλεπως, το δε κουφον ῥᾳον, ἀγεσθαι προς ἀλλοτριον τοπον ...[63]

But Sambursky, who quotes this passage though he does not refer to Plato, is wrong in saying that this is an identification of heaviness with weight.[64] Plato has shown no more than that the terms light and heavy are relative and that they are purely relative. It is not hard to understand therefore why these terms may have been dropped from discussion of the "one and the many" problem.[65]

I want to draw attention however to the model Plato used in the Timaeus to reach this position, and its limitations. Both explicitly (μερη του πυρος ἀφαιρων ἱσταιη τιθεις εἰς πλαστιγγας, αἰρων τον ζυγον και το πυρ ἑλκων ... 63b) and implicitly (ἐπι γαρ γης βεβωτες γεωθη γενη διισταμενοι, και γην ἐνιοτε αὐτην, ἑλκομεν εἰς ἀνομοιον ἀερα βια ... ἀμφοτερα του συγγενους ἀντεχομενα 63c) a balance is used and objects are weighed against each other. Thus: [1] Light and heavy, though relative terms, are purely relative, not absolute, and no closer to being degrees on a single calibrated scale than earlier Platonic theory. The closest to this remains Heraclitus' ὁδος ἀνω κατω μια και ὡυτη and does not appear to have been developed beyond this recognition of relativity. [2] Similar objects (μερη πυρος or parts of earth) are weighed against each other, and the considerable complication of weighing one type of thing against another, with different kindred aggregate, is nowhere envisaged in theory or in practice.[66] [3] The resultant view of weight was another departure by Plato from a long-established traditional view, where light and heavy were distinct (whether self-implicating or, after the Sophist, not necessarily so). It was not to survive for long, however, as I shall now show.

2.(5) Aristotle and De Caelo

Turning from Plato it is disappointing to find that Aristotle reversed the advance of the Timaeus, and reinstated the old dichotomy between heaviness and lightness as absolutes. He recognised that light and heavy could be relative (of two heavy things such as bronze and wood the former is heavier, 311b3-4 by implication). But, claiming that his predecessors had only considered relative heaviness and lightness, he concluded that some things naturally move towards the centre (downwards) while others naturally move away from it (upwards) (308a29-31 et seq.). Aristotle's treatise as a whole (the section in de Caelo runs from 308a - 313b) contains much that is interesting and especially several references to what appears to have been experiments carried out by Aristotle himself.[67] The return to the absolutes lightness and heaviness, however, is not justified by any practical considerations but seems to have been made simply in order to complete Aristotle's total theory of matter as made up out of a combination of

opposites, hot/cold, dry/moist .... . It also betrays a lack of understanding of the philosophical implications of Plato's work.[68] The author of the de Caelo, moreover, cannot have written also the treatise in the Aristotelian Corpus entitled On Mechanics which clearly shows understanding of the mechanical laws of lever and balance and is not circumscribed by the properly Aristotelian theory of heaviness and lightness.[69]

2. (6) The aftermath and conclusions

Nevertheless, despite the Pseudo-Aristotelian treatise On Mechanics, and despite the earlier work of Democritus, the completeness of Aristotle's system secured for it general and lasting acceptance. The theory of opposites continued its existence only briefly affected by Archimedes almost to the beginning of modern science. "Before Archimedes Greek physics had for nearly four hundred years been unable to free itself, despite all efforts, from the vicious circle of "heavy" and "light", because of its inability to define specific weight. But even the discoveries made by Archimedes through this new concept could not entirely do away with the absolute antithesis of heavy and light" (Sambursky).[70]

This is well put by Sambursky, and I think it is possible to venture in addition an explanation of this "inability to define specific weight". There are two sorts of reasons relevant, one group philosophical, the other concerned with the actual practice of weighing as carried on by the Greeks and the apparatus they had available. To anticipate the general picture I hope to establish,[71] the almost invariable Greek practice was to weigh to compare not to measure (in terms of weight) and metaphors confirm the representations in art we have of this being done. With few exceptions, all balances down to the time of [Arist.] Mech. consisted of two pans and a beam, that was suspended from its centre. With such a machine heaviness necessarily involved lightness, as one side down meant the other went up. Interest moreover seems to have been focused more on the inclination of the beam than on its being level; and the inclined beam of a balance, combined with the motion required to reach that inclination, is a graphic justification of the Greeks' feeling that lightness and heaviness were different things. They had no means of direct access to any third scale, no means of weighing that did not

involve comparison. Without wishing to claim priority for either the terms light and heavy or the Greek use of a two-pan balance, I think that there is good reason to suppose that the development of a theory of absolute, or "specific", weight was limited, impeded,if not blocked,by the practical Greek experience of weighing.[72]

But it was equally limited by the philosophical approach to the problem. Bad reasons, such as the attractiveness of the "one and the many" puzzles and the wish of Aristotle for a complete system of opposites, which are popularly taken as examples of the stranglehold metaphysics or unrelated theorising had on Greek science in general,[73] need not obscure the more legitimate ones. The regarding of statements of the form "x is φ" as identity statements (Antisthenes) or at least as expressing a direct relation between x and Form Φ (Plato) as well as the alternatives of Heraclitus and Protagoras in the Theaitetus, are far from superficial attempts to come to terms with the real world. Similarly the problem of negation is a physical one. If there was no actual opposite to hand, it was difficult to explain "x is not φ" except as "x is (~φ)" which risked, until the Sophist, the problem of attributing existence to the non-existent and encouraged the philosophical retreat from the real world (Parmenides onwards). Finally, the confusion that there was between the existence of an object and of qualities that object had, although perhaps not felt by Plato and Aristotle, had certainly before them greatly impeded understanding of such concepts as light and heavy, and no doubt the confusion continued in less informed circles well into the fourth century. There is no evidence in the Greek language of any attempt to remove, or awareness of, the ambiguities of ἐστιν.

Fourth-century theory had developed from an earlier approach to problems raised by the real world and even if the emphasis was changed, and perhaps critically so for the further development of Greek science,[74] the gulf between philosophical arithmetic, measuring and weighing and commercial or everyday was one caused by differing objects and aims (ἐπι or κατα), not techniques.[75] As philosophical models show (the weighing of fire in the Theaitetus, or of pleasure and pain in the Protagoras), the techniques are common to the philosophical and to the everyday world. No amount of practical experience with two-pan balances will lead to a theory of absolute weight. It is therefore my opinion that, though clearly both practical and some philosophical considerations limited the development of any such theory, at least up to the period I have examined here (late fourth century), it was

practice that formed the most crucial block to this development, while philosophy (in Plato's Sophist and Timaeus and the work of Democritus) attempted a way round it.

This question has led me outside the immediate context of this chapter although it is of the first importance for an evaluation of the results I am hoping to assemble. For the present therefore I shall briefly restate the direct evidence from Greek literature and philosophy about weight. Essentially the Greeks thought of it in terms of the dichotomy light and heavy. There is no reliable evidence of an awareness of the concept of absolute, or "specific", weight, and if the terms light and heavy were thought of other than as absolute opposites it was as purely relative expressions, the one always implying the other. The physical model behind all this was that of the two-pan balance, and of weighing to compare or distinguish, almost invariably with like set against like. There is no evidence of weighing to measure weight, indeed the foregoing analysis has tended to indicate a lack of awareness of this process. Though it would be rash to suggest that Greek philosophical interest in the dichotomy light/heavy derived from the use of this type of balance, it seems certain to me that the subsequent development of Greek theories of weight, or rather lack of any real development, was critically limited by its use.[76] This conclusion holds for literary metaphors of lightness and heaviness and for the scientific writings of Greek philosophers and physicists. Though the early Presocratics are perhaps often difficult to interpret, the most developed and most detailed evidence of the later period, the fourth century, offers only confirmation and is all the more striking an indication of the total unawareness by the Greeks of the concept of absolute weight and the practice of measuring it.

3. Allegory

3(1) Dramatis Personae

It is interesting to begin with a list of the various deities and personified ideas with which the ancient Greeks associated the balance in one form or another. The list is remarkably long, but as will be seen not particularly consistent. Its usefulness in the present context is therefore restricted, and a more helpful approach will emerge by considering the same evidence, classified under various metaphorical contexts, 3(2), and thence under aspects of weighing more generally, 3(3). The problems of reconciling the surely incompatible balance hierarchy, and of precisely determining the symbolism in the light of this hierarchy, have generated a mass of modern scholarship to which I shall only briefly refer here. The more direct approach I adopt subsequently, by considering simply the balance, its contents and operation, has no need to draw upon this literature.

Ares. ταλαντουχος Aesch. Ag. 439. Though the context is neutral (the Trojan war in general), Aeschylus' earlier epithet for Ares (Ag. 438 χρυσαμοιβος σωματων) may indicate that the weighing is comparable to the ransoming of Hector and Achilles' bodies rather than the tides of battle (Aesch. is known to have portrayed on stage the former in the Phrygians[77] Schol. Ariston. A. Hom. Il. 22.351; Hesych. s.v. ἀντιρροπον; though no god was involved apparently). More likely however, (as Ares has a balance nowhere else)[78] is simple personification of war (ἀρης): more usually Zeus (q.v.) operates the balance in such contexts, though Poseidon (q.v.) may be tentatively associated in a comparable metaphor.

Athena. Despite the epithet σταθμια (Hesych. s.v.),[79] Athena's only relation to the balance is as a bystander to the κηροστασια between Hector and Achilles in Homer Il. 22.202-223. In later pictorial representations her place is taken by Thetis (a result of the Αἰθιοπις or Aeschylus' trilogy Memnon-Psychostasia-[?]: see Plut. Mor 16F-17A). Although Athena comes close to playing the part of Justice in Aesch. Eum. there is no reference to a balance being used (all is done by voting: Athena's the casting vote; the metaphor at 1.888 is not significant).

Dike. "The balance of justice", appearing as in Bacchylides 16.24ff. [ὅ τι ... Δικας ῥεπει ταλαντον (apparently ῥεπει governed by ταλαντον with ὅ τι its object)] is a doubtful personification and has no explicit parallel as the comparable Διὸς ἱρὰ τάλαντα of Il. 16.658. Justice and Zeus are closely linked in this way cf. Diotimos ap. Anth. Pal. VI.267 οὐ γαρ ἀμαυρως ἐκ Διος ἰϑειης οἰδε ταλαντα δικης; and the lines at Aesch. Ag. 250f. Δικα δε τοις μεν παϑουσιν μαϑειν ἐπιρρεπει should probably incorporate Zeus from l.177.[80] Justice is alone however at Aesch. Cho. 61f. The problem of the relationship between justice and the balance is discussed in VI.3(2).iii below. The first Greek representation I know is of "Dikaiosyne" on a Seleucid weight probably first-century A.D.[81]

Dionysos. The weighing scene in Ar. Ran. 1378ff. is of course conducted by Dionysos.[82] The implications can be tortuous. The scene is most straightforwardly a pun both on the use of weight as a criterion to judge style and metre (cf. l.797 etc.), but no less in the ways the lines of Aeschylus and Euripides are actually compared. It could also be seen as a parody of Aeschylus' lost play Psychostasia, in which a balance appeared on stage (Poll. 4.130 and Plut. Mor. 16F-17A), or of another lost play Phrygians [var. The Ransom of Hector], in which again weighing was conducted on stage (Schol. Iliad 22.351).[83] At another level the scene has been argued to be a parody of the idea of underworld judgment,[84] or of Egyptianising ideas of the underworld popular in contemporary Eleusis.[85] As I shall show later, it is difficult to square the usual Greek use of the balance as a symbol with post-mortem judgment. In Aristophanes' play Aeakos and Pluto are involved (where only Minos (q.v.) is otherwise associated with the balance by Greeks) and the props, including the balance and the idea of using it for a competition, are Pluto's (cf. esp. l.784ff.). This in itself should be sufficient to secure Dionysos' dissociation, though the whole scene does everything to dispel the notion that Dionysos was acting in a normal context. Despite the presence of a balance in certain Cottabos variations (see ch.VII.2.(13)), and despite the importance Greeks attached to inclined or unstable balances, I can find no connection made between them and drunkenness.

[Eris. In the fourth century A.D. Quintus of Smyrna wrote of Eris holding the balance for Achilles v. Memnon (2.540ff.). The development is comparable to the much earlier appearance of Eros (q.v.) holding balances to decide love contests, but the idea has no Greek antecedents.]

Eros and Erotes. Although without literary backing, the presence of a winged figure holding a balance, or of small winged figures in the pans of a balance, is well attested on Greek vases, and forms the only element of scholarly agreement over the Boston "Throne". These representations are collected in ch.I.1.(2).Reps.E- . The most direct and natural interpretation, which I accept, is that Eros simply indicates the subject matter - love, the scales the deciding between two people, the Erotes representing suitors, just like their armoured counterparts in a life-death κηροστασια represent the opposed warriors (cf.Eris q.v. in κηροστασια of warriors, though Roman and late).

Hermes. In Homer's version Hermes accompanied Priam towards Achilles' tent in order to buy back Hector's body with gold, but let Priam meet Achilles alone (Il. 24.460-7). This is clear, and even though Aeschylus and others (e.g. Lycophron 269-272 with scholiast) misinterpreted the weighing involved (Il. 22.351 οὐδ' εἴ κέν σ' αὐτὸν χρυσῷ ἐρύσασθαι ἀνώγοι | Δαρδανίδης Πρίαμος with scholiast), it seems to me wrong to identify Hermes amongst those shown on subsequent representations of the scene (see above ch.I.1.(2)Reps.H-). There are no identifying features to support this.

There can be no doubt however from the presence of caduceus, petasos, and/or winged sandals that the figure most commonly depicted as holding the balance in κηροστασιαι is Hermes. Of Reps. in ch.I.1.(2), P.1 alone shows Zeus holding the scales. The change from Homer, where only Zeus is associated with the balance, is remarkable, and cannot derive from Aeschylus' Psychostasia where Zeus apparently remained the central figure (Il. 8.69-72, 22.209-212 cf., for Aeschylus, Plut. Mor. 16F-17A πλαστιγγος του Διος and less clearly Poll. 4.130 mentioning ὁ Ζευς και οἱ περι αὐτον). As most identifiable κηροστασιαι appear to be between Achilles and Memnon (rather than Achilles and Hector, as Homer Il. 22.209-12) the origin of Hermes' involvement may be the lost Αἰθιοπις. But this argument is complicated by the fact that Eos seems identifiable on P.1, which therefore shows Zeus weighing the κηρες of Achilles and Memnon (at a later stage Eris (q.v.) took Hermes' part).

I can find no connection between the balance and those aspects of Hermes related to commerce (Ἑρμης ἐμπολαιος and παλιγκαπηλος Ar. Plut. 1155-6; Pouilloux Recherches I (1954) p.406 on no.153 and ibid. II on no.194; IG XII.402). These are more probably derived from the travel commerce necessitated, or the meeting with strangers.

Kairos. The symbolism of Kairos as a youth with razor and balance may date from Lysippos' statue in the fourth century B.C., or may well be a later development. See refs ch.I.1(2) K- and discussion later in this chapter of the possible association of balance and razor (VI.4.(1)). The connection seems to lie with the idea of see-saw unstable balance, and ἀκμή, and I reject the view that the balance here symbolises the moment of a person's death just as in κηροστασιαι;[87] Kairos' involvement with Nemesis and Metanoia seem to lie beyond the chronological limits of this enquiry.

Minos. This semi-legendary king of Crete appears in Od. 11.568-72 as legislating (θεμιστεύοντα) in the underworld for the shadowy souls of the departed and answering their queries with judgments (δικαι). On these two words cf. Od. 2.68 and Stanford's note, suggesting δίκη means the way or fashion of applying and distinguishing between (κρίνειν) various rulings (θέμιστες). Comparable therefore is the reference in third-century B.C. Herodas 2.90 f. to an accurate distinction: ταυτα τρυτανη Μινως οὐκ ἀν δικαζων βελτιον διητησε. This is the earliest Greek reference I can find to the balance used by Minos (though his function is specially to distinguish opposing embassies in Plato Gorgias 524A); and the only other reference I know to a balance in the underworld is Pluto's (q.v.) of Ar. Ran.. Whatever this latter's function, it is important to recognise that underworld administration concerned only the shadowy dead. I shall briefly consider the underworld as a whole below VI.3(2) iv. Herodas' reference is to the accuracy with which distinctions can be made with a balance: see below on whether "justice" involved any more than this (VI.3(2) iii).

Pluto. His owning a balance has already been noted from Ar. Ran. (above s.v. Dionysos). I can find no evidence for its other uses. The competition in that play is for sitting on a throne at Pluto's side (760ff.), and though Aeschylus' victory leads to his returning to his city this is simply to give advice (1500ff.) and the throne awaits his return (1515ff.). It would be wrong to suppose a possible metempsychosis.[88] Further the competition is not decided solely by the balance, indeed Dionysos refuses to judge by it at 1411 and another test follows. No other judges in the underworld are associated with a balance: longest list in Plato Apol. 41A adds Aeakos, Rhadamanthus, and Triptolemos. Again see below VI.3(2) iv.

Poseidon. At Il. 14.510 Poseidon "turns the tide of battle" or "tilts the scales" against the Trojans while Zeus is asleep. No balance is mentioned though the metaphor might be comparable to earlier Il. 8.69ff. when Zeus used a balance and the Achaeans' lot sank. For a bridge between the metaphor and weighing operation cf. Il. 19.223 .

Zeus. Zeus is the individual deity most frequently, and variously, associated with a balance. As already noted he holds the scales for κηροστασιαι in Homer (Il. 8.69-72, 22.209-12 and cf. 16.658) even though pictorial representation tended to assign this part to Hermes (q.v. above). Related, if not identical, is the occasion when he turns the tide of battle: Il. 19.223f. ἐπὴν κλίνῃσι τάλαντα | Ζεύς, ὅς τ' ἀνθρώπων ταμίης πολέμοιο τέτυκται (cf. also Nonn. D.2.553).

The balance is associated with Zeus as Justice: Hom. hymn Merc. 324; Cercidas 4.33; Diotimos Anth.Pal. VI.267; Aesch. Ag. 250f. taken with 177. (See below VI.3(2) iii). But otherwise for general decisions: Aesch. Suppl. 822f.; and for general dealing-out of fortunes: Theognis 155-8; Aesch. Suppl. 402f. Again these individual references will be picked out below; they are essentially extensions of the κηροστασια-association and the Greek view of human destiny.

At this point can be included references to unspecified θεος, δαιμων, or θεοι, invariably altering the inclination of the balance of destiny: Bacchylides 16.25 μοιρα ἐκ θεων Δικας ῥεπει ταλαντον; Aesch. Persae 346; Sophocles fr.576; Eur. Hecuba 57f. ἀντισηκώσας δέ σε | φθείρει θεῶν τις τῆς πάροιθ' εὐπραξίας; and even Xen. Hell. VI.iv.23.

I have excluded, and shall not pursue, the disputed identification of all assistants and/or bystanders to pictorial representation of ψυχοστασιαι/κηροστασιαι. Though Aphrodite began as such, she was to wield a balance in her own right as Venus Verticordia (see Rep.II.VI). Dike I postpone to a separate section below (VI.3(2) iii) as Kairos (VI.4(1)) and the Afterlife (VI.3(2) iv).

3(2): Human Destiny, Justice and the Afterlife

Next I propose to consider the commonest literary context in which the balance appears, that of human destiny. To a great extent the balance in this context is as allegorical (or metaphysical ?) as the figures listed in the last section. I shall not attempt to draw any line however between this level and the metaphorical.[89] For our purposes it is sufficient to note what aspects of the balance are used in this context. From this, and from the more general metaphors, inferences can be drawn of normal Greek experience of the balance.

Just as the Greeks were not always consistent over what deities were associated with the balance and detailed analysis is highly likely to be misconceived, so it is not immediately obvious how to classify the various aspects of the destiny of men to which the balance is applied, and equally is probable that no definite classification can legitimately be urged. Because my interest lies in the practical implications of the balance allegory, I shall proceed by arranging references according to what might be supposed to lie in the balance pans.[90] The order in which these following categories occur is roughly chronological: life/death; good/bad fortune; justice; afterlife. It may be possible to suggest a development (especially with the awkward infusion of non-Greek ideas in the last section) but I do not wish to insist on this. The origins of most categories can after all be found in Homer.

i - Balance of Life and Death

Perhaps the Greeks would simply write of the "balance of death" in contrast to that "of life" (Soph. fr.576). This ever-changing balance will be the second general category; for the present I am concerned with the balance used by a single inclination to decide an issue. Most simply the stakes are life or death, but the idea is easily transposed into love affairs, and legal decisions.

[A] One person weighed against another - or a symbol of a person. This is the fundamental κηροστασια, for individual duels (Il. 22.209-12; Aesch. Psychostasia ap. Plut. Mor. 16F-17A; and all Reps. P-), or for contests between whole armies (Il. 8.69-72).[91] It is applied to love affairs, no less unhappily, to judge by the loser's expression on the Boston "Throne" EE.1: see other Reps.E- though as already noted above under Eros (q.v.) there are no literary references. The symbolism is simple and decisive: down signifying Hades and death, up the more favourable alternative. The same seems to apply to Erotostasiai. Aristophanes fr.488 noted the illogicality (cited at the head of this chapter).

The idea is easily applied to opposing forces in a war: thus Isoc. 12.50 on sea battles as the ῥοπη of the Peloponnesian War. ῥοπη however though always decisive[92] need not be used of the balance of life-death, and more often appears with changing fortunes (ii following). In Soph. OC 1508 however, ῥοπη βιου is used of an individual, meaning his death. It may therefore be that the idea of life-death contests can be seen as also
[B] restricted to an individual, with only the movement (up and down) of one pan emphasised, though its relation to the other is implied. This is a modification, rather than a fundamentally different concept. Compare quite simply the view that θανατος is a "heavy" word, decisively sinking the pan, in Ar. Ran. 1392ff.

While the notion of using a balance to decide an issue between parties was certainly applied to legal decisions (for example between πρεσβεῖα, taking (perhaps not unfairly) Herodas 2.90f. with Plato Gorgias 524A), it is not clear which side "won". Aristophanes' joke (fr.488) throws the matter wide open. This will be pursued below under Justice which is related. Note however that though Zeus (admirably) consulted his scales to find out the result, at other times Greek gods were not averse to influencing the inclination of the balance themselves (perhaps Poseidon at Il. 14.510 see above Poseidon (q.v.)).

ii - Balance of fortunes (or "of life" Soph. fr.576). In this the pans represent one the good, the other the bad events, actions or fortunes of a single individual. The balance is thought of as constantly representing, or dictating, such aspects of a person's life; it is not simply consulted on a certain occasion, and usually a contrary inclination is not decisive.

[A] Most usual is the application of this balance to the overall fortunes of a person's life: e.g. Men. Mon.[93] 465 ῥοπη ὁτιν ἡμων ὁ βιος, ὡσπερ ζυγος; Soph. fr.576 -

> ὁταν δε δαιμων ἀνδρος εὐτυχους το πριν
> πλαστιγγ' ἐρεισῃ του βιου παλιρροπον
> τα πολλα φρουδα και καλως εἰρημενα.

This is exactly what is behind the notion of περιπετεια, so central to Greek tragedy and a straightforward description of the balance allegory we are discussing.[94] Such changes are attributed to several causes: most commonly it is Zeus' or another god's whim (Theognis 155-8; Soph. fr.576; Aesch. Persae 345-6; Suppl. 402-6, 822f.; Eur. Hec. 57f.; Rhian. 1.2 θεων ἑτερορροπα δωρα);

alternatively a mortal could be sufficiently powerful to inspire the same idea (as Hieron of Syracuse in Pind. Pyth. I.75); or again "chance" τυχη (though τυχη in Aesch. Persae 346 is "outcome", see for "chance" Bacchylides 9.47 πα τυχα βριθει). The changes can be dictated by chance or by considerations of proper justice (Aesch. Ag. 250f.); the balance itself does not operate as a symbol of these ideas - its tipping is neither a matter of chance, nor said to be particularly just or precise: those altering it can act from these considerations, using force or simply adding to one pan or the other.

The allegory is suitable because it enables a description of the overall state of good or bad fortune even where elements of both are present.

[B] Individual events etc. are added into the respective pans: cf. Dem. I.10; Aristotle NE 1101 a 29; but the clearest example is the extension of the idea into

[C] the operation of the hedonistic calculus esp. Plato Protag. 356B, also Rep. 550E. Instead of only actualities, potential good and bad is now compared with present and with themselves - in three operations. First, present pleasure is weighed against future pleasure; then present pain against future; then the greater of each of these pairs is weighed against the other, and action taken if future pleasure is what here preponderates. The simplicity is of course in practice illusory, just as the balance is entirely allegorical. The possible calculation is dropped at later Laws V.733A-734D but the metaphor of the balance, and the principle remains: an ἰσορροπος βιος is not ideal (733C-D see VI 4(3), 5(3)), the description of health is of a state where pleasures outweigh the pains (ὑπερβάλλουσι), and the general principle for action (or choice of life to lead) is to achieve the preponderance of pleasure.

[D] Another application of the balance is in describing the course of a disease, health being but a specialised part of the whole of an individual's fortunes, or more specifically health looked at in particular rather as the hedonistic calculus. A general example is Plato Laws 734B-C already mentioned above: ταὐτὰ δὲ περὶ νοσώδους τε καὶ ὑγιεινοῦ βίου διανοητέον, ὡς ἔχουσι μὲν ἡδονὰς καὶ λύπας, ὑπερβάλλουσι δὲ ἡδοναὶ μὲν λύπας ἐν ὑγιείᾳ, λῦπαι δὲ ἡδονὰς ἐν νόσοις. More specifically Plato Rep. 556E σῶμα νοσῶδες μικρᾶς ῥοπῆς ἔξωθεν δεῖται προσλαβέσθαι πρὸς τὸ κάμνειν. It is not necessarily this balance however that is behind the Hippocratic description of the κλιμαξ after which the patient can recover or relapse (ἑτερροπος Hipp. Art. 43): a see-saw configuration would possibly be a better interpretation (see below VI.4) especially as the moment is so decisive.

For the same reason I would hesitate to suggest καιρος as relevant here: [E] (and see further below VI.4(1)). Nevertheless περιπετειαι can be decisive. As already remarked the subject of a balance allegory can be vulnerable to any set-back: this is one interpretation of Thuc. V 103.2 where the Melians are said to be ἀσθενεις και ἐπι ῥοπης μιας ὀντες, i.e. unable to recover from a single set-back. Thus P.A.Brunt in Thucydides (New English Library 1966) "a single turn of the scale may be your ruin"; rather than the possible alternative "with only one possible future (i.e. disaster)" on the analogy of the usual two possibilities in any uncertain moment cf. Eur. Helen 1090 μέγας γὰρ ἀγών, καὶ βλέπω δύο ῥοπάς either death or return home. Andrewes and Dover HCT IV offer no comment on the Thucydidean passage . Without the possibility of an alternative outcome, the balance the Melians are involved with approaches that of life-death [type i above]. But the Athenians should then occupy the other side, and so also be vulnerable. The Melians perhaps hoped for this (V.102), but the Athenians reject the idea. For this reason, with some hesitation, I prefer to take the passage in this present context. A second set-back coming after partial recovery from the first may be the right interpretation of Aesch. Persae 436-7:

τοιάδ' ἐπ' αὐτοῖς ἦλθε συμφορὰ πάθους,
ὡς τοῖσδε καὶ δὶς ἀντισηκῶσαι ῥοπῇ.

In conclusion to these two balance allegories, and moving beyond attempts to keep them apart, we can note those aspects of the balance most emphasised. These are the distinction between up and down and the decisiveness of the distinction. The unhappy indecisiveness of equilibrium is manifest (Plato Laws 733C-D; Aesch. Suppl. 402-6), it is certainly not stable (Eur.Helen 1090). The relevance of these allegories to actual weighing is most directly indicated by the straightforward simile introducing Plato's hedonistic calculus at Protag. 356A-B ὥσπερ ἀγαθὸς ἱστάναι ἄνθρωπος. This will in particular be reconsidered below (VI.6).

iii - Justice and the balance

Dike appears only incidentally associated with the balance in Greek literature. There are no pictorial representations to my knowledge till the first-century A.D. Seleucid weight, in fact of "δικαιοσυνη" (see ch.I.1.(2) Rep.U.VII.(1)). Yet the context of Justice is perhaps the most familiar for the balance today. The origins and development of the modern symbol will be discussed later but its interpretation is briefly reviewed at the end of this section in contrast to the Greek.

It is impossible to attempt to pin down precisely such aspects of justice as are associated with the balance by Greeks on particular occasions. The idea itself underwent considerable changes, or could adopt several forms.[95] At one extreme it was no more than the distinguishing of rival or competing parties or principles (δικη and δικαζειν as suggested above for Minos (q.v.) in Od. 11.568-72); but equally the moral absolute element of δικαιοσυνη was separated from the relative (Arist. NE V.1129a26 and 30a12). When it comes to the balance (metaphor, allegory etc.) Dike occupies several positions: (a) procedural: the use of the balance to distinguish is related to Δικη, or rather δικαζειν, in Herodas 2.90 f. ταυτα τρυτανη Μινως οὐκ ἀν δικαζων βελτιον διητησε; (b) as a contributing factor in the balance of fortune Dike can counteract (or is it not compensate for ?) an adverse inclination of the balance: Aesch. Ag. 250f. Δικα δε τοις μεν παθουσιν μαθειν ἐπιρρεπει (c) Mention of Dike can further describe the manner of Zeus' use of the balance of fortune (as εἰκοτῶς in Aesch. Suppl. 402f, and ὀρθος in Cercidas 4.33 (Powell) [Zeus] ὀρθος ὠν ζυγοστατας). This optimistic interpretation of fate and fortune is probably the sense, (d), in which the balances are said to be those of Dike: Bacchylides 16.24 ff.; Aesch. Cho. 61ff. The obscurity of Dike's operations in this last passage reflects surely uncertainty about the relevance of justice. The gods could act perversely simply to delight in upsetting human affairs (Xen. Hell. VI.iv.23 χαιρει); and the balance of fortune could well be inclined unjustly (Aesch. Eum. 888 οὐ τὰν δικαιως τηδ' ἐπιρρεποις πολει). In this sense Δικη reverts to (c) above. However the impartiality of the balance of justice may be noted at Hom h.Merc. 324, and its decisiveness at Diotimos Anth.Pal. VI.267.

While in (a) Δικη relates to the activity of distinguishing with a balance, senses (b)-(d) approach more to an independent judgement on the justness of either operation or effect of the use of the balance. The question of whether something is δικαιον appears here to lie outside and to be independent of the weighing itself. As there is virtually no evidence for supposing Greeks suspected cheating in the operation,[96] the element of justice must lie in the selection of what to put into the pans (their applicability to the individuals concerned), and the justness of the resultant verdict. This reduces the direct connection of Δικη with the balance to very little, and it is significant that Aristotle makes no reference to the balance while searching for means of expressing the idea of justice (especially NE V.1131a10ff.

where ἴσον and μεσον are brought up; but also even in discussion of the view that τὸ δίκαιον is τὸ ἀντιπεπονθός at 1132b21ff.). There is some evidence of use of the balance idea to explain how a moral decision can be reached (thus Plato's simile, introduced by ὥσπερ, at Rep. 550E where πλουτος is weighed against ἀρετη) but the example just cited shows how far removed is the idea of δικαιοσυνη.[97]

There is therefore no firm association of justice with the balance except in the sense of distinguishing. This, as I have agreed, is far from being the limit of the Greek notion of justice any more than it is of the modern. Impartiality and decisiveness have been noted, but the former is not clearly related to the balance (as opposed to the way Δικη uses the balance), and the latter is not necessarily a particular feature of Δικη, though it may be of the balance in question. More particularly there is no evidence that the balance was felt to be a particularly precise and just way of deciding an issue, no evidence of its connection with measurement of just punishment (all Aristotle's procedures are couched in mathematical terms), nor any mention of its being particularly level, or minimally inclined, in the context of justice.

All these elements can be however suggested for modern symbolisation of justice with a balance and with judgment connected with weighing. This symbolism is not absolutely standard, but the female figure, her blindfold, and her sword (all of which can be varied or omitted) are not necessary to interpretation of the balance. The more usual, two-pan balance has been said to symbolise the part justice plays in distinguishing one person's claims from another's (the two sides being represented by the two pans); the balance has since the Greeks been conceived of as a very accurate machine: thus, "if the scale do turn but in the estimation of a hair thou diest".[98] This is the interpretation put upon the "scales of justice" by Daube in a historical study,[99] But though closest to the Greek antecedents, he does not properly consider the alternative, and more likely, interpretations of the modern symbolism.

Consider criminal cases and what might be being distinguished. The prosecution evidence from the accuser's protestations? Truth from falsehood (but if in a single person's testimony who is to decide which parts to set on either pan; otherwise where is the truth?)? In fact distinction need not be the idea at all. Most modern "scales of justice" are shown with the pans level,[100] the beam equal, the pointer present, but hidden by the shears. Usually the whole machine is somewhat clumsily clasped at this point making pan movement impossible and allowance must be made for potential inclination (just as for potential punishment with the sword). A most significant variant is the figure of

justice holding a steelyard (unique to my knowledge) in the west window of New College Chapel . Such representation indicates an equalisation procedure,[101] if not actual measurement. We should compare in this context I suggest: "weighed in the balances and found wanting"[102], and the passage already cited from the Merchant of Venice; further the idea of "weighing the evidence" and "meting out punishment".

The contrast with the earlier and very restricted symbolism of Δικη is largely in the association nowadays of measurement, precision, and detection of very slight deviations (from level rather than from the other side). The idea of comparison and distinction is common to modern and Greek. Surely the idea of justice is no less compatible. The difference in symbolism sharply reflects the difference in modern and Greek experience with, and use of, the balance. In this the Greek, I am arguing here, was very restricted. Clearly the intervening period from the ancient Greeks to the present day has affected the transmission of the symbolism and in particular has allowed in the different notions of other cultures (noteably Egyptian). This I shall review later in ch.IX. My present point can be neatly illustrated by gently contesting Daube's concluding remarks "a statistical laboratory ... is perhaps destined to become the symbol of modern justice in the place of a simple pair of scales".[103] I have disputed his identification of the "either/or" nature of ancient justice; the balance remains the symbol for modern justice but this is because in this highly specialised age few have seen (nor would it be easy to recognise) an electro-balance.[104]

iv - The Afterlife: Psychostasia proper, the judgment of the dead

It is frequently pointed out that the weighing of Il. 8.69-72 and 22.209-12, and illustrated on many pictorial representations of this and related occasions (Reps P-, E-), is properly κηροστασια rather than ψυχοστασια.[105] It is worth remembering that Aeschylus' play (depicting the weighing to decide the contest between Achilles and Memnon) seems to have been entitled Psychostasia (Poll. 4.130; though Plut. at Mor. 16F-17A could conceivably be applying the word to the scene on his own initiative). This said, it is nevertheless convenient to retain the distinction as applied properly to the use of the balance of life/death or fortune (κηροστασια) and to its part in post-mortem judgment (ψυχοστασια). Where the former is, as shown, very common in Greek literature, there is very little evidence for the latter. Certainly it plays no part in orthodox Greek beliefs about the afterlife.[106]

Homer must represent the starting point. Earlier Bronze Age beliefs were demonstrably very different, and did include a developed view of the afterlife with a place for the balance.[107] Significant survivals may be seen in the Cretan background of the Homeric judges of the underworld (Rhadamanthus Od. 4.564; Minos Od. 11.568) and the non-Greek term Elysion (at Od. 4.563).[108] Though there are special places in the Homeric underworld for reward (Elysion itself) and for punishment (Tityos, Tantalos, Sisyphos: Od. 11.576ff.), these rewards and punishments appear to relate only to direct involvement with gods. They are not part of a usual system of post-mortem judgment (though they perhaps indicate the partial survival of such a belief, and later are developed into one). For most humans the afterlife is a shadowy existence, reflecting the same sort of life as on earth. Minos acts as judge in an entirely administrative capacity; he is not judging new arrivals at Od. 11.568-72 (see above s.v. Minos).

A similar part-historical account can be derived from Hesiod Op. 106-175: no prizes or rewards for the fifth generation of men in the afterlife. The belief that life and life alone was what mattered appears central in fifth-century thought. It reflected the values of a society which recognised only the public virtues of greatness. Success, valour, high birth and wealth were criteria for judging a man ἀγαθος, or ἐσθλος, and in fifth-century tragedy it is common to find the idea that retribution (or reward) came in life itself rather than be reserved for some awful reckoning afterwards. When life was completed comment could be passed on whether a man was happy or not (Soph. Trach. 1-3, OT. 1528-30 cf. Solon ap. Hdt. I.86.3); no subsequent judgement and punishment was thought to follow.[109] Corresponding to this view was that of Homer's shadowy (but parallel) afterlife. The balance was an important symbol in illustrating the vicissitudes of life, and was used to decide the issuesof life up to the final one, but not beyond.

Alongside this central Greek conception of the afterlife are traces of variant esoteric beliefs which introduce the relevance of what is done on earth in life to the type of existence afterwards. These may have first reached Greeks in the sixth century, their origins associated with Egypt and Pythagoreanism and connected with other cults such as the Bacchic.[110] Their simplest form, that initiation in a certain cult guaranteed some future happiness in the afterlife, was painted in the mid fifth century into Polygnotos' picture of the underworld in the Lesche at Delphi (Paus. X.28-31 esp. 31.9 τῶν οὐ μεμνημένων and 11 mentioning Eleusis). While this picture showed the traditional punishments of Homeric Hades, and representations of several mythological events, it went much further in showing the punishment of moral crimes (e.g. sacrilege Paus. X.28.4-5-6) and included an allegory of Sloth (29.1-3).

The idea of metempsychosis, a variant on reincarnation, is found in a fragment of Pindar (OCT fr.127; Schroeder fr. 133). After a nine-year period the "penalty of former grief" is paid to Persephone and the soul returns upwards. Attempts have been made to compare the "Boston Relief" (Ch.I .1.(2) Rep. EE.1) by identifying the right-hand figure as Persephone from the pomegranate beside her.[111] The comparison can be no more than a conjecture in the total lack of supporting evidence; further it raises many more problems than it solves: it requires identification of the central winged figure as a very youthful Thanatos rather than the easier Eros; no explanation is given for Aphrodite; but, more relevantly, it is unclear on the most central element in the relief - the balance - who is being weighed, how is distinction (indicated by tilted scales) relevant, and why is Persephone sad if the ποινη πενθεος is paid? There is no corroboration for the balance in any later references to metempsychosis.[112]

Aristophanes may have ridiculed such ideas of Hades as a place of retribution (Ran. esp. 145ff.), but I have already argued that his balance scene is unlikely to have any religious connections with metempsychosis.[113] In the fourth century, however, all these stories about the Underworld suddenly become accepted: Plato Rep. 330D - 331A οἵ τε γὰρ λεγόμενοι μῦθοι περὶ τῶν ἐν Ἅιδου, ὡς τὸν ἐνθάδε ἀδικήσαντα δεῖ ἐκεῖ διδόναι δίκην, καταγελώμενοι τέως ... .
Plato's views are most clearly found at Gorg. 523-6 where all souls are immediately judged on entering the Underworld, naked and stripped of all the deceptive protections of a superficially successful life (523C - 524A). Minos, Rhadamanthys, and Aeakos, mentioned here as judges, are augmented by Triptolemos and others in Apol. 41A. Triptolemos, noted as an Orphic figure, places the idea in its wider context of near-eastern beliefs;[114] and the fate of the uninitiated (ἀμύητοι) at Gorg. 493B recalls Polygnotos' earlier representation of Eleusinian beliefs.[115]

Nowhere in the Platonic descriptions however do we find reference to a balance used in these post-mortem judgments. Thus souls are stripped naked so the judges can see their crimes (Gorg. 524B θεᾶται ἑκάστου τὴν ψυχήν ... κατεῖδεν οὐδὲν ὑγιὲς ὂν τῆς ψυχῆς, ἀλλὰ διαμεμαστιγωμένην καὶ οὐλῶν μεστὴν ὑπὸ ἐπιορκιῶν καὶ ἀδικίας). Even Minos' task of judging between πρεσβεῖα is apparently to find what otherwise was hidden, i.e. again visual (524A Μίνῳ δε πρεσβεῖα δώσω ἐπιδιακρίνειν, ἐαν ἀπορρῆτόν τι τὼ ἑτέρω.). The only reference to balances in Greek esoteric eschatology is the fragmentary χειρὶ τάλαντα in the Orphic Katabasis,[116] and the possible appearance of Persephone in what seems to be a simple Erostasia ("Boston Relief").

The balance played however a central part in Egyptian eschatology:[117] from this area the transmission into Christian iconography can be traced.[118] Given the eastern origins of Orphicism and other esoteric Greek cults, and the popularity of these cults in Greece certainly by the fourth century B.C., it is surprising that

so little evidence exists of the use of the balance (allegorically or symbolically) in this context by Greeks.

To some extent the explanation may be the strength of the earlier Greek balance symbolism - fortunes of life, and deciding between life and death. However it is interesting to note that pictorial representations of this allegory, in the κηροστασιαι, appear to cease during the fifth century.[119] Just at this time the balance begins to be applied instead more popularly in Erotostasiai. By the fourth century, moreover, Greek interest in the tragedy of human destiny had been supplanted by analysis of the individual's position in Society, and of moral values.

I should prefer to relate Greek reluctance to take up the balance as a symbol for post-mortem judgement to the incompatibility of their idea of the balance and of what was required in such a judgement. As already indicated in the last section on Justice, measurement (absolute, or in order to ascertain discrepancy from a fixed standard) was required. In so far as the operation concerned each individual, no comparison applied between one and another.[120] The Greek balance, unstable, wildly inclined, and essentially comparing two pans, was just not suitable.

3.(3) The Constellation Libra

The seventh sign of the zodiac, Libra, is generally explained by the fact that the sun reaches it at the autumnal equinox.[121] It is a clear symbol of equal balance between night and day, marking the midpoint of the whole cycle, which begins at the other, vernal, equinox (for example Vitruvius IX.iii.2). Recently Dicks has shown that the zodiacal divisions, and the ability to recognise equinoxes, cannot be attributed to Greeks till late in the fifth century B.C. at the earliest, and probably for the latter only in the fourth.[122] For the former a Babylonian source is likely, though tradition associates Oinopides of Chios (fl. 450-425 B.C.)and the zodiacal signs and circle were apparently known to Aristotle.[123] It is perhaps striking confirmation of this tradition, and a further argument for the late establishment of equinoxes, that the Greeks did not call any sign "the Balance", but gave to the sign Libra the name αἱ χηλαί (or "the claws"): Achilles Tatius ap. Petavius Uranologion p.168: Aratus 89, 232; Ptol. Tetr. 24 etc. Whether the naming of this sign as the "Balance" be attributed to the Babylonians (zibânîtu cogn. ziba)[124] ortothe Egyptians (as Ach. Tat. cited above) is immaterial for the present point. The change to τὸ Ζυγόν had occurred by the time of Hipparchus (c. 194-120 B.C.).[125]

If, as this argument would indicate, the recognition of equinoxes came only some time after the Greeks first adopted the zodiacal signs, their early alternative "Claws", has itself no significance. The change to "Balance", however, becomes all the clearer recognition symbolically of the autumnal equinox. It would seem that the change was made in the third to second centuries B.C., most probably in Alexandria. Thus while the acceptance of the symbol by Greeks is very late in the period I am reviewing here (and from a time when use of levelled balances can be most easily found), the basis for the symbol might most easily be seen in the Egyptian tradition, in which the level balance beam had played for a long time a central part.[126]

This conclusion is I believe confirmed by a remarkable passage about weather following the equinox in the unfortunately undateable [Arist.] Prob. (XXVI.26 942b25ff.): "Why does rain follow if the south-west wind blows around the time of the equinox (περι ἰσημερίαν)?" The answer involves comparison with a level balance (καθάπερ ἐπὶ τῶν ἰσαζόντων ζυγῶν), on which winter and summer are equally balanced (ἰσοκρατες), so that the addition of either wintry or summery weather will cause the balance to incline; the south-west wind, being wintry, produces an overbalance in favour of winter (ῥοπὴν

χειμῶνος ἐποίησεν). For the present I wish simply to point out that the simile is not invoked to describe the equinox itself (simply ἰσημερια), but for the weather around the equinox.[127] Further the simile is applied to equinoxes generally, or more properly in fact to the vernal equinox (ὅταν συμβῇ τὸν ἥλιον ... ἐκλείπειν τοῦ ἀκριβοῦς ὅρου καὶ εἶναι μᾶλλον ἐν τοῖς χειμερίοις: 942b32), and not to the autumnal. The application of the Balance symbol to the constellation of this (autumnal) equinox would seem therefore to derive from other than the basic Greek weather-lore indicated in this passage.[128]

3.(4) The Apatouria ceremony of μειαγωγεῖν

The enrolment of new phratry members at the Apatouria festival was accompanied by sacrifices of animals. One of these was called μεῖον, its name[13] generally derived from the fact that it was held to be, or found to be, underweight. The idea of a weight test is indicated early by Ar. Ran. 798. Aiakos is describing the various tests to be made to decide between Aeschylus and Euripides, and makes a reference to the weighing of music (a pun on metre: καὶ γὰρ ταλάντῳ μουσικὴ σταθμήσεται) Xanthias reacts

τί δέ; μειαγωγήσουσι τὴν τραγῳδίαν;

No further reference is made to the Apatouria ceremony in the later scene where actual weighing takes place: in fact the comparisons are more generally commercial (τυροπωλῆσαι 1369; ἐριοπωλικῶς 1386). About the same date, late fifth century B.C., Eupolis made a comparison with the ceremony, indicating that it was necessarily the case that the μεῖον, brought forward by the μειαγωγός, was underweight (K.fr.116 cited below VI.6).

Ancient commentators are not consistent in their explanations. Eratosthenes (F.91 Str. ap. Harpocr. s.v. μεῖον καὶ μειαγωγός) refers the comment to disparaging remarks from onlookers and makes no mention of weighing; Apollodorus (FGH 244 F.108 ap. Harpocr. ibid.) says weighing was demanded by phratry members' wanting a larger contribution and claiming (sc. before weighing) the sacrificial offering to be too small. The long scholiast on Ar. Ran. 798 offers various accounts: that it is called μεῖον as found to be underweight on weighing against a certain defined weight, first with a fine for underweight (referring to Ar. fr.286 ἀλλ' εὔχομαι 'γωγ' ἑλκύσαι σε τὸν ζυγόν, ἵνα μή με προσπράττωσι †γραῦν† οἱ φράτερες), second because overweight was not permitted (καὶ οὐκ ἐξὴν μεῖζον παρασχεῖν). The suggestion could be made that the μεῖον applied to the enrolment of children, the κουρεῖον and γαμήλια to young men and women; and the weight of the μεῖον had to be less than these last to symbolise the fact that the child was not yet of age.[129] Thus some sense could be made of the MSS reading γραῦν in Ar. fr.286 if the would-be sacrificer is not presenting a child, but in fact a mature young man (or woman), and is very afraid of being fined for underweight. Alternatively however he could be afraid of going overweight. The stipulation against overweight is somewhat surprising in the light of other comments by the ancient commentators of the phratry trying to make most capital out of the ceremony; could another interpretation be that underweight/overweight symbolised being too young and too old? (cf. ἀώμη and its relation to the balance via kairos below VI.4).

Attractive though these suggestions may appear I do not feel any are justified on the present evidence. The ceremony may involve some allegorical symbolism, but there is nothing to prove this, nor to establish what the symbolism definitely was. All that can justifiably be deduced from the evidence is that weighing took place, that it was comparative (note no reference to equality, esp. in the explanation of μεῖον because οὐκ ἐξην μειζον παρασχειν), and that some standard was used ("fixed" but not defined in metrical terms: schol. Ar. Ran. again ἐδει γαρ αὐτο ἐλαττον ἐχειν σταθμου τινος ὡρισμενου). The ceremony is therefore most relevant to the next chapter that considers practical contexts of actual weighing.[130]

4. Metaphor

The classification adopted between allegory, metaphor, vocabulary and simile breaks down most seriously in metaphors. To avoid excessive repetition I shall relegate a general survey of metaphors to a small concluding part in this section, 4(4), and in the earlier parts consider one central question, best approached from metaphors, that of the equilibrium of a weighing balance. Much confusion has I feel been caused by considering metaphors which are not in fact of the weighing balance. In part this confusion occurred to the Greeks and in the overlap between the see-saw- and weighing- balance metaphors is a possible indication of the principle on which the latter operated (see following 4(1)).

4.(1) ἐπὶ ξυροῦ ἵσταται ἀκμῆς, and Kairos

Variations on the phrase ἐπὶ ξυροῦ ἵσταται ἀκμῆς have been interpreted as reference to some sort of delicately-balanced weighing machine, comparable in principle to the modern chemical balance with its knife-edge pivots.[131] There is little justification for this interpretation. Apart from late representations of Kairos with scales balanced on a razor's edge, there is nothing to indicate that scales were normally associated with the phrase. Even where the idea of balance was involved, which was not invariably the case, the emphasis lay for the Greeks in the instability of such balance rather than in the precise equivalence it might approach in the principle of the modern balance.

The phrase owes its literary origin to Homer. Nestor tells Diomedes that the fate of all the Greeks, either miserable death or life, is set upon a razor's edge: Il. 10.173-4,

> νῦν γὰρ δὴ πάντεσσιν ἐπὶ ξυροῦ ἵσταται ἀκμῆς
> ἢ μάλα λυγρὸς ὄλεθρος Ἀχαιοῖς ἠὲ βιῶναι.

Still in the pre-classical period it recurs in Simonides (97 ap. Plut. Mor. 870 E) and Theognis 557-8:

.... κίνδυνός τοι ἐπὶ ξυρῷ ἵσταται ἀνμῆς
ἄλλοτε πόλλ' ἔξεις ἄλλοτε παυρότερα.

Later it is found with the dramatists (though not with Aeschylus despite his predilection for weighing metaphors) thus Eur. Heracles 630 ὧδ' ἔβητ' ἐπὶ ξυροῦ; (a simple question), and the related Soph. Ant. 996 φρόνει βεβὼς αὖ νῦν ἐπὶ ξυροῦ τύχης.

Hdt. VI.11.2 most closely approaches the Homeric formula,

ἐπι ξυρου γαρ ἀνμης ἐχεται ἡμιν τα πρηγματα ... ἢ εἶναι ἐλευθεροισι ἢ δουλοισι.

Finally note Theocritos 22.6; then Lucian Jup. Trag. 3; Plut. Mor. 234 F; and the proverbial collection Mantissae Proverbiorum 1.55. 56; Apost. 3.50, 6.100; Zenobios 3.47; Diogenianus 4.41. Ancient commentaries on the phrase are given by Eustatius ap. Iliad 10.173 and the scholiast to Soph. Trach. 82.

[I.] These references can immediately be subdivided into two sorts of ideas. First, and apparently earliest, the uncertainty of outcome at a particular moment (esp. Homer and Hdt.). As alternatives are given we should think of some sort of balancing. There is however no suspicion of up and down, so the image is simply the balancing of something (neither see-saw nor weighing machine) on a precarious edge.

[II.] Second, Sophocles and Euripides suggest instability continuing over a long period. If τυχης in Ant. 996 is a gloss on ξυρου, then the general vicissitudes of life seem implied rather than a long-standing particular uncertainty as Homer above. This is clearly indicated by Theognis, where ἄλλοτε ... ἄλλοτε ..., and the comparative παυρότερα, seem fairly straightforward references to the oscillation of something unstably pivoting over the razor's edge. Again however I prefer to find here reference to an object thus oscillating, rather than to the movements up and down of ends, or of pans attached to ends, of such a pivot. The see-saw is involved and there is no reason yet to suppose a balance.

Interpretation of the phrase in terms of knife-edge balances has appeared attractive for a combination of reasons: the modern parallel; the fact that the result is presented as alternatives; the connection with representations of Kairos balancing scales on his razor's edge together with

such phrases as Aristophanes Plutus 256f. ὁ καιρος οὐχι μελλειν ἀλλ' ἐστ' ἐπ' αὐτης της ἀκμης; and finally the fact that ῥοπη in Soph. Trach. 82 ἐν οὖν ῥοπῇ τοιᾷδε κειμένῳ is glossed by the scholiast as ἐν κινδυνῳ και ἐπι ξυρου ἀκμης ἱσταμενῳ. On the contrary, I feel that the explanation given above is quite satisfactory, and that several different ideas and images are being confused in the apparent similarity of these clearly related balance (equipoise) phrases. I shall therefore pursue these related phrases, beginning with the ancient explanations for that which most concerns us here: the razor's edge.

[III.] Eustatius offers an unconvincing but revealing explanation of Homer's image. He rightly notes the danger of the Greek predicament, but associates this with the razor's edge because it was sharp and likely to cut - οἱον ἐπ' αὐτῃ τῃ ὀξυτητι και τομῃ του ξυρου. He compares other phrases involving this same idea - Soph. Ajax 786 ξυρει γαρ ἐν χρῳ τουτο μη χαιρειν τινα. Clearly this interpretation leaves no room for any concept of balance; it is ingenious, but hardly, I feel, convincing for Homer's day at any rate.

[=II.] The Scholiast's gloss on Soph. Trach. 82 is not a firm argument for his understanding a weighing balance. Neither ῥοπη nor the razor's-edge balance need involve here more than the image of a see-saw. This is as argued above. The scholiast registers however the danger implied by the phrase.

[=I.] Other phrases indicate suspension and balance as dangerous without involving weighing metaphors. Eustatius cites ἐκ τριχος ἠρτησθαι, and quotes Theocritos 14.9. Further Diogenianus offers ἐκ τριχος κρεμαται as an illustration of the danger in ἐπι ξυρου βαινειν (4.41). Apost. 6.100 uses it as similar to ἐπι ξυρου ἀκμῃ ἑστηκεν. These two phrases are presumably referring to problems of balancing on a thin line, the verbs however rule out a weighing metaphor. The individual himself is standing on the razor's edge, as vulnerable to catastrophe as if hung by a single hair. The fineness of the razor's edge increases the difficulty of balance, and makes catastrophe more imminent.

A minor misconception could lie in the appearance of the word ἵσταται. This is restricted however to Homer and Theognis or quotes from them. It can equally mean "is stood" as "is weighed", and the former seems plainly understood by Herodotus' close reproduction of the Homeric metaphor, but using the verb ἐχεται (cf. other variants ἑστηκεν and βαινειν already noted).

[IV.] A rather different idea is I feel behind the apparently related use of ἀκμη alone (without ξυρου). It is true that it is used more positively (incisively ?) than the simple English "on the point of doing something". In Eur. Hel. 897 it is the critical moment around death; Dem. IV.41 rhetorically urges the time for doing nothing is passed νῦν δ' ἐπ' αὐτην ἥκει τὴν ἀκμην, the time for real action come. Sophocles repeatedly uses it for the time for not doing something inactive, an extraordinarily negative use El. 22, Philoct. 12, Ajax 811: the time for action seems the basic idea, decisively contrasted with former inaction. Again Aeschylus Ag. 1353 μη μελλειν ἀκμη. That Aeschylus can say this, and more strikingly at Persae 407 κοὐκετ' ἠν μελλειν ἀκμη, must rule out the idea of instability, hesitation, oscillation, indecisiveness that would seem to be basic in the ἐπι ξυρου ἀκμης types I and II above. The phrase now seems used with reference to a certain time, to which matters come, and a time for doing something.

That ἀκμη is therefore close to καιρος needs hardly illustrating. Perhaps ἀκμη is slightly more vivid - as Soph. El. 21-2 ὡς ἐνταῦθ' ἐμὲν| ἵν' οὐκέτ' ὀκνεῖν καιρός, ἀλλ' ἔργων ἀκμή. The two ideas are again associated in Ar. Plutus 256f. as cited above.

No-one any more is in any doubt about what to do at the ἀκμή. It is a certain point of time. Certainly the weighing balance metaphor is not involved, and I should seek a relation with the further meaning of ἀκμη of ripeness (cf. καιρος as a season). Things grow to a point at which they must be cut or they will decline.

Καιρος however introduces another line of development inextricably bound up with the various metaphors so far considered. It is important to consider carefully the chronological direction. The earliest representation of Kairos was apparently by Polyclitos; of it we only know he was shown naked, walking on tip-toe ("nudum talo incessentem" Pliny NH. 34.55); the idea of stealth[132] is understandable but not relevant here. Next came Lysippos' statue: [for refs. etc. see above ch.I.1.(2) Rep. K.2: date second half fourth-century.] This Kairos was depicted with a razor in his right hand, and, significantly, a balance in his left. The two, it is to be noted, are not combined yet. Poseidippos (Anth.Pal. xvi 275) explains the razor's symbolism as ἀνδρασι δειγμα ὡς ἀκμης πασης ὀξυτερος τελεθω , which seems to play on the sharpness of ὀξυς and comes close to the Homeric imbalance idea (above I) especially through reference here to ἀκμη even if this is not the razor's edge.

Another sense however is given to ὀξυτης by Callistratos (Descr. 6), who uses the word to explain the swiftness of Kairos. In fact Callistratos was commenting on the statue's winged feet, he does not mention the balance and neither does Poseidippus. The only evidence for it is in Himerius (Ecl. xiv.1), who gives no explanation.

If it is fair to pursue these somewhat inconsistent accounts of the statue, it is clear that the balance does not symbolise either sense of ὀξυτης (this being done by the razor and winged feet). Most likely is representation of the possible change of fortunes if a certain opportunity is taken. This brings the idea into line with metaphors of good and bad fortunes discussed above, rather than oscillation - Sense II of this section); the balance is probably inclined fairly obviously one way or another already. If however the balance was level, it would indicate not a balancing of equals (because there are no relevant factors to consider equal), but the moment of level on an unstable balance. This sense would be a departure in balance metaphors and of some importance even if it retains the idea of an unstable machine rather than a stable.[133] Quite apart from the weakness of the evidence, however, I cannot see that the idea is properly appropriate for Kairos: again because there is no sense in alternatives once the moment is passed. Relevant here is the idea of balance, but not balance involving the weighing machine.

Cook has suggested that Lysippos meant in fact to show an athlete with strigil.[134] This argument does not rely on interpretationsof the balance symbol, but if correct there is clearly no room for a balance at all. The evidence is indeed weak (only Himerius, despite the detailed discussion of symbolism by other authorities). Furthermore it is possible that the weighing balance was subsequently imported into the Kairos symbolism (and anachronistically applied to Lysippus' statue by Himerius), by later misinterpretation of the idea of the razor. I have shown that the Homeric ἐπι ξυρου ἀκμης ἱσταται refers to the balancing of something on a razor's edge, and not necessarily an actual weighing balance; further Lysippos did not associate razor with weighing machine even on Himerius' description, as they were held in different hands. On late Hellenistic gems however Kairos is shown supporting the midpoint of a balance on what must be his razor and later Roman versions of the figure continue this idea.[135] The balance is not shown level but inclined.

[V.] So we come at last (and significantly late) to the idea of a weighing machine pivoted on a razor's edge. The symbolism is somewhat empty beyond the

idea of unstable balance, and as the beam is inclined we need not think of the moment of level as at all relevant. It remains to observe that even at the late date at which this idea can first be found, unstable balances were apparently very much in the artist's mind. If, however, I have been over-sceptical and argued too strongly against earlier association of the weighing balance with the idea (in both καιρος and the earlier Homeric ἐπι ξυρου ἀκμης) of instable equilibrium, there is no difficulty in accommodating it within the experience of earlier Greeks who I have argued would have been more likely to use the unstable balance. The idea is totally inappropriate to the stable balance; its awkwardness with the unstable is that the position of equilibrium is not the most obvious feature of practical (or indeed, to judge from other evidence in this chapter, even metaphorical) use of that balance.

4.(2) .... ἐπὶ ἴσα μάχη τέτατο πτόλεμός τε

Pursuing the idea of balance, we must consider the implications of a series of metaphors in Homer and later writers for the equal, indecisive direction of the course of a battle. Several of the passages were collected by West and claimed by him to derive from weighing with a balance.[136] This view can I believe be shown to be mistaken: the metaphor being rather that of a tug-of-war involving two sides pulling on a rope.

The impression of a balance metaphor is perhaps given by the misleading simile (of a χερνητις with a balance) that precedes the line (Il. 12.436) quoted as this section heading: 433-5 . The simile has been already discussed in ch.I.3.(2) as evidence of weighing procedure, and the equalisation aspect of the simile must be returned to below in this chapter. It is this aspect that is relevant to the battle, rather than the operation of weighing or the performance of the scale pans. The preceding balance simile seems to me to rule out a second balance metaphor in 12.436. This judgment may be subjective, but it is confirmed by the vocubalary and by other parallel passages.

The verb τεινω and related words do occur in the operation of a balance. At Il. 8.69 and 22.209.12 ἐτειναι νε is what Zeus does to his balance before loading the pans; in ch.I.3.(1) I have shown it refers to taking the strain in the pan-suspension cords. The lifting of the balance uses another word (ἑλκε δε μεσσα λαβων), the inclination of one part yet another (ῥεπε δ' αἰσιμον ἡμαρ ..). There is nothing in the balancing of pans that involves strain or tension other than that already taken up in the suspension cords.

Let us consider parallel passages. At Il. 15.413 exactly the same line as 12.436 follows a different simile; in this case that of a shipwright's line (σταθμη). The point of comparison is the straightness of the line ἐξιθυνει and though the details are not clear[137] the idea of a stretched rope seems common to both ship-building and battle metaphor.

The idea of stretching is evident in another simile, though involving the stretching of a bull's hide, at Il. 17.389-395. Comparison is more closely made to the fighting around Patroclus' body, ὣς οἵ γ' ἔνθα καὶ ἔνθα νέκυν ὀλίγῃ ἐνὶ χώρῃ | εἵλκεον ἀμφότεροι.

That reference is more often to stretched rope in this metaphor is however clear from the following passages:

Il. 7.101-102 αὐτὰρ ὕπερθε
νίκης πείρατ' ἔχονται ἐν ἀθανάτοισι θεοῖσιν.

Il. 11.336-7 ἔνθα σφιν κατὰ ἶσα μάχην ἐτάνυσσε Κρονίων
ἐξ Ἴδης καθορῶν.

Il. 13.358-60 τοὶ δ' ἔριδος κρατερῆς καὶ ὁμοιΐου πτολέμοιο
πεῖραρ ἐπαλλάξαντες ἐπ' ἀμφοτέροισι τάνυσσαν
ἄρρηκτον τ' ἄλυτόν τε (Zeus and Poseidon)

Il. 14.389-90 δή ῥα τότ' αἰνοτάτην ἔριδα πτολέμοιο τάνυσσαν
κυανοχαῖτα Ποσειδάων καὶ φαίδιμος Ἕκτωρ

Il. 16.661-2 ... πόλεες γὰρ ἐπ' αὐτῷ
κάππεσον, εὖτ' ἔριδα κρατερὴν ἐτάνυσσε Κρονίων.

Il. 20.100-103 εἰ δὲ θεός περ
ἶσον τείνειεν πολέμου τέλος, οὔ κε μάλα ῥέα
νικήσει', οὐ δ' εἰ παγχάλκεος εὔχεται εἶναι.

The vocabulary is consistent and related. Subsequently Hesiod Theog. 633 ἶσον δε τέλος τέτατο πτολέμοιο (between the gods and giants, until Zeus intervened and, a possibly different metaphor, ἐκλίνθη δὲ μάχη: 711). The idea of gods manipulating men by means of a rope was put into practice, apparently to no avail, by the Ephesians who, when they faced Croesos, ran a rope from the Artemision to the city wall seven stades away (ἀνέθεσαν τὴν πόλιν τῇ Ἀρτέμιδι Hdt. I.26.2).

To return to the Homeric battles. They were indeed "evenly balanced", but that is an English metaphor that finds no parallel in the Greek.

4.(3) Metaphors relating to the balance of a weighing beam

There are a number of passages, however, in which it seems that the Greeks were referring to the level, balanced beam of a two-pan weighing machine. The word ἰσορροπος is especially used in this context (and see further below VI.5.(3)). As the basic meaning is related to the turning force or effect of objects in the pans of a balance, it may be correct to regard as metaphorical even the application of the word to the level balance beam itself, though other contexts are more clearly metaphorical.

Thus I shall include here ἰσορροπος used inside balance similes or the extended metaphors of, for example, Plato Phaedo 109A, explaining the equilibrium of Pythagorean Earth ἰσόρροπον γὰρ πρᾶγμα ... οὐχ ἕξει μᾶλλον οὐδ' ἧττον οὐδαμόσε κλιθῆναι, ὁμοίως δ' ἔχον ἀκλινὲς μενεῖ. Again at Plato Tim. 52D the unstable formation of the Earth: διὰ δὲ τὸ μήθ' ὁμοίων δυνάμεων μήτε ἰσορρόπων ἐμπίπλασθαι κατ' οὐδὲν αὐτῆς ἰσορροπεῖν, ἀλλ' ἀνωμάλως πάντῃ ταλαντουμένην ... . This virtual level-by-definition use of ἰσορροπος may be behind later references to the actual use of the balance to weigh, though it is also possible they reflect a more straightforward experience of a stable balance: IG II^2.1013 (Plekemata 14) 31, 34, 35 [cited below in VI.5.(3)]; also Archimedes clearly contrasted ἰσορροπία with inclination one way or another (e.g. postulates 1 and 2 at the start of his work entitled Ἐπιπέδων ἰσορροπιῶν ἢ κέντρα βαρῶν ἐπιπέδων α΄β΄.)[183]

However the more general (and interesting) Greek attitude to the point of ἰσορροπία, or balance expressed in other terms, was that it was a precarious point, the beam likely to tip one way or the other. This is indicated by the superlative "very balanced", of Plato Polit. 270A (διὰ δὴ τὸ μέγιστον ὂν καὶ ἰσορροπώτατον ἐπὶ μικροτάτου βαῖνον ποδὸς ἰέναι) which in effect reminds the reader more forcibly of the likelihood of tilting. Further, "the balanced life" ἰσόρροπος βίος is not the ideal life, but one in which pleasure and pain are equally balanced, neither preponderating and either likely to prevail: Plato Laws 733 C-D τὸν ἰσόρροπον βίον ὡς τῶν μὲν ὑπερβάλλοντα τῷ φίλῳ ἡμῖν βουλόμεθα, τῶν δ' αὖ τοῖς ἐχθροῖς οὐ βουλόμεθα. Similar anxiety about the ambiguous balanced position has been seen in many metaphors relating to the changing fortunes of human life: and the danger lies in the small weight needed to overbalance either way (e.g. Soph. OT. 961).

Though there should be noted possible exceptions (e.g. ἰσοφορος of well-proportioned limbs at Xen. Symp. II.20)[139], the general impression is that the position of balance was felt to be unstable. The parallel with the see-saw is direct, and the first part of this section has shown how close the ideas come. Here I hope to have introduced at least some occasions where the weighing balance is intended.

4.(4) Other metaphors

The greater part of this section has concentrated upon metaphors of equilibrium because it is the most interesting area for this general study. These metaphors are however but a small part of the many derived from weighing: most relate to the allegorical balances of ch.VI.3, and several could be agreed to lie in the vocabulary of weighing itself (below ch.VI.5). While not quoting all passages here, I shall briefly indicate the extent of these references to weighing.

Possibly the most productive source for weighing metaphors is the weighing scene in Aristophanes Ranae. The whole idea of the scene reflects the use of weighing to distinguish by comparison.[140] Compare Ar. Vesp. 41 δημον βοειον ... διισταναι (a reference to weighing missed by commentators).

Another common metaphor is the independent contrary weight objects, items, considerations might have in the course of building up material for such a comparison: of Dem. 1.10 where the δικαιος λογιστης of things done to Athens by the gods must count as ἀντιρροπον the recent alliance with Philip; similarly Soph. Electra 120 λύπης ἀντίρροπον ἄχθος; [Plato] Def. 412A ἀνδρεια· ῥωμη προς κινδυνον ἀντιρροπος.

Much here contains also the idea of recompense, or making up for something: Il. 13.745f. τὸ χθιζὸν ἀποστήσωνται ... χρεῖος; Ar. Ran. 1389 ἕτερον εἰπάτω τι κἀντιστησάτω; Soph. Electra 571f. πατὴρ ἀντίσταθμον | τοῦ θηρὸς ἐκθύσειε τὴν αὐτοῦ κόρην. This may or may not be equivalence which is more difficult to illustrate: ?? Antiphanes 26.23-4 [K.ii.12ff.] ἀφυας δε λεπτας τασδε και την τρυγονα | χωρις θεανοι δευρ' ἐθηκ' ἀντιρροπους; Plato Laws 794E τῆς φύσεως γὰρ ἑκατέρων τῶν μελῶν σχεδὸν ἰσορροπούσης; cf. Xen. Symp. II.20 (ἰσοφορος cited below under similes) and Plut. Mor. 723 BC (ἀντιζυγος of leaves on a stem: ibid. under similes).

For the ups and downs of fortunes a further single reference must suffice: Pindar Pyth. I.75 Ἑλλαδ' ἐξελκων βαρειας δουλιας; and for the various overtones of light and heavy we return to Aristophanes: Ar. Ran. 1393f. τὸ τοῦδε γ' αὖ ῥέπει | θάνατον γὰρ εἰσέθηκε βαρύτατον κακόν.

Finally it is interesting to note the various contexts of actual weighing that can be found in metaphors: thus the Apatouria festival in Ar. Ran. 798 μεταγωγήσουσι τὴν τραγῳδίαν; and various commercial contexts: Ar.Ran. 1369 τυροπωλήσαι : 1386 ἐριοπωλικως (compare the simile at [Dem] 25.46 below VI.6).[141]

3. The vocabulary of weighing

It is a major logical error to suppose that a word can both describe and refer to an object at the same time. Nevertheless in this section I propose to waive the philosophical stricture and consider the descriptive content of the words used by the Greeks for their balance, its parts, and the various stages of the weighing operation. It can be admitted that any individual use of a word will in its logical context be in a referential capacity, but I should argue that descriptive inferences are legitimate in one of several ways. First: the original adoption of a word for a certain object or event may very well involve recognition of the descriptive value of the word, or its association with related words. Second: frequently the Greeks had available several words for a single object or event (this is certainly the case for the balance), so that the word used on one occasion can be supposed chosen, and one reason for such a choice could be its descriptive content (the context, type of writing may help decide the likelihood of this). Third: it is more likely that negative inferences can be drawn (from the absence of words, or from the absence of words referring to certain events or aspects). Fourth: much of the literature considered is of a highly poetic nature, and is written with awareness of overtones or ambiguities. This is even marked in prose, where balance similes are often introduced by (if not subconsciously generated by) words with the balance in a metaphorical overtone. The Greeks, in other words, were self-conscious writers.

To analyse fully the complete vocabulary of weighing would take a great deal of space and be very repetitive. Interesting results come only from a relatively small number of words. I have reduced this number even further here by considering only selected aspects of the vocabulary: (1) the various words for the balance and its parts but especially ταλαντον and related words (see also ch.I); (2) words for the relationship between the two pans (and especially ἑλκειν); (3) the notion of level and of inclination in ῥοπη etc.; and (4) the idea of "standing" in, for example, ἱσταναι the basic word for weighing, and σταθμός the basic word for weight. (5) Finally I consider negative aspects and in particular equalisation. The "light and heavy" discussion in ch.VI.2 can of course be considered an extension of the argument of this section though it was approached differently.[142]

5.(1) The balance: τάλαντον and related words

Of words used by the Greeks for the balance as a whole some are simply derived from its most noticeable parts: thus πλαστιγγες (Plut. Mor. 16F-17A; Poll. 4.171), ζυγα or ζυγια ([Dem.] 25.46; schol. Ar. Ran. 1378) from the pans; or ζυγον (Pl. Rep. 550E; Dem. Prooim. 55.3; Lysias 10.18; IG 2^2.1013.32; Pleket 10.39 and IG XI (2) 287.B.142) and probably φαλαγγες ([Arist.] Mech. 853b25) from the beam.

Another word used is σταθμός (remarkably, named on the Arcesilas Vase Rep. C.1; also Ar. Ran. 1365, 1407 and probably Hdt. 2.65.4; the possibility of "balance" in Hom. Il. 12.434 has been discussed above ch.I.3.(2)). This is related to the "standing" aspect of weighing and will be discussed in 5.(4) below; it is not a common word for the balance. Nor is the related κρεωσταθμη, if this was indeed a butcher's balance and mentioned by Aristophanes (Ar. fr.799 ap. Poll. 6.91 cf. Poll. 10.108). Cf. Latin statera.

Most puzzling is the rather commoner word τρυτάνη (Ar. Vesp. 39; Dem. 5.12, 18.298; Herodas 2.90; Lycophron 270). It appears to have operated no differently from two-pan balances of the usual sort, but I can find no clue to its derivation in Greek. Egyptian mḫ3t and Babylonian zibânîtu are not related.[143] Yet the word is common in Latin trutina and related words (none however are related in Greek).

The χαριστίων, if it existed, is most probably named after its inventor (see above ch.I.2.(1)).

The most common, and certainly most interesting, word is τάλαντον (with var. plural τάλαντα in Homer and elsewhere, perhaps suggesting double pans). Related words revealingly fall into two groups. First the talant weight (τάλαντον, ταλαντιαῖος).[144] While it could be argued either that the weight determined the balance size or vice-versa, the priority of the absolute weight is ruled out by, second, the idea of movement in [? ταλαντεία], ταλαντεύω, ταλαντόομαι, ταλάντωσις.[145] But what sort of movement? The passages cited by LSJ show clearly that it is a rising and falling. Used of the tide, it is a form of oscillation (Arist. Meteor. 354a8, 11), but the idea of returning (present in oscillation) is given by additional words: δεῦρο κἀκεῖσε (so also in the battle metaphor at Diod. XI.22 τῆς μάχης δεῦρο κἀκεῖσε ταλαντευομένης). The basic idea in ταλαντεύω etc. is the single downward swing of one side associated with the consequent rise of the other. This is quite

clear in the following further passages: Philo 2.170 τῇ μὲν ἐταλάντευε τὸ ἔλεος, τῇ δ' ἀντέβριθεν ὁ νόμος; Diod. XVI.4.6 (another battle) ὁ κίνδυνος δεῦρο κἀκεῖσε τὰς ῥοπὰς ἐλάμβανεν, ταλαντευόμενος αἰεὶ ταῖς τῶν ἀγωνιζομένων ἀρεταῖς; Plato Tim. 52E (in the original chaos there was no equilibrium ἰσορροπεῖν) ἀλλ' ἀνωμάλως πάντῃ ταλαντουμένην.[146] Comparable is the idea of ἀντισηκωσις (Hdt. IV.50)[147] and it is surely because of the operation involved that ταλαντεύω etc. comes to be used of "weighing out", or "measuring",[148] τάλαντον of the device that so operates, and also by transference of a weight so derived.

I have shown that related to τάλαντον is an idea of motion, that this is the motion of the balance beam which swings down on one side with the other rising. This is therefore comparative weighing. In so far as the references I have cited would suggest there was a tendency to so swing, they must be taken therefore to support the view that the balance was unstable and used by overtilting. There is nothing of "balance" (after all, the reason for our so calling our weighing machines), nor of the oscillation or repetitive swinging of a stable balance as it approaches level equilibrium.[149]

5.(2) Weighing as a relationship observed between two pans: ὁλκή

Most references, direct or indirect, to weighing involve the notion of a relation between two forces acting against each other. This has already been observed, and discussed at length, for the basic ideas of light and heavy - the words being treated as incompatibles, opposites.[150] Some further indications of such a relationship can be seen in the following phrases.

Perhaps obvious, and superfluous for the general argument towards comparative weighing, is the description of weighing one thing against (πρός) another: Hdt. II.65.4 τριχας προς ἀργυριον; Soph. fr.256 'Αρης πρὸς ἀναγκη: Xen. Symp. II.20 (ἄρτους or σκέλη in simile) τὰ κάτω πρὸς τὰ ἄνω; Plato Protag. 356B ἡδέα πρὸς ἡδέα etc.; IG XI (2) 287 B.142 f. inventoried objects weighed πρὸς ἀργυριον 'Αττικον ὁλοσχερες; IG II^2 1013.32 πωλειν πρὸς ἀργυριον (Pleket 14). Hence the verb ἀνθιστάναι e.g. Ar. Ran. 1389; Soph. fr. 256 as above; Plato Symp. 196C (εἰς).

Objects considered compared with each other in this manner exert a potential contrary force without its being decisive - especially ἀντιρροπος (Potidea epitaph IG I^2 945.12f.[Tod I. no.59]; Dem. 1.10; [Plato] Def. 412A; Soph. El. 120) but more explicitly Plato Rep. 550E ἀεὶ τοὐναντίον ῥέποντε; also ἑτερορροπος etc. (Rhian. 1.2; possibly Aesch. Suppl. 403); and ἀντιζυγος (Arist. PA. 666a27; Plut. Mor. 723BC, though this word in Plut. may simply refer to the spatial relationship; see below under similes). A force, if large enough, can be of course decisive, which is open in Aesch. Suppl. 403 ἑτερορροπος, but more clearly expressed by παλιρροπος, or the use of ῥεπειν elsewhere. Such an idea is not related in the first instance to the relationship of the objects in the pans so much as to the overall result of their comparison. Similarly these words do not in themselves indicate equality, though this may be the overall result:Aesch. ap. Hesych. s.v. ἀντιρροπον (ἀντισταθμον); Antiphanes K.fr.26.24 (ἀντιρροπος). For equality, ἰσορροπος, see following ῥοπη: the idea remains one of contrary forces, in this last case equal.

A frequent word to express weight is ἑλκειν and related noun ὁλκή.[151] These forms occur whether the operation of the two-pan balance is explicit (as Dem. 5.12 καθείλκυσε)[152] or whether it is simply implied as in the more usual use of the words to express weight (Hdt. I.50.2-3 ἑλκειν σταθμον δεκα ταλαντα; II.65.4; VII.36.3; Eupolis K.fr.116; Arist. Caelo 311B9; [Plato] Minos 316A; and passim in inscriptions e.g. IG XI (2) 287.B.142). The basic

sense of ὁλκη, ἑλκειν etc. is "dragging", and its use in Greek weighing vocabulary clearly reflects the effect one balance pan has upon the other. This effect is however that of the heavier pan on the lighter (which is "dragged" passively), and is hardly applicable to such occasions as when the two are equal. Measurement of weight (ὁλκη, ἑλκειν) is seen therefore to be by overbalancing, and to judge from the forceful overtones of the words[153] it is over-tilting: i.e. unstable balances seem implied. This point, of fundamental importance to this study as a whole, can be reinforced by the static elements of weighing vocabulary (see 5.(4) below): this only can occur at the extremes of over-tilting.

For the present section it remains to note that there is no necessary Greek word for distinguishing by weighing. Διιστανai exists[154] but ἱστάναι can be sufficient (and is frequently employed to this sense as a metaphor or simile). Greek weighing, as I am maintaining, was itself little more, and certainly no less, than distinguishing by weighing.[155]

5.(3) 'Ρόπη, ῥέπειν etc.

Of the words in the Greek weighing vocabulary, ῥόπη, ῥέπειν (and related words) are the most difficult to analyse. The basic question is whether they refer to an effect[156] or a force. It may not prove possible to decide the issue without making certain assumptions on the character of Greek weighing.

Superficial classification is not an unhelpful way to start. Thus the swing of the balance: [Arist.] Mech. 849b33 το μεγεθος της ῥοπης increased with a longer beam; cf. Aesch. Cho. 61 where it is described as swift; Isoc. 4.139 μικραι δυναμεις μεγαλας τας ῥοπας ἐποιησαν; Plut. Mor. 928 BD where the varying positions of stars are compared to the varying angles of inclination of a beam (see also below on similes). Such swing can be considered as directional (one side or the other inclined): Eur. Hel. 1090 βλεπω δυο ῥοπας as opposed to the more unfortunate Melians Thuc. V.103.2 ἐπι ῥοπης μιας ὀντες.[157] The change of direction is not significant until it produces a change in the relative position of the pans - i.e. only after the level position is passed, but any movement either side of this position seems to be called ῥοπη however small and is decisive: Soph. OT. 961; Eur. Hipp. 1163. At this point we should ask - why decisive?, and though explanations are possible with both stable and unstable balancing principles in mind, it is difficult to square the decisive nature of such ῥοπαι with the former. With unstable balances the slight inclination will continue to the complete overtilted position (Isoc. 4.139 cited above).

This explanation is the only way I can see of taking the idea of ῥοπη from effect to force, i.e. from swing to force producing swing. For only on unstable balances will a small force (or additional weight) produce a decisive contrary swing.

For references to ῥοπη as such a force (or additional weight) see Pl. Rep. 556E;[158] Polyb. 16.14.6 ῥοπην διδοναι as giving a casting vote; Dem. 2.22 τυχη considered a μεγαλη ῥοπη but not το ὁλον in human affairs (taking the overall allegory of a balance representing these); ibid. 9.8 Macedon has a certain usefulness and ῥοπη i.e. weight but not decisive weight; Aesch. Persae 437; and Arist. Caelo 307.b. 33f. where ῥοπη is used for weight in general, although defined as downward momentum.[159] Finally, and most flatly, in IG II^2 1013 (Pleket 14) 31, 34, 35 e.g. τὸ δὲ πεντάμνουν [τὸ | ἐμπ]ορικὸν ἐχέτω [ῥο]πὴν ἐμπορικῆν μνᾶν, ὅπως ἰσορρόπου τοῦ πήχεως γινομένου ἄγηι ἐμπορ[ι|κὰς μ]νᾶς ἕξ:

the sense being that the commercial 5-mina is to be increased by one (former) commercial mina;[160] ῥοπη itself refers to increase in weight, though the earlier overtones remain in ἰσορρόπου τοῦ πήχεως γινομένου.

For ἰσορροπος we can retrace our steps. As already noted in 5.(2) above, both ἑτερορροπος and ἀντιρροπος seem used simply to indicate contrary forces, though they can also reflect the decisiveness of such forces. ἰσορροπος unites both ideas: of contrary forces, and of their effect (equalisation). Further discussion has shown however that despite this equalisation, the word retains its basic notion of contrary forces, at least until Archimedes and the period of IG II^2 1013.[161] Such equalisation is basically unstable.[162]

Effect is clearly the sense of παλιρροπος (e.g. Soph. fr.576), and is it seems the basic element in ῥοπη. This effect is fundamental to the use of weighing to distinguish; that a small ῥόπη can be decisive, would seem to imply unstable balances; nowhere is there an element of stable equilibrium.

5.(4) Σταθμός, ἱστάναι : the stationary element in weighing

In the midst of a vocabulary largely consisting of words implying movement (especially the central ῥέπειν), it is surprising to find a stationary element. The words σταθμός and ἱστάναι are furthermore basic to the vocabulary of measuremental weighing, though the verb ἱστάναι can also be found outside it. Do these therefore reflect a later development in weighing? a second layer of vocabulary overlaid on the first? or are they compatible with it?

If they do represent a "secondary layer" the occurrence of these words in Homer (Il. 12.434 σταθμός; 19.247, 22.350, 24.232 ἱστάναι of gold) can only be countered with the many other, independent arguments that I have advanced in this study that indicate only the "primary layer".

But the stationary element is not incompatible with even the most extreme comparative weighing techniques if carried out with unstable balances. As shown by my own experiments the beam in these cases, once overbalanced, will continue tilting until it is checked by the apparatus by which it is suspended. This final position is completely stable and will not tend to oscillate as occurs at the level position on stable balances.[163]

The preceding analysis of ὁλκη, ἑλκειν etc. should be reintroduced here. This indicated that weighing was performed by overbalancing: the object weighed being, we should say, in fact heavier than its overbalanced (and so measured) weight. I feel that the use of ἱστάναι is precisely comparable in that the object weighed "causes to stand" up in the air the weight (from which, if standardised, its own weight can then be decided). In practice weighing was a matter of determining the heaviest weight an object could "cause to stand" in this manner.[164]

5.(3) Negative aspects and balance or equalisation

It remains to note the several "lacunae" in the vocabulary of Greek weighing in commenting upon the very slight references to what is central in the modern vocabulary: balance and equalisation.

The Greeks had no word for the pointer or plumb-line on a balance: contrast ancient Egyptian  th "plummet"[165] and Roman examen.

If my discussion of ταλαντευω etc. above 5.(1) is accepted, they also had no word for oscillation in the sense of ever-decreasing swings approaching stable "equilibrium": in Latin simply librare with the dominant sense of making level or even (a sense shared with related words from libra to librator).[166]

Greeks did describe the level position of a balance beam, but appear to have thought it precarious, and defined it negatively in terms of not inclining to one side or the other: thus ἰσορροπος (see above 5.(3)) and νενευκεν οὐδαμῃ in Cercidas 4.28 (Powell; 1.20 Diehl).[167] Further ἰσόρροπον as οὐδαμόσε κλιθῆναι and ἀκλινὲς μενεῖ Plato Phaedo 109A, and the revealing superlative (degrees of ἰσορροπία !) at Plato Politic. 270A διὰ δὴ τὸ μέγιστον ὂν καὶ ἰσορροπώτατον ἐπὶ μικροτάτου βαῖνον ποδὸς ἰέναι. (even if not necessarily thinking of a weighing machine). Another negative definition occurs in Plato Tim. 52E ἀνωμάλως πάντῃ ταλαντουμένην. The positive word ὀρθος is used in this context of a level balance beam [Arist.] Mech. 850a11 and 854a2 (of the bisman); it occurs twice in Cercidas 4.27 and 34, but the first occurrence is hindered by a break in the text[168] and in the second (ὀρθος ὢν ζυγοστατας) ὀρθος is clearly acting as equivalent to δικαιος, as elsewhere (though Demosthenes' alternative synonymn is ὑγιὴς in Dem. 5.12 cf. 18.298) meaning "just".

Next should be noted the existence of words for equalisation of weight: ἰσάζουσ' Il. 12.435; ἰσότητα ... ἀποδίδωσιν Plut. Mor. 723 BC;[169] ἐπανισουν ... και ἐξεταζειν τα μετρα και τα σταθμα IG II^2 1013.(Pleket 14).15; and ἰσοτης ἐταξε μερη σταθμων Eur. Phoen. 541f.[170] There is no indication from these passages that the process of equalisation involves levelling and balancing level the beam of a balance. As most other references show that weighing was done by distinguishing, it is not excessively perverse to take the idea of equalisation in these passages as referring to the weights of the commodities involved[171] rather than the operation.[172]

Ἐπανισοῦν in IG II^2 1013.15 (just cited) is the only reference I can find to double-weighing, and it is fairly uncertain even here (as applied also to μετρα).[173] The procedure is thought now essential in the use of the two-pan balance.[174]

Finally there appears to be no recognition of degrees of accuracy in weighing in the Greek vocabulary. Weighing can be done honestly (δικαιως, ὀρθως, ὑγιῶς, and ἀδολῶς [conjectured in Pleket 4 I.4: Erythrae mid-fourth century]), or the opposite, including ἐριοπωλικῶς (Ar. Ran. 1386).[175] The only reference to accuracy of actual balances is [Arist.] Mech. §1, and it is the balance that varies in accuracy according to its size rather than the accuracy of weighing that varies with the care of an operator. The accuracy of the balance is described as a matter of detectable movement of its beam ends. This has been shown (in ch.I) to refer to unstable rather than stable balances. The point I am making here is that lack of reference to the care of the operator (and its effect on the accuracy of a balance and on that of weighing) would be most surprising if stable balances were in use, as it is this aspect that is most stressed in the operation of modern balances of the stable sort.[176]

The elements of the Greek vocabulary of weighing reviewed in this last section are largely negative. They add up however to a powerful argument against the use of the balance by levelling it, and so against the possibility (already largely discounted in what has gone before) of Greeks having used stable balances. The operation of the unstable balance on the other hand is well described by the majority of this vocabulary. Contrast the modern English word "balance" with the Greek "ταλαντον".

6 Direct comparison: simile

These references have been left to last because they are not only more direct, but lead straight into practical contexts of weighing to be considered in the next chapter. For the most part these similes and comparisons involve the same aspects of weighing balances that have been seen to underlie the more unconscious usages of metaphor and allegory. Significant additions however lie in references to positive equalisation and to the use of weights with a balance: once as a typically commercial, once as a particularly accurate way of tackling something. As thenumber of passages that I have collected for this section is relatively small,[177] it may prove more helpful to consider them in approximately chronological order. The concluding section of this chapter will then briefly review the particular aspects of the balance these and earlier references reflect.

Homer Il. 12.433-6 ἀλλ' ἔχον ὥς τε τάλαντα γυνὴ χερνῆτις ἀληθὴς ... cited above in full, ch.I.3.(2) on procedure, where I discussed in particular whether the equalisation (ἰσαζουσα) was between wool and wool, or wool and weight. The point of comparison is the equalisation, though (as I also pointed out above) this does not necessarily imply balance. The context of the simile is a cottage industry, but could usefully be called commercial. Compare Nep. C.2. (in ch.I.1.(2)).

Eupolis fr.116 (K.I p.288)
τοιγαρουν στρατηγος ἐξ ἐκεινου του χρονου
οὐδεις δυναται ὡσπερ μειαγωγος ἐστιων
της τουδε νικης πλειον' ἑλκυσαι σταθμον

which I should translate: "So generals since that time are like the μειαγωγος at the Apatouria festival, unable to gain a weightier victory." Comparison is directly made to the Apatouria festival (on which see chs. VI.3.(4), VII.2.(14)); and the idea is comparative weighing. The simile no doubt can be seen as generated by metaphorical "heavier, weightier victory", which is again comparative weighing.

Xen. Symp. II.20 καὶ γὰρ οὖν οὕτω τὰ σκέλη τοῖς ὤμοις φαίνει ἰσοφόρα ἔχειν ὥστε δοκεῖς ἐμοί, κἂν εἰ τοῖς ἀγορανόμοις ἀφισταίης ὥσπερ ἄρτους τὰ κάτω πρὸς τὰ ἄνω, ἀζήμιος ἂν γενέσθαι. Charmides' legs and arms are implied as being equally small. The weighing metaphor in ἰσοφόρος is picked up by the direct simile of ἀγορανόμοι weighing loaves from top and bottom of a stall against each other. I have suggested elsewhere[178] that this is possibly to check their staleness, but it could simply be to ensure a constant size.[179] As the fine (implied by ἀζημιος) would follow on a detectable difference in weight, the weighing is again comparative (and also compare the verb ἀφιστάναι). Note that no weights are involved as standards; the context is clear.

Plato Protag. 356 A ff. The Hedonistic calculus is explained by means of a simile ἀλλ' ὥσπερ ἀγαθὸς ἱστάναι ἄνθρωπος ... (see above ch.VI.3.(2) ii [c]). The operation is one of comparing, and distinguishing which is greater, of present and future pleasure and pain. The procedure is complicated, and the simile is of someone good at weighing: so we might infer either that Plato imagined weighing of this sort to be usually rather simpler (presumably only involving one of the three comparative processes he describes here), or (better) that he recognised the difficulty of getting the relevant items into the pans ~~wished the operation to be particularly precisely conducted~~.[176]

Plato Rep. 550B ἢ οὐχ οὕτω πλούτου ἀρετὴ διέστηκεν, ὥσπερ ἐν πλάστιγγι ζυγοῦ κειμένου ἑκατέρου, ἀεὶ τοὐναντίον ῥέποντε; A possible metaphorical verb (διέστηκεν) leads to simile of balance to indicate how things can pull in different directions. No comparison between ἀρετη and πλουτος is being directly made, the reference is, I feel, simply to the effect of inclination from an object placed on each side of a balance.

Dem. 5.12 ὅταν δ' ἐπὶ θάτερ' ὥσπερ εἰς τρυτάνην ἀργύριον προσενέγκῃς, οἴχεται φέρον καὶ καθείλκυσε τὸν λογισμὸν ἐφ' αὑτό, καὶ οὐκ ἂν ἔτ' ὀρθῶς οὐδ' ὑγιῶς ὁ τοῦτο ποίησας περὶ οὐδενὸς λογίσαιτο. Comparison is made between the effect of bribery on political calculations and the effect of a weight added to one pan of a balance, a weight large enough to take that pan down with it. There is no idea of fine balance here disturbed by the weight added; Demosthenes is simply concerned by the way the λογισμός is falsely determined by an irrelevantly added weight. The implication must be that the λογισμός would be decided by whichever pan sank, and this, combined with the extreme tilting of οἴχεται φέρον καὶ καθείλκυσε, strikingly calls to mind the overtilting - unstable balance. The idea of "level" which can be found in ὀρθος, is not relevant to ὀρθῶς οὐδ' ὑγιῶς here, nor in ὀρθὸν ... το συμφέρον φαίνεταί μοι

(the sentence preceding the quoted simile) nor, similarly, in the next simile Dem. 18.298. "Correct", in the moral sense alone, is meant.[180] This interesting simile therefore attests to the overtilting balance, and use of this overtilting to distinguish: i.e. again comparative.

The context, the λογισμός, of the use of the balance here is not clear. The silver (money ἀργύριον) is most immediately outside the simile, indicating the bribery aspect Dem. is denying. It would, however, be interesting if this word leads into the simile and if ἀργύριον is also conceived of as being what overbalances the scales. For further connection of λογισμός with the balance see Dem. 1.10 (noted above under metaphors) where δίκαιος λογιστής leads into ἀντίρροπον, and compare the first (if not also the second) of the following similes from the same author. I suspect, but cannot prove, that this overbalancing may be appropriate to the conduct of temple inventories.[181]

Dem. 18.298 οὐδ' ὅσα συμβεβούλευκα πώποτε τουτοισί, ὁμοίως ὑμῖν ὥσπερ ἂν τρυτάνη ῥέπων ἐπὶ τὸ λῆμμα συμβεβούλευκα, ἀλλ' ἀπ' ὀρθῆς καὶ δικαίας καὶ ἀδιαφθόρου τῆς ψυχῆς. Demosthenes is maintaining he has never been influenced by personal gain in the advice he has given Athens. Reference is apparently being made to the sort of calculation the statesman might make over public advantage as was described in 5.12 (above). The balance comparison is relevant in that conclusions are drawn from the tilted balance, which distinguishes the better course of action. In this simile Demosthenes' advantage on one side is weighed against public advantage on the other, and Demosthenes' advice is what might (but according to Dem. never actually did) incline the scales to his side. The image is therefore slightly different from 5.12 where Demosthenes' advantage, the bribe, was actually placed in one of the pans making that side seem the better course of action. The operational aspects of the balance are the same however in both similes.

Dem. Prooim. 55.3 (end) ἂν γὰρ ὥσπερεὶ ζυγῷ ἱστῆτε, πρόεισιν ὃς ἂν ἄξιος ᾖ του μετὰ ταῦτ' αὐτός. Thus the OCT (W.Rennie 1931); the MSS read ὥσπερ εἰ ζυγὸν S — εἰς ζυγὸν D; and Blass, retaining the reading of S here, emended πρόεισιν to πρόσεισ' in the following clause. Rennie's change, for which he cites Lysias 10.18, does not to me greatly affect the sense of the simile, but I find it very difficult to understand Blass' version with πρόσεισιν. The reason for the simile (with πρόεισιν) is that offering public office to the assorted talents of the masses will induce a sort of competition in which the best man, or the capable man, will come top. The idea in the simile

is the use of the weighing balance to distinguish similars. There is no justification (nor sense for Dem. to argue the point) in feeling that simply offering the offices will induce men "to come forward" (πρόσεισιν): for the balance is not in itself a trial on the lines of Aegeus' rock.

[Dem.] 25.46 εἰ δὲ κάπηλός ἐστι πονηρίας καὶ παλιγκάπηλος καὶ μεταβολεύς, καὶ μόνος οὐ ζυγὰ καὶ στάθμ' ἔχων πάνθ' ὅσα πώποτ' ἔπραξεν ἐπώλει, τί τοῦτον, ὦ μάται', ἀνῆς; Aristogeiton, the sycophant, is described here as hawking his scandals in the most cold-bloodedly, professional way. The point of comparison is commercial activity, the balance comes in to underline the professionalism of the activity being, with weights, the special equipment of traders. Trading is of course a far from respectable profession: and this undertone can be detected here. The passage is of exceptional interest in indicating a context for use of the balance and inclusive of weights.[182] The simile, however, tells us nothing of what Demosthenes and others like him might understand of the operation and use of the balance.

Aristotle PA 666a27. In highly developed animals the liver has, ὥσπερ ἀντίζυγον, the spleen. This is part of an explanation for the liver not being the primary organ, or source of blood. The phrase seems more like an apology for a metaphor, and compare below Plut. Mor. 723 BC. The idea is the counteracting effect of what is placed in one pan or another, as in Plat. Rep. 550b above. Not explicitly comparative, but certainly no element of equality or balance is implied in the weighing machine's use.

Herodas 2.90f. In the context of a court of justice and the decision reached, reference is made to Minos' judgments in the underworld: ταυτα τρυτανη Μινως οὐκ ἂν δικαζων βελτιον διητησε. The allegorical content has been mentioned above;[183] but the comparison can also be noted here as indicating the precise distinctions detectable with a balance; an entirely comparative aspect of weighing.

Herodas 7.33ff. Also mentioned above in the discussion of Justice.[184] I prefer the interpretation that the balance again is invoked as a machine capable of detecting small distinctions:

καὶ γαρ ταλαντα γ' οὐδ' ὅσον ῥοπην φευδος
βριθει κοτ', ἡ Κερδωνι μη βιου ὀνησις
κώνεων καλων γενοιτο.[185]

[Arist.] Prob. XXVI.26. (942b36 - 943a1) ἔτι δὲ ἐπειδὴ ἡ ἰσημερία ἐστιν καθάπερ χειμὼν καὶ θέρος ἰσοκρατές, ἐὰν ὁποτερωοῦν αὐτῶν τι προστεθῇ εὔσημον τὴν ῥοπὴν ποιεῖ καθάπερ ἐπὶ τῶν ἰσαζόντων ζυγῶν ... . At the time of the vernal equinox (which is the only one Aristotle is talking about in fact), the south-west wind overbalances the scales in favour of winter, as it is a wintry (rainy) wind. This passage has already been mentioned above (VI.3.(3)) in connection with the constellation Libra, but as I argued there the simile is not associated by [Arist.] with a period of the year (to which the constellation might be relevant) but to a meteorological phenomenon. The reference is clearly to the instability of a level balance. Any additional weight is obvious (εὔσημον) - presumably because it overtilts the pans to that side: the effect of the SW wind at this equinox is very similar to rain on St. Swithun's day. There is no indication in the simile of the context in which the balance might be level, and we need not infer that any such context necessarily existed: it is the characteristic of the balance, not its operation, that provides the point of comparison: thus contrast ἰσάζουσ' in Homer Il. 12.435 (above).

The following two similes in Plut. Mor. are marginally relevant for this survey of Greek weighing:-

Plut. Mor. 723 BC describes the way nourishment in a plant is equally distributed to the various leaves: καὶ γὰρ ἄλλα πάμπολλα μόνον οὐ μέτροις τισὶ καὶ σταθμοῖς ἀκριβῶς τὴν τροφὴν διανέμοντα τοῖς ἀντιζύγοις πετάλοις ἰσότητα θαυμαστὴν καὶ τάξιν ἀποδίδωσιν. The simile should offer striking contrast to earlier Greek references to the balance: here it is used with weights to ensure a precise, and even, distribution. The metaphor in ἀντιζύγοις may be intentionally in keeping with the simile; but here refers simply to the leaves' positions on sides of the stem. Cf. Arist. PA 666a27 above.

Plut. Mor. 928B. describes the various positions of stars in the sky as being as if they had been tipped differently in the pans of a balance. The text is not entirely certain; but the idea of varyingly inclined positions of the balance-beam is not found elsewhere.

In addition are several borderline references that I have found it more convenient to discuss in earlier sections of metaphors and allegory. Most significant are the direct references to commercial weighing contexts, especially those in the weighing scene of Ar. Ran. The intent of the scene is of course to undermine the sort of distinctions I am drawing here !

Conclusions

The general conclusions for this chapter have already been somewhat repetitively indicated by the individual sections, and it should not be necessary to dwell long on them here. A considerable number of indirect references to weighing and to the balance has been found scattered through Greek writing from Homer into the third century B.C. In general these refer primarily to the way a balance distinguishes: this is used of like and like, but not necessarily, for the balance can compare. The essential features of the balance, and its relevance to these ideas, is the inclination of the beam, the reciprocal (alternating) movement up and down. In this sense the balance is precise.

Certain qualifications surround the possible interpretation (in metaphor etc.) set upon the middle, level, position of the beam. Basic here is the idea of its being a precarious position, defined as likely to tilt each way. It is recognised as one of equality, but is not necessarily sought after even though the idea of equalising can be found in references to weighing. There is no reference to apparatus provided with means to register the level position, nor to the problems of detecting it accurately. Further, the basic Greek vocabulary of weighing, the most general application of the balance (inclined to distinguish)[186], the fundamental opposition felt between light and heavy, are all incompatible with the idea of weighing by levelling the balance-beam. Small differences in weight dramatically tip the scales. The weight of the evidence suggests that weighing was usually imagined as being performed with an unstable balance. This conclusion is substantially confirmed by much of the independent direct evidence considered in chapter I.

The Greeks liked to call their balance ταλαντον, a word related to its swing and inclination; contrast the English word "balance"; contrast the German for level or horizontal "Waagerecht"; contrast the Egyptian verb mḫɜ meaning both "to balance" and "to equal".

Put more simply the evidence in this chapter characterises general Greek weighing as comparative. It can be opposed to the measuremental weighing, characteristic of most modern, and, as will be shown in ch.IX, also most ancient cultures.

But if this was the general Greek attitude to the balance and their general experience of weighing, we must next consider how extensive it was in practice. There are immediately obvious areas to which it does not relate: the comparison made to a trader with his balance and weights at [Dem.] 25.46 introduces an element, the use of weights, that is virtually ignored by the general metaphor etc. which makes no references to weights, only refers to underweight in the context of a religious ceremony (μεταγωγειν) and not as an element of deceit, and contains no moral precepts on the maintenance of correct weights. There is an apparent clash of evidence here, not least in view of the vast numbers of weights, coins, and measured weights assembled in chapters II and III above. It can best be resolved by considering the contexts in which actual weighing was done, and by examining the type of weighing (comparative or measuremental) carried out.

chapter seven

WEIGHING IN PRACTICE: methods and contexts

Introductory

The general aim of this chapter and the next is to discover how far the typical Greek attitude to weighing, derived from indirect references in chapter VI, is in fact compatible with the evidence of actual weighing in ancient Greece. This evidence comprises large numbers of weights and coins (the value of which is basically determined by the weight content of precious metal); further in chapter III above are collected a large number of references to weighed amounts of various commodities. Yet there is nothing in Greek theory, allegory, metaphor or simile that reflects any concern for the measurement of weight that this evidence indicates occurred; instead the only mentions of weights are in very practical comparisons, while the basic attitude to the balance is that it distinguished similars. Further (though more relevant to the following chapter) there is no general indication that Greeks were concerned with precise measurement of weight.

This contradiction with the extant weights and accounts of weights is perhaps further increased by the agreement between the type of balance that I have argued the Greeks used (in chapter I) and the general attitude (of chapter VI). This balance was probably unstable, it certainly did not register the level position which we now take as an essential for measuremental weighing. Such an unstable balance is ideal for distinguishing.

However I have also shown (especially Appendix B on experiments) that the unstable balance can be used for measurement. Indeed it may have been more accurate even for this, than the levelled stable balance designed for the purpose. The type of balance does not therefore totally rule out the measurement of weight, though that the Greeks used such a type is very important for the historical development of weighing in Greece. For the present chapter the point once made need not be reconsidered: but we must return to it with consideration of likely precision and accuracy in the following.

The present problem is to determine how this balance was used: whether with weights (and if so whether with single ad hoc weights or with weights that formed part of a system), whether to measure (with a view to discovering the weight of something) or to measure out (in order to reproduce a known weight). Further, I am concerned to see how far such weighing went in Greek society, and in particular whether it might be said to be general and widespread, or was restricted essentially to certain specialist activities.

That weight measurement, or the use of weights in weighing, was in fact restricted to a small group of specialist activities, can I believe be shown to be the case. "Measuring out" collapses under analysis to an aspect of simple comparative weighing, and, though perhaps of widespread familiarity, does not involve any sophisticated notions of absolute weight measurement: "minas" of cheese are not essentially different from "such and such a stone's worth" of cheese. There is room however for some degree of measuremental weighing. It never was significant. In this way the apparent contradiction noted with the general Greek attitude to weighing can be resolved.

The analysis in this chapter will be based on the commodities and contexts assembled in chapter III above, and will also take further the discussion of weights and standards of chapters II, IV-V. I shall examine first the contexts immediately indicated by this evidence, and these are the most important for the possible widespread use of weights: especially commerce, coin, and official inventory and control: [part 1 (1-5)]. In the second part of this chapter I shall review a series of contexts in which weighing may have occurred (or has been thought to occur). They offer for all their interesting variety no significant extension for the practice of weighing [2 (6-16)].

At the end of this chapter I briefly summarise the conclusions drawn about the contexts of weighing, and the types of weighing in these contexts. I consider how far the operation of weight measurement in particular was restricted to specialists, and how much it might be expected to have impinged on general Greek society. At this stage it is possible to introduce a further factor, namely doubts about the importance of weighing in several contexts including the public accounts which are a major source for our picture of weighing so far constructed. These doubts are best investigated in terms of precision and accuracy, with

which the first two parts of the next chapter are most directly concerned. From consideration of these elements of weighing, in the light of what has been said of the procedure, and especially the point of weighing, ~~In this chapter,~~ the further apparent discrepancy (between extant but inaccurate weights and apparent accounted precision) can be resolved (see VIII.2 end).

1. (1) General Commerce (buying and selling).

The comparison made at [Dem] 25.46 between the sycophant and a trader selling wares with scales and weights might give the impression that the balance was the normal tool of the trader, and that it was usually used in a measuremental manner (σταθμα being plural not a singular standard weight). However there is evidence of different commercial practices in the long period from Homer down to the second half of the fourth century when this speech was composed: and at very least a development in the use of the balance must be postulated. In fact I believe that the trader at [Dem] 25.46 was exceptional because of the way he sold with weights and balance.

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It is naturally unreasonable to suppose traders used systematised weights until such systems should be introduced. This I have suggested only occurred after the establishment of coinage, and in mainland Greece (in fact Athens) not till the late sixth century B.C.[1] Before systematic and standardised weights existed there is however clear evidence of both weighing and of weighing with weights in actual or related commercial contexts. Such weights were mainly ad hoc single units; they varied from trader to trader or occasion to occasion though they may have achieved some more widely recognised standard value in certain particular trades: thus the unit for handling gold, to take the only standard weight unit in Homer's day, was not applicable to iron.[2] Except in these latter special cases, the use of a weight made no significant difference to the weighing procedure. To judge from all pictorial representations, this was essentially the weighing of like against like.

It may be presumed that the function of such weighing was (1) to measure out so many times an agreed amount; alternatively (2) the procedure could be used to repeat individually an agreed amount. Whether

the principle be that of multiplication or distribution, the basic unit could be any agreed quantity represented by a variety of means - pan-ful container-ful, or even a stone that happened to be to hand and of a convenient size. For this last compare Agora SW 16;[3] and for a pan-ful of commodity see the Arcesilas vase.[4] This is the relevance of the σταθμος (if correctly interpreted as an actual weight) in Iliad.12.434[5].

(3) A third application of weighing in the pre-coinage period could also be to facilitate exchange. For example, supposing barley to be three times as valuable as wheat, the two commodities could be exchanged by weighing a set amount of barley three times against wheat. Though there is no evidence directly supporting this application, it seems a likely parallel to be inferred from the apparent reduction of values to a cereal unit base of capacity in early Athens, compare the Pre-Solonian τελη with πεντεκοσιομεδιμνοι etc.[6] However it should be recognised that only capacity or item units (e.g. the Homeric ox) are actually thus attested as value bases. Weight is only involved in such cross-category equivalence systems as indicated by the various ordering of prizes in the Funeral Games (Iliad 23).[7]

Thus weighing in this period can be seen to have had a part to play in commercial transactions, or the operation of trade, even if not an essential or basic part. The extent to which commodities were weighed is difficult to assess as there are no suitable accounts, nor is it clear that weighing could be inferred from them (in the absence of systematic weight standards). The weighing of wool is particularly well attested (Il. 12.434: and chapter I.1(2) Reps.C.1, rather than silphion; C.2). Somewhat surprisingly, grain may be identified from C.3 if the central figure is pouring something into the right-hand pan as is likely; the rectangular objects on C.4 are best identified as metal bars (rather than wood) and the weighing of gold is specifically indicated by Homeric gold talents.[2] These examples moreover offer a comprehensive range of Greek society involved in the weighing: from the humble χερνητης ἀληθης (Homer Il.12.433) to King Arcesilas actually named on the vase Rep.C.1.[8]

The weighing process in all but the measurement of gold, consisted in the reproducing or measuring out of units defined or agreed by other means. Measurement of gold must be considered in the light of later, more general measurement below; for the present I wish to pursue the present model for non-measuremental weighing. In this model the unit selected is haphazard but nevertheless reflected in the price decided upon, in

whatever manner (in practice) this may have been paid. The introduction of coinage alone does not therefore affect the model.

It is relevant to assess the procedure. I have argued the Greeks are more likely to have used for weighing the unstable balance in this sort of context. Not only is it a possible procedure, but it can be shown to have distinct advantages over alternative use of level balance.[9]

First it is very rapid as only a single "weight" is used - the other pan being simply filled until it overbalances. Secondly it can be more practical than such alternatives as capacity measurement.[10] Most important however is third the decisive nature of weighing with an unstable balance that overbalances when registering difference. There is left no room for doubt in the eye of the spectator (potential, or actual, customer) which side of the balance is the heavier. As argued in chapter VI it was this aspect of the balance that most struck the general Greek mind; it is this method Zeus used for his difficult decisions; and, as will be pursued in the next chapter, it is in this sense alone that the Greeks regarded the balance as a precise instrument.

This justification is perhaps not necessary in so far as, fourthly, the overbalance procedure is ideally suited to the psychology of trading. What is important here is that the buyer feels he is getting at least a certain weight. The price may be fixed or bargained for but is independent of this element of the transaction. It is interesting to find the practice of "giving a little more" even today on balances designed to register level (with the pointer allowed to go over the central position) in markets around the Mediterranean where balances are still normally used; it occurs also on more sophisticated butchers scales operating on the direct measurement principle, which are nevertheless normally under-read. A common reaction to the over-balance procedure that I have argued was used by the Greeks is to question its practical application. This last point shows how wrong-headed such scepticism in fact is. The overbalance procedure actually minimises the amount lost by the seller for it takes very much more overweight to overbalance significantly a stable balance.

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This discussion of the type of weighing in the earliest Greek period has been purposefully detailed. The same considerations can be shown to continue to apply for the majority of commercial weighing in subsequent periods. The difference is perhaps most significantly that in these the state on the one hand and further specialist activities using weighing on the other are also involved. Both infiltrate the area at present under discussion of commerce. The introduction of coinage, though as I have argued probably leading to the systematisation of weights, did not in itself affect the commercial use of weighing: its effect would be to facilitate exchange, regularising pricing procedure. Even this effect probably came some time after the initial introduction of coinage,[11] but for significant changes to weight systematisation we can only start with the very end of the sixth century B.C., when the marked weight-series begin. For the actual application of these weights the evidence is rather later: beginning with Herodotus' reporting of the Delphic accounts (I am ruling out the Olympian/Sicyonian possibility of Paus. VI.19.1-4),[12] and continuing with Attic inventories and building accounts of the late fifth century, alongside which comes the important testimony of the late fifth-century comic writers (especially Aristophanes). I have argued that the development towards a fully standardised weight systematisation was slow; certain groups of weights appear associated with certain commodities and a clear variation existed between official and commercial contexts from the late fifth through the fourth century. This may have ceased to be significant in the fourth and third centuries, but by the late second century B.C. a distinction was maintained, now officially, between commercial and other weights (see IG II^2 1013; Pleket 14).

All this is to repeat the conclusions of chapters III-V. Though coin and official involvement introduced new elements and will be considered separately below, there is, however, little reason to suppose that this development of standard weight systems significantly affected the practice of weighing already described for the earlier period. Officially standardised weights would facilitate operations involving weighing in so far as their relative consistency would tend to enable clearer understanding of prices. A buyer would not have to assess from first principles (or with his own standard stone) the amounts he was

purchasing from different traders at different times. Similarly the seller could measure his profit more clearly by comparing the price at which he bought a certain weight unit against that at which he sold it.

However these advantages should not be over-exaggerated: there is no reason to suppose bargaining played any smaller a part in pricing than before; there were no absolute price controls (though the regulations on profit margins for sale of Attic grain in various stages of its manufacture into bread must point to a possible parallel in areas based on weight, rather than in the case of corn, on capacity); and further though official systematisation might guarantee consistency inside one area, it did not (and never did in classical Greece) extend necessarily to wider areas. The trader might indeed have found that the weights standard in, say, Sicily (where he bought) varied from those in Athens (where he sold).[13] It is interesting to note the strength of the commercial world's interests in standardisation opposed to the official: thus the demand for recognising "commercial" standards alongside the local ones (cf. IG II^2.1013). Even officials when operating in the commercial market were conscious of the problems; and in the classical period went to considerable lengths (and expense) to buy in the coin and measures of the states to which their suppliers (?) belonged.[14] The recognition of "commercial" systems was itself late (second century B.C.), and we must assume that earlier official attempts at standardisation (as mid fifth-century Athens) were to what the state rather than the traders really wanted, and proved abortive.

Though the introduction of standardised weight systems facilitated commercial weighing, there is no need for it to have affected the manner of such weighing. However, standardised weight systems do enable measurement to be carried out; and the evidence from the fifth century onwards is of an increasingly wider use of weighing, some of which involves weight measurement. We must now consider whether this evidence in fact points to changes in general commercial practice, and, where such changes seem to have occurred, who were involved and how.

The significant changes indicated by this evidence are four-fold.
(1) The increasing numbers of actual weights. The find places, sizes, and

in many cases the legends (e.g. Μετρονόμων, Ἀγορ[ανόμων] etc.) point to their application to general commerce. However the increase is only marked from the later fourth century B.C. Further, the simple presence of isolated weights does not indicate any change in type of weighing. Significant indeed would be series of weights in a single context but these have not been found, and are only attested from official accounts of centralised weight standards (those from which others are made).[15] The relevance of these series is to the manufacture of weights and their official checking; but not to their use.[16]

Secondly (2) can be noted the increasing official concern for weights and measures. At times the evidence connects such concern to actual commercial practice. It is in regulating this practice however, and is not properly part of it. The reasons for official concern and the people involved will be investigated below alongside other official weighing. Though earlier than the greatest increase in actual weights, official interest in weights simply attests the use of weights, while also accounting for the appearance of recognisable weights in the first place. The question at issue in this chapter however is how, and how extensively, such weights were used; more immediately whether a change occurred in the use of weighing in general commerce.

Thus the most significant changes indicated in the fifth century and following period are (3) the great increase in the range of commodities weighed for sale (for which see the evidence set out in chapter III) and (4) the introduction of unit weight pricing, involving measurement, in contracts (and related work). Even these changes can be shown to belong most especially to a very restricted (perhaps artificial) area of weighing, and are not necessarily relevant to general commercial buying and selling. Discussion of the first of these, the range of commodities, will largely also cover the argument to disregard (as evidence of general commercial practice) the second, unit weight pricing.

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The range of commodities weighed. This derives essentially from building accounts, or rather from certain building accounts which pay particular attention to weight and pricing by weight. In chapter III I

examined variations in weight systems on these accounts for evidence of external (i.e. commercial) practice, but the argument that such variations indicated non-official weighing systems does not imply that weighing was necessarily so widespread in practice in the non-official, commercial, context. The intense interest in weight shown by public-works officials may have forced the people with whom they were dealing into weighing where usually they would not have done so. This point will be pursued here in subsequent sections and I suggest that the degree of weighing on such accounts is more an extension from contract or inventory procedure. The independent evidence for the range of commodities attested as weighed in general commerce shows in fact that the practice was not much more widely used than in the earlier period already considered: certainly it was only in very special circumstances at all usual, as opposed to possible.

The firmest evidence is for the general sale of metal by weight. [Dem] 49.48-52 describes the problem of the loss of an amount of χαλκος (for which 1000 drs. had been paid). No one can be found to say whence it came (πόθεν) nor how (κατ' εμπορίαν ... ἢ ἀπ' ἀλχμαλώτων); no-one received it and no-one weighed it; and without being weighed, the speaker claims, it cannot have been sold or have changed hands (οὐ γὰρ δήπου ἄνευ γε σταθμοῦ ἐμελλεν οὔτε ὁ ὑποτιθέμενος <παραλήψεσθαι> οὔθ' ὁ ὑποτιθὰς τὸν χαλκὸν παραδώσειν)![17] An important qualification on drawing inferences from this example is clearly that the metal was in bulk (compare, where precious, bullion) and the general public cannot be expected to purchase metal this way. They would buy objects, after manufacture, and as objects.

Ar.Ran.1386f refers to the weighing of wool wet as a means of cheating:

ὅτι εἰσέθηκε ποταμόν, ἐριοπωλικῶς
ὑγρὸν ποιήσας τοὔριον ὥσπερ πάρια ...

Wool is known to have been weighed earlier, as just shown; and the danger of cheating in the weighing of wool, ergo evidence of the continued weighing of it, is repeated by the mid fourth-century Erythrae Decree, Pleket.4 esp.l.9: ὅσ[τ]ιν[ω]ν δὲ μὴ ἐχσέρ[ε]ιν ... . I have however noted no other reference to wool weighing, none to its measurement by weight.

Cheese is shown to have been sold by weight at Ar.Ran.1369, though it is interesting to consider if any further inferences can be drawn from

the equation of cheese selling to weighing here:

ἴτε δεῦρό νυν, εἴπερ γε δεῖ καὶ τοῦτό με
ἀνδρῶν ποιητῶν τυροπωλῆσαι τέχνην.

Nothing special is known of cheese-selling, beyond that it was done by weight: thus the scholiast glosses οἱ γὰρ τυροπρατοῦντες σταθμῷ τὸν τυρὸν πιπράσκουσιν. Surprisingly the weighing of cheese is not particularly well-attested on inscriptions.[18] The modern reaction to a comparison with cheese-selling technique in the context of distinguishing would be to think of an element in the selling peculiar to cheese-selling - in effect we should imagine the use of a wire to divide up sections of a whole cheese. It is possible that the implication of the τυροπωλῆσαι passage is that cheeses were similarly divided up (the division being checked on a balance); this is something different from the usual Greek comparative weighing of like against like (though it involves such comparison of course). The alternative implication, that cheese uniquely, or most specially, was sold by weight, would be remarkable, but should be allowed as an outside possibility.

While μειαγωγεῖν at Ar.Ran.798 is simply a reference to the Apatouria festival,[19] more general weighing of meat is possibly attested (for the late fifth century) by Ar.Vesp.39-41 where the joke is weighing meat fat (ὁ δημός) confused with weighing the people (ὁ δῆμος). Though barley and wine are measured in the Sphakteria rations (Thuc. IV.16.1), the κρέας is not measured.[20] By the third century, meat dealers had developed a specially suitable machine, the bismar described at [Arist.] Mech.para.20.853 B25 αἱ φάλαγγες τὰ κρέα ἱστῶσιν.[21] The way this machine is described indicates that it was used to measure the weight of pieces of meat, or whole animals (ὥστε συμμετρεῖσθαι πόσον βάρος ἕλκει τὸ ἐν τῇ πλάστιγγι κείμενον : 853.b.end). The weighing is not explicitly related to selling, but this must surely be understood. Meat after all cannot be subdivided like wool might or cheese. If sale was to be by weight it had to be by measured weight. This point was reached, but note that the evidence is only for the third century. Previously only fat was weighed, and that could be divided.[22] Pollux treated meat-weighing machines as worth a special title: Poll.10.108, 6.91 (κρεωσταθμη). This indication of specialism is significant and will be returned to later.

Back in the fifth century, Aristophanes refers to the weighing of figs for sale in very humble contexts. At Ar.Pax 1248-9 the trumpet-maker is to convert his trumpet into a one-pan balance:

κἀτό σοι γενήσεται
τὰ σῦκ' ἐν ἀγρῷ τοῖς οἰκέταισιν ἱστάναι.

The machine involved I discuss above (chapter I.2(1)); with a single counterweight arm, the weight of which was immaterial, it clearly was only suitable for measuring out the figs.[23] A more interesting point however is that figs are usually measured and described on official accounts as priced by measure, in capacity terms.[24] The Pax reference shows how commercial practice could prefer the more convenient operation of weighing, and was less concerned with absolute measure.

Not much later, in the early fourth century, Xenophon mentions indirectly that the Agoranomoi checked bread (ἄρτοι) on sale in the market: τὰ κάτω πρὸς τὰ ἄνω (Symp.II.20). I have suggested elsewhere[25] that the reason was probably to check for staleness (detectable by weight: cf Arist. Ath.Pol.51.1 also of the Agoranomoi: τῶν ὠνίων ἐπιμελεῖσθαι πάντων ὅπως καθαρὰ καὶ ἀκίβδηλα πωλήσεται). By Aristotle's day an actual weight seems to have been fixed by law for these ἄρτοι. Administered by the σιτοφύλακες (καὶ τὸν σταθμὸν ἄγοντας ὅσον ἂν αὐτοῖς τάξωσιν) 51.3, this set weight must not be confused with selling by a weighing operation. The distinction is important when we are, as here, considering who might be involved in weighing. The set-weight loaf could be considered as a constant unit and the Greek buyer would purchase it straight from the stall as does the modern housewife: only H.M. inspectors check the actual loaves. However, the baker must be presumed to have used weighing in the process of producing the set weight loaf: this is a special manufacturing context to be noted, but best kept separate from general commerce (see below chapter VII.1(2).1).

Wood can be shown to have been weighed generally for sale outside building accounts and inventory (though it is very frequently found in these contexts). The late third-century B.C. Delos inscription Pleket 10 (ID.509) lays down rules for the apparently open trade in wood, which had to be sold by weight (the weights and balances being specified). I have already commented upon the use of the single talent weight unit for wood, and suggested that, despite the late date of this inscription, the unit, and the practice, may go back well into the earliest period though no references for it there exist.[26] Very many

references to talents of wood occur on inscriptions.

Finally I should note here the public sale by weight of purple-dye. Again the evidence is a single, late reference: [Arist.] Mech. Section 1. 849.b.35 οἱ ἁλουργοπῶλαι. These traders are cited to illustrate a form of cheating with the two-pan balance.[27] It is surprising, and incredible, that only traders in a certain commodity should so cheat, yet this implication seems unavoidable: unlike an Aristophanic "particular for the general" (as just possible for τυροπωλήσαι above) there is little place for humour here in [Arist.] Mech. The explanation must be either that the traders are themselves a particularly suspicious group,[28] or that their weighing dye is somehow peculiar (as argued for τυροπωλήσαι in effect above). A clue may lie in the fact that dye was very expensive;[29] so that cheating would be really significant. Alternatively, as [Arist.] shows that one side of the balance is meant to incline in favour of the seller, we can suggest the peculiarity lay in the essential selling by weight of this commodity. Probably both explanations together best account for the reference.

I can find no other commodities described as being weighed for sale in contexts other than the official accounts (state or temple). The effect of the list I have considered is to extend the earliest range of commodities by 3 items (cheese, meat-fat, figs) in the fifth century B.C., and further by 4 items (bread in the fourth century; wood, meat, purple-dye in the third century) in subsequent periods. One of these last (wood) is likely I feel to have been weighed very early.[30] More significant than the slightness of the quantitative change, however, is that some qualifications in general on the extent of weighing are indicated by several of the references discussed in that they very much narrow down minor variations in the procedure used (especially cheese, wood, meat, and purple-dye). Raw metals may be more widely handled by weight by the fourth century B.C.; but it is important to note that the most general selling contexts are those in which use of weights is explicitly ruled out (cheese, figs, meat-fat; the checking of loaves in the early fourth century also could be included here).

Natural explanations for the greater range of commodities weighed on official accounts could be (1) that many of these commodities are too expensive for normal individual buyers (especially gold, ivory, etc.),

but also (2) that they are being bought in bulk with different pricing procedures. Thus for example δικελλαι are bought in quantities by fourth-century Eleusis, fourth-century Delphi and third-century Delos priced per stater weight; surely the small farmer would buy these individually at so much a δικελλα . The difference is accounted for by bulk difference, but also (3) by the large bulk order, being as it were a special order, and reaching down towards the sort of considerations relevant in contract work (materials involved, labour, and so on). This will be pursued following below. A further explanation (4) is suggested by the consistencywithin certain accounts, and the variation between accounts, in the manner (and fulness) of recording transactions involving the purchase of materials or the pricing of materials.[31] Lack of full weight detail may not imply weighing did not take place (as quite clearly many contracts are inadequately specified on accounts). Nevertheless, there is room also for the suspicion that the officials (who were not professional contractors) have operated a procedure of purchasing properly applicable to only certain commodities (I should in fact restrict it to experience of temple inventory procedure),[32] in all their purchasing. The procedure is therefore not at all typical. Furthermore this suspicion is supported by the fact that the official accounts were publicly displayed and such precision as unit weight pricing would involve would then be seen to have been used, and in consequence be commended.[33]

These considerations indicate that the sort of records that survive of large-scale, public building operations are not necessarily typical of normal general commerce. As far as the range of commodities weighed is concerned, these records should not be used to counter the independent evidence that weighing was hardly more widely used in the classical and later period than in the earlier. The procedures indicated by the building accounts, if they actually took place, involved certain groups of individuals that can properly be regarded as specialists as opposed to the normal trader of general commerce. They are the amateur officials, manufacturers, and their assistants. The rare overseas trader, with contacts outside, or on the edges of the Greek world, are equally apart. Thus for the third-century Delian purchase of two elephant tusks: IG XI (2) 203.71 priced with reference to a unit weight; or the copper merchant who was to obtain his copper from Marium in Cyprus for

columns at late fourth-century Eleusis: IG II^2 1675 (SIG^3 971).

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This point applies also to the principle of unit weight pricing which I have not found attested outside official building accounts. For examples: the χαλκός from Marium mentioned above is used in an operation priced per mina of χαλκός used (μισθώσεται δὲ κατὰ μνᾶν IG II^2 1675.26-31); at fourth-century Eleusis δοκέλλαι are purchased @ 1 dr. 2 ob. per stater IG II^2 1673.51; tin is transported for Delphi at a price per unit weight: FdD III(5)25 [SIG^3 247] I.3-6. I should however argue that this procedure is not an indication of general pricing by weight: it is rather dictated by the context, invariably that of contract work, and only involves those immediately concerned with large public works. A short digression on the contracts of Greek building will be necessary here.[34]

One of the greatest difficulties in supervising building operations, experienced both by the builder (contractor, if not his irresponsible workmen) and much more by the non-professional employer (the Greek temple commissioner), is the estimating and control of time and materials. Without such control, costs can escalate and completion be endlessly deferred. The Greeks experimented with several procedures, penalties and costings, though only with the latter are we here concerned. An early procedure of costing, used for building on the fifth-century Acropolis at Athens, was for officials to purchase materials needed themselves and then hire workmen to work the materials on a time basis. Alternatively officials (e.g. for the Asclepeion at Epidaurus, early fourth century) let out a block of work to a single "contractor" for a lump sum (and against a time limit). Through the fourth century it became more usual to decrease the size of work done, and to pay for time and materials (supplied by the workmen): thus later Epidaurus and Eleusis for example. Even if no less open-ended in many cases than earlier procedure, such contracts enabled the officials to itemise work actually completed (the contracts being for smaller pieces of work) and to control, or appear to control, more closely, the work being carried out.[35] More importantly I believe the procedure enabled both employer and employee to work together towards the completion of the job which neither was competent to estimate accurately (and so without loss to one side or the

other) at the outset.

Weight unit pricing can therefore be seen more plausibly as the result of a need for a type of open-ended costing that could take into account the amount of material to be used without that amount having to be estimated at the start of an operation. It need not have been brought about by the fact that the builders involved necessarily handled their materials in such a way. The measurement comes only in the final reckoning; the basic unit costed is no different essentially from the ad hoc unit of general commerce.

This point is further confirmed by the variety of ways in which unit costing was operated: weight being the least usual basis, as opposed to linear or capacity measurement. Consistency cannot be found even for gold: bought in πέτταλα for the Erechtheum, but sold by weight for the Parthenon.[36] Such references could be expanded at length; but only a comprehensive analysis would properly be justified, and that is beyond the scope of this thesis.

Unit weight pricing, though measuremental weighing, should best be regarded as closest to measuring-out repeated amounts of set unit weight (the price of which has been bargained for as in normal commerce).[37] The difference lies in the requirement of the particular building context, and so, finally, only those involved in such contexts are concerned with the measurement.

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In conclusion, the contrast between two passages already cited, Ar.Pax 1248-9 and [Dem.] 25.46, can be considered. The former describes the selling of figs in standard but unmeasured weight units (on a single pan balance); the implication is that the procedure was very general (sold to countryfolk). [Dem.] on the other hand compares the sycophant to a trader who all but sells his wares with balance and weights. I have found no evidence to support the view that weights (plural) were used in general commerce, apart from meat selling (and classical Greeks rarely ate meat).[33] The use of several weights implies a form of measurement, and that is only to be found in unit weight pricing in the highly specialised context of public works contracts. Even there the measurement involved rarely other than a standard (repeated) unit.

A further argument derives from the lack of complaints about weights and weighing. Greek weights were wildly inaccurate;[39] yet there is no reference to their falsification.[40] The crimes of IG II^2 1013.15-18 and 56ff are anticipatory; and the decree is of course very late, second century B.C.. The only complaints I can find are about weighing, and these are restricted to the sale of wool wet (where it should be sold dry: refs. collected above), and purple-dye sellers ([Arist.] Mech Section 1). The operation of a two-pan balance is indeed difficult to falsify (as opposed to single-pan models), and the cheating of the purple-dye sellers was highly sophisticated.[27] This virtual lack of reference to complaints about fraudulent weighing, and especially weights, contrasts strikingly with the many instances of short measures of capacity and simpler quality-shortcomings in general commerce (Ar. Eq.1009 μετρεῖν κακῶς (ἀλφιτα); Nub.640 with Eccles.424 (ἀλφιταμοιβοί); Thesm.347-8 (χοῦς and κοτύλη , of drink) and Plut.435-6; Theophr.Char.30. 11). This contrast can be significantly pursued by comparing other Near Eastern cultures especially Hebrew and Mesopotamian (see further chapter IX below.) In these, cheating with weights and weighing will be shown to have been central to the general suspicions surrounding traders' profits. Greeks suspected and despised traders, but not for any such reason.

The same conclusion was reached with regard to the general Greek attitude to weighing as expressed indirectly by the passages discussed in chapter VI. There was no place for measuremental weighing, and no concern for accuracy, especially in relation to weights (absolute). The emphasis in general on distinction, comparative weighing, basic in literature and in pictorial representations, precisely suits the sort of operation I have argued to be typical of the general commercial context: the use of an overbalancing machine, and a single weight unit (ad hoc, and possibly simply an amount of the material weighed out). Standardisation helps such weighing in enabling separate transactions to be (roughly) compared;[41] but standardisation is not essential.

The extent of such weighing in commerce is a further question. It is not likely to have been considerable - the farmer surely bought his δικελλα as an item for 2 dr. etc... I see no way to pursue this further. As I have removed the apparent paradox (weights but no measurement; and

the non-measuremental, like against like, general attitude to weighing), there is no need for further limitation on the quite general use of simple overbalance, comparative weighing. No balances have survived, but they were probably of perishable materials, and weights have survived in fairly high numbers. Furthermore the procedure I have described for weighing has distinct practical advantages - immediate, quick, and psychologically acceptable to commerce.

[Dem.]25.46 cannot however be ignored. I have perhaps already indicated in my initial paraphrase how I feel it should be understood. The sycophant is not an ordinary trader, nor even a dealer or μεταβολεύς[42], but he "all but sells with balance and weights". I suggest the reference is to a particular specialist trader, who is extraordinary in that he uses such paraphernalia (the phrase comes in [Dem.]'s rhetorical list, and is even then qualified by μόνον σ̓). He may have been a butcher? or a metal dealer?

In the remainder of this chapter I shall consider the various possible (and then improbable) specialist contexts for weighing in ancient Greece.

1. (2) Manufacturing processes

In the preceding discussion of buying and selling it was shown that many commodities, sold or handled by weight, were in fact only weighed at an earlier stage of their manufacture. The commercial market appears to have accepted such weights, with occasional checks upon them by officials. Here I shall collect the possible areas of weighing in manufacture and consider the part of weighing involved. Again it can be shown to be not necessarily measuremental.

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1. Bakers. Bread was sold by weight and the "full" weight or consistent weight, was regulated by officials (Arist. Ath.Pol. 51. 3; Xen. Symp. II.20 See above in VII.1.(1)). The bread being sold as loaves (ἄρτοι), clearly only the bakers could affect the weight involved when they were in the process of making them. The implication of the singular defined weight (of Ath.Pol. 51.3) and of the check-weighing between loaves on top and underneath on a stand (of the Xenophon passage) both imply a single set weight. The bakers were concerned to repeat this weight in each loaf they made. Thus in the first place no measurement is involved.

The reason for weight regulation presumably was to ensure that bakers kept up to a certain weight and did not seek to profit by underweight loaves. The Xenophon passage is a slight problem here as it implies loaves singly weighed against each other: partly for this reason I have suspected that the check is rather for staleness than full weight, and Ath.Pol. 51.3 would certainly support the view that the σιτοφύλακες, rather than Xenophon's ἀγορανόμοι, were properly concerned with the absolute weight. The point in controlling absolute weight here is that the price was also fixed by the price of grain (καὶ οἱ ἀρτοπῶλαι πρὸς τὰς τιμὰς τῶν πυρῶν τοὺς ἄρτους καὶ τὸν σταθμὸν ἄγοντας ὅσον ἂν οὗτοι τάξωσιν Ath.Pol. 51.3). This price of grain was by capacity measures,

and formed part of a series of controlled profit margins back to the original importer.[43] It can therefore be supposed now that the bakers were concerned to approach as close as possible to the minimum weight requirement, the officials concerned that the loaves weighed at least this minimum weight. Given the undesirability of prosecution, it is clear that the latter concern was the predominant one for both parties. The requirements are therefore ideally suited to over-balance weighing.

The bakers should however be absolved yet further of close involvement with weighing. It is likely that they operated entirely in capacity measures rather than weights. First, the chain from importer of grain to baker, who bought grain, operated ~~entirely~~ in capacity measures. At least one side of the baker's business was therefore priced in capacity measures. Second, to allow for any estimate of profit after selling baked loaves, it is necessary for some capacity measurement at some stage to be taken of the ultimate loaves. Without direct evidence of baking processes it is nevertheless reasonable to suppose grain was measured out by capacity for individual loaves.[44] I do not think it necessary to insist that grain or flour or dough was so measured, as long as at some stage such measurement[45] took place. This was sufficient for the baker's operation of his business:[46] and, thirdly it is only as an independent check, for the benefit of customers, that weighing of ultimate loaves occurred. Consideration simply of why weighing at all was involved of baked produce, should show that the consumer (represented by the official) and not the baker was concerned to perform it. Loaves could not be measured by capacity (given the nature of bread); but equally unbaked dough cannot usefully be weighed in any way that corresponds to the ultimate product that is checked outside the bakery on the market stall.

Bakers, in conclusion, appear to have baked with a finished minimum weight in mind but without weighing until that stage was reached. The chemical, let alone physical, variables of the baking process imply that they cannot have worked to a single precise weight; rather (as with modern bakeries) they operated to a minimum weight by ensuring that their products went over that minimum. Those most concerned with weighing loaves appear to have been market or corn officials, rather than the actual bakers, and rather than (as already said) the potential customers: so see further VII.1.(4) below.[47]

2. Common metalworking. Under this heading I mean to include all handling of metal that is not either weight- or coin- making (to be discussed in the two remaining parts of this section). As metals were generally measured by weight by the late classical period (extending from the early measurement only of gold), this is clearly a more likely context for manufacturers weighing than the grain chain just considered. The evidence however is slight, and, as regards weighing, particularly unhelpful. The few points that can be made do not amount to a complete account of the subject: they will be considered in the order of manufacture from mining to finished article.[48]

I have found no evidence of weighing at the extraction stage. Parallels from other commodities would suggest capacity, linear, or rough load measurement to be more likely: thus stone dust usually in medimnoi (IG ii.^{2} 1672.108,198,199,200,207; IG xi. 203B.101; Burford 21.C.103f) more rarely in metretai (IG xi. 146.70,74); stone, for transport, measured linearly (IG xi(2) 199.77; 199.C.27ff; 203.B.11,12,14,91) or by piece (IG xi(2) 203.B.14; 204.51); wood measured by waggon loads (IG i.^{2} 313.100-1; Burford 10.162ff; 21.B.17,30,107,143f,159; 21.C.22; Polyaen. Strat. 4.3).[49]

The operation of purification (ore to metal) results in a solid lump of metal. Practical considerations demand not only that this be handleable, but also that the size of the lump (determined by the mould, repeatedly used) be constant. This I feel alone to be sufficient explanation for apparent standardisation of metal spits or ingots.[50] Whether ultimate weight standards developed from such standard ingots, or whether the ingots were made to reproduce a weight standard (and why not, when such standards existed?), does not greatly affect our present consideration of practical weighing. Once a mould size has been found to produce an ingot of suitable weight no further weighing need be involved. Ingots, or spits, indeed continue as units of measurement into the period when their weights could be measured in systematic terms: thus the κρατευτάι of lead at IG i^2.371.12-13, though the variability of such sizes is perhaps the most noticeable feature of the weighed tin spits of IdD. 320.B.66 and 442.B.170ff (end third-century to early second-century Delos).

Metal was certainly bought and sold by weight. This has already been noted above in the section on commerce.[51] Those involved seem however

to have been only the officials of building commissions and particular metal dealers, or manufacturers (the two last being most usually identical - thus the single account for new drills to replace old ones sold as scrap on late fourth-century Eleusis IG II^2 1673.53-54, or the copper contract specifying origin of metal, again Eleusis, IG II^2 1675). The problem is to decide whether the apparently excessive detail, and constant weighing, reflects normal metal-handling procedure or rather the desire to check and control (and to be seen checking and controlling) on the part of the officials concerned. In the preceding section I argued that the whole operation was removed from general commercial requirements, but it could be urged that building commissioners, because of the scale of public works, bypassed retailers and dealt directly with importers and metal manufacturers who did use weighing techniques. The issue is not easy to settle, but I incline to prefer over-assiduous recording by officials as the major explanation for the large body of evidence of metal weighing.

Four reasons seem to indicate this: (1) officials did the weighing or supervised its performance); (2) metal-workers presumably operated with bulk ingots (which whether of standard weight or not need not have been weighed for use) or moulds, and precision technology (minimum weight metal for a certain function) cannot be postulated; (3) at no earlier stage, in metal extraction or purification, ~~stages~~ were weights involved; and equally, as will be shown, in subsequent; (4) inter-state standardisation of weights was not achieved till well after the classical period and the metal came from outside to most major Greek building sites. On the other hand (1) that there is a recognisable difference between weight systems of commercial and non-commercial contexts[52] must indicate that the commercial sector (the metal dealers and manufacturers in the present context) used weighing to <u>some</u> extent in its own operation of buying and selling. (2) The conduct of metal businesses, especially in the calculation of profit margins, surely demanded some way of measuring materials purchased against those sold. The point was made above of the grain chain, it recurs below in coin manufacture: metals seem best measurable by weight. The argument is inconclusive, but I should end by modifying this last point: ingots of standard mould-size (even if of standard weight) are also measurable by fractions of themselves; weight, but also linear measurement is here possible. Such alternatives to absolute weight

measurement are important to recognise, and are, I believe, supported by both general considerations of Greek approaches to weighing and by a further aspect of metal working yet to be examined, the actual handling and use of metal.

Though there is evidence for weighing in the handling of metal there is none for its measurement by weight. In a sense this point is obvious as most metals have to be melted in order to be moulded, and the conditions in which such temperatures might be achieved hardly lend themselves to the introduction of a wooden beam balance. Nevertheless the point can be illustrated from the mixing procedure for alloys: the proportions of such mixes are expressed without reference to weight: thus fourth-century Eleusis IG ii^2.1675 specifies that 11 parts of copper (from Marium in Cyprus) are to be mixed with one part of tin. The contract is indeed priced by weight of copper used, but this is open-ended: the metal worker is to use his own system to achieve the desired 11 : 1 ratio. Practical considerations demand that sufficient alloy be prepared for the job in hand but also according to the capacity of the furnace, cauldrons etc. at the worker's disposal. Thus the open-ended metal-working contracts, which, I have suggested, derived from the difficulty of estimating total amounts in advance. There is a need for consistency between mixes where several are involved, and it would seem likely that such mixes (especially the last, if wastage was to be avoided) would vary in size. To my mind the simplest, and entirely satisfactory, method of achieving a variable output, but consistent mix, is to measure-out multiples of any suitable basic amount. No reference need be made to the absolute values of such a base, and like should be compared with like. Such measurement can be by capacity,[53] but more flexible (as well as more practicable with metal) would be comparative measuring-out by means of a weighing balance. This I suggest is the explanation for the scene on the Vienna Oinochoe: Rep. C.4.[54]

I am therefore far from convinced that general metal-working involved measuremental weighing to the extent that official building accounts might suggest. It can be argued that the manufacturers, as in the twelfth-century bronze-age foundry at Enkomi in Cyprus,[55] manufactured balances but did not themselves possess them. Roman blacksmiths' forges illustrated with detailed instruments are not shown to have had balances (SEHRE^2 pl. XXXII.1, XXX.4). Different are Roman goldsmiths' workshops,

for example the House of the Vettii painting of a jewellery shop with no less than three different sizes of balances (SEHRE[2] pl. XV.3 and several "aurifices" stelae).[56] This difference clearly reflects the higher value of gold. It must also be allowed for the Greek metal-workers in view of the early evidence for the weights of gold. However, these weights are (by virtue of the preciousness of the metal concerned) a description of value, and not measurement specifically of quantity either for manufacture or sale. The distinction is nice but important, and especially for the question of coin manufacture which must now be considered.

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3. Coin making. Coins of precious metal are an important limiting case of more general metal-working techniques in so far as small amounts of the metals involved must be carefully controlled. They also move this discussion much closer to the subject of weighing in that coins were valued and described as weights, were used as weights, and played the most central part in the development of weight systems in ancient Greece. Use and handling will be considered in the next section (VII.1.(3)) and official control in the following (VII.1.(4)). For the present I wish to examine the actual manufacture of weights: first coins then the more bulky lead and larger weights proper in the remaining part of this section.

Very little evidence exists of how coins were manufactured in the earliest and classical periods which are naturally the most important for this study. The use of dies to produce types can be inferred from resultant coins, but this does not approach the basic problems of (a) how equal weight flans were produced, and (b) how their weights corresponded to a standard and to the subdivisions of a weight system. Several processes can be conjectured[57] for reproduction of equal weight flans: apart from weighing, there is the mould technique (evidenced rather later[58] and noticed by tags on the sides of coins where moulds have not survived): and the possibility of linear measurement (either slicing off a thick bar at small regular intervals or taking certain lengths of thin metal wire[59]). The problem of correspondence to a standard and its subdivisions, while apparently quite easily answered by postulating the use of weighing, is in fact much more complex. Such correspension begs the question of whether coins and their fractions reflected weight systems and standards

or produced them, and also whether any validity attached in practice to the weights of small fractional coins.

I have already indicated above that I believe coins preceded weight systems and that the higher weights appear to have been brought into line with the central coin unit.[60] Lack of concern for the weights of fractional coins (and also of the larger ones) will be seen further from the general disinterest in their weights.[61] This need not apply to the manufacturing mint of course, but there also it can be shown that interest was not focussed upon the weights at least of individual coins.

First an intriguing paradox. Several coins were produced of incredibly high accuracy,[62] clearly beyond the capability of any likely ancient Greek weighing machine.[63] On the other hand many more coins than should be expected if their weights were of real concern, were inaccurately minted. This applies especially to certain fractional coins where inaccuracy is greater than the subdivisions the coins are supposed to represent. The point can more precisely but also more generally be made, that Greek balances are unlikely to have been able to detect less than 0.2 gm so that 6 Attic obols could be as much as 2 obols over the true drachma weight. Both these considerations apply to the mint manufacturing coins, not simply to the general public's use of coin and appreciation of mint activity.

A second argument arises in part from this first. Not only did the Greeks lack balances capable of accurately weighing the smaller fractional coins comparatively; but they also lacked small units with which to measure the fractional coins, except, that is, in fractions of the standard coin unit.[64] There is no evidence of the naturally occuring small weights (seeds or grains) being used by the Greeks though there possibly is for other Near Eastern cultures and of earlier dates. Given the lack of these lower weight units the problem of arriving at fractions of a standard coin weight (say the drachma) by weighing were great. Not impossible - as trial and error and equivalence procedures could be used; but as the weights become smaller in such a process the likelihood of the limit of the ancient balance intervening is increased.

In other words construction of these coin weights cannot have begun by measuremental weighing; and the fractional coin weights themselves are unlikely to have been reproducible by weighing in general. Such weighing

as would take place in coin manufacture could only be comparative (rather than measuremental), as lower units (for measurement) did not exist. Two further arguments will show the use of weighing at all as unlikely, and suggest a much better alternative for the manufacturing stages.

Thirdly there is no evidence that mint equipment included a balance (despite Seltman GC^2.21 who begins his list of such equipment with the πλαστιγξ). Mint weights are mentioned on the late second-century decree IG II^2 1013.30 (Pleket 14) πρὸ[ς] τὰ στάθμια τὰ ἐν τῷ ἀργυροκοπίῳ but none earlier can be securely identified.[65] But more significantly no weights are noted as left over in Athens with the anvils (obverse) and punches (reverse dies) when the late fifth-century gold series, on different weights to the silver, was terminated.[66] No one in the mint is mentioned as responsible for weighing.[67] This largely negative picture must amount to strong evidence against weighing playing a part in the individual manufacture of coins (I shall return to the relevance of weights at an earlier and later stage in the production below).

Fourthly no official decrees instruct the mint to maintain particular accuracy in weight.[68] I have argued already that ~~Even the profit involved, or~~ the cost of minting ~~is~~ could be more likely to be expressed, in Arist. Ath.Pol.10, in terms of the coin ultimately produced rather than as a percentage of any weight involved.[69] Regulations for the mixture of gold and silver in the electrum coinages of Mytilene and Phocaea make no reference to what this mixture was to be.[70]

The obstinacy encountered so far in the evidence for the determination and production of small coins, and fractions, has been entirely generated by the need to consider the possible use of weighing. In fact a much more practical method can be suggested, which is not only more accurate, but also fits the characteristics of ancient Greek coin weights. My suggestion is that the basis of coin flan production was thin wire of the metal involved, cut and subdivided to the required fractional lengths. Though I have noted no positive evidence to support the suggestion, this may be due to the fact that scraps of thin wire have not been thought relevant to mint work. The likelihood of odd pieces of metal being thrown away[71] seems moreover much greater with this method than others, especially the mould techniques. Nor is it necessarily important if a high accuracy or consistency in wire diameter proved impossible. Wire of the size and consistency as was used in Greek jewellery was fine enough

to make negligible the errors variable diameter might introduce to the (not inconsiderable) length of wire needed for even small fractional coins. Equally the variations between differently-drawn pieces of wire can easily account for coin weight variations (i.e. with fractions simply measured off a continuous length rather than being subdivisions of a controlled total unit length).

If weighing need play no part in the actual manufacturing process of coin it would be wrong to infer it was totally irrelevant for the wider operation of the mint. The mint weights of IG II^2 1013 play their part in this wider context. Three different occasions can be suggested, but a fourth (individual coin weighing) is most unlikely.

First, is the maintenance of proper standards once established. This is indeed the sort of operation envisaged in IG II^2 1013; it involves the checking of coins against the higher weight unit (mina) to which they were supposed to be related in a certain ratio. Second, such a check might equally be made of bullion lumps from which the proper number of coins was eventually made by a procedure similar to linear subdivision described above. Some confirmation can be found in the facts that mint charges were calculated in terms of the higher, non-coin, weight unit, and that standards were described as so many drachmae to this unit. The sort of weighing involved in both operations is straightforward equivalence-weighing.

Thirdly, can be considered the operation of exchanging coin for bullion (or old worn coin to be reminted?). There is no evidence for how coin reached the general Greek public apart from state payment. Temples surprisingly seem to have hoarded their old coin rather than turn it in for reminting.[72] At Athens the silver mines were only operated by contracts from the state; the procedure for handling the silver ore - bullion is obscure; it involved private individuals and we might suppose some of these were faced with the problem of taking bullion to the mint.[73] In other states importers of bullion would certainly fill this role. The context I am moving towards is the way the mint buys the bullion or sells its coin. The customer cannot be expected to wait for his particular bullion to be coined (nor be expected to trust, without a measured receipt, the amount received). It seems likely that the mint would set coin against bullion - then subtract the mint fee from the coin found equivalent in

weight to the bullion. As a sort of sale the overbalance principle of weighing apart from minimising inaccuracy, would ensure satisfied custom. The fixed charge would be made to cover the minor loss to the mint involved. Again the weighing is comparative, not measuremental (as the charge can be taken out of the final number, or amount, rather than weight, of coin), and does not involve necessarily amounts as small as individual coins.

Fourthly we might ask whether individual coins were ever checked for weight as part of the minting operation. There is evidence for supervision and control - thus Delphi late fourth century FdD III (5) 74.57f.[74] - but not explicitly of weight. Suspicion is confirmed by the fact that official decrees concentrate on type-face being in good condition, and metal content (though unspecified) consistent. This will be pursued in the next section when the handling of coin outside the mint is considered. There is no evidence for the weight-checking of individual coin in the mint; the arguments adduced above of excessive accuracy and inaccuracy tell against its being used in general. A further (practical) objection to individual coin weight-checking is furnished by the sheer mass of coins minted that might require checking. It seems to me that the position reached greatly underlines the importance of postulating minting techniques that could break down higher weight units into controlled subdivisions without the use of weighing (i.e. the linear wire-cutting technique suggested above).[75]

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4. Weight manufacture. I have already suggested, in chapter II.1 (1).iv, that public weights were probably made by the state mint. The two operations, coin and weight production, have much in common. However the larger weights present several characteristics that could point to a more likely use of weighing in their manufacture. Again, each of the following indications of such a possibility encounters some difficulty.

First, because they are higher units than coins, weights can be expressed as multiples of such lower units. Coins are used independently as weights,[76] so there seems to be no objection to their being used to produce larger weights. Basically this point obviates the difficulty with subdivision encountered above in considering coin manufacture. A

valid objection here however is that not all larger weights are in fact multiples of lower coin weights. The 1/3 and 1/6 etc. staters and minai cannot be expressed in round numbers of drachmai in the Attic system, yet these are apparently the most common weights.[77]

Secondly, the larger sizes, and indeed also the greater general inaccuracy of actual weights, do not raise the same difficulties for weighing precision and accuracy that the coins raised. But it is only fair to object here that they are generally far more inaccurate than it seems reasonable to suppose Greek balances (on the over-balance principle in particular) would be-even in the clumsiest hands.

Thirdly, the most popular material for actual weights, lead, is easily trimmed.[78] Few weights however of the Agora series appear actually cut: their adjustment[79] consisted mainly of tampering with a still-soft moulded piece resulting in blurred but round edges. Clearly such adjustments were subsequent to the manufacturing process in which the weight received its symbol. As the later check-stage involved weighing it is improbable that the earlier did also. Bronze weights were clearly cast, and although infrequent, the technique for making bronze weights seems most likely to have also been used for lead.[80]

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It would thus appear that manufacturing processes did not in themselves involve weighing though the control of an end-product (and so the initial determination of tools, moulds, lengths of wire etc.) might be related to an equivalence check. Exceptional are elements of metal-working - for example the alloy technique which could be done by weighing out multiples, but was not measuremental. The commercial context of metal-working and the fact that it was handled and priced by weight, involved most people in the weighing. Those most interested, as indeed only interested in checks elsewhere, were public officials.

1.(3) Coin handling

It is generally believed that the value of a Greek coin was determined by its weight. Though probably the most convenient statement, this does not, however, properly reflect the Greek approach to coinage in practice. This was not consistent: for though coins were used as weights, their weights do not appear to have been individually checked, nor concern felt for them. A great deal of trust was placed simply in the ability of the mint to produce coins of good weight and good metal content and neither was subsequently questioned. The general implication would appear to be that most Greeks felt inadequate to checking the former (as they could never, until Archimedes, have checked the latter).[21] In practice, therefore, somewhat paradoxically, the value of a Greek coin determined its weight.

The questions surrounding the weighing of coin have been touched upon at various points in earlier chapters. Here I shall briefly review the more important, though largely negative, pieces of evidence.

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There is no indication that officials or private individuals checked the weights of individual coins in circulation. No decree stipulates weight control, and it is only relatively late that demands for coins being of full-weight appear. The evidence is collected in Appendix E. From the various coinage decrees it appears that emphasis was laid exclusively on coin type (see especially the 375/4 B.C. Attic law AS I.7180; and other insistences on conformity in coinage used, as the mid fifth-century Attic decree ML.45, the later SEG X.87, the parody Ar. Aves 1040-1, Polybios II.37.10). Aristotle's theoretical account of coinage shows clearly that Greeks felt that the type was sufficient (τὸ δὲ τελευταῖον καὶ χαρακτῆρα ἐμβαλόντων ἵνα ἀπολύσῃ τῆς μετρήσεως αὐτούς Pol.1257.a.40f). Even the late second-century

Attic decree regulating commercial weights in terms of coin drachmae (IG ii^2. 1013) makes no reference to the individual accuracy of these coin drachmae, and I have already noted that there is no reason to suppose (independently of the present discussion) that anyone in Greek mints was able or responsible or concerned to check the weights of individual coins. The first official check on coin weights comes from outside: in the Treaty of Apamea (188 B.C.) the Romans stipulated a minimum weight for Attic coin, and this was in terms of Roman pounds (Polyb. XXI.42.19; Livy XXXVIII.38.13).[82]

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A cautionary note can in fact however be found, and it ~~is fullest~~ can be placed squarely in a "commercial" context. Thus the agreement concerning the repayment of loans made to the city of Arcesine (Amorgos, end fourth or early third century, stipulates the coin as νόμισμα (Α)ττικὸν ἢ Ἀλεξάνδρειον ἢ Δημητ]ριεῖον ἐλοσχε[ρ]ές, δόκιμον, [ὁ]λόκληρον, ἀνεπίφορον, ἀτε[λές] πάντων (IG xii (7) 69.21-23). The last three of these epithets refer simply to the status of the coin,[83] i.e. no other claims apply to it. Δόκιμος should imply no more than "official and current" (as opposed to παλαιός or ἀρχαῖος cf. IG i^2. 310.195; ii^2. 1533.7-8; 1542.10; 1544.12f or to more obvious counterfeiting: στατῆρες κιβδηλοι παρὰ Λακωνος (!) IG ii^2. 1388 61-2 etc.). Some element of control (some δοκιμασία of sorts) must be assumed; but there is no necessary implication of weight control.[84] As already concluded the mint itself cannot have checked individual coin weights, and no officials seem to have been interested. Besides, room must be left for the epithet which seems to come closest to concern for weight: ὁλοσχερές.

The word does not necessarily mean of full-weight, though the implication may be there. Compare [Soph.] fr.1127.4 where used of a man; and see further references in LSJ, suggesting completeness rather than completeness in any particular sense. Greek coins suffered from more than weight incompleteness - they could be bored for string suspension; corrosion is possibly noted: see IG ii^2.1400.49-50 (ἀργύριον ἐπιπηκτον);[85] and at least one example of "clipping" is known - IG xi^2.158.A.5 early third-century Delos τετράδραχμα χαλκᾶ δυο καὶ παρερρινημενον ἓν.[86] It is surprising that this is only found mentioned of bronze coinage. Finally, is the manifest incompleteness of the stamp on so many Greek coins.

This called for some comment in antiquity - DL Vita Philosoph VII(1)18 citing Zeno (late fourth early third century). Zeno's point however was to support the older Athenian coins which, though carelessly struck, nevertheless were of better weight than the more artistic Alexandrian products :

> εὐοφθάλμους μεν και περιγεγραμμενους καθα και το νομισμα, οὐδεν δε δια ταυτα βελτιονας · τους δε τοὐναντιον ἀφωμαιου τοις Ἀττικοις τετραδραχμοις ὡκη μεν κεκομμενοις και σολοικως, καθελκειν μεντοι πολλακις τας κεκαλλιγραφημενας.

I shall be returning to this passage shortly below, for the present we should note that perfect minting was not, in Zeno's mind, what made a good coin.

Ὁλοσχέρες, to resume, on the Arcesine inscription probably should be taken as a reference to weight. Of other occurrences when it is used of coin, one is uncertain: IG XII (5) 593.7 (Ceos), but the other: IG XI (2) 287.B.143 (mid third-century Delos), offers strong confirmation for weight. This is a reference to the weighing of part of the temple inventory: προς ἀργυριον Ἀτ(τ)ικον ὁλοσχερες.

Though coins were certainly used quite generally as weights, only on this single occasion at Delos have I found their proper weight apparently a matter for concern.[87] Equally no other documents insist on ὁλοσχερες quite as forcefully as that cited from Arcesine above. Zeno's comments therefore only underline the problem, as he seems to indicate that coin weighing was somehow frequent (καθελκειν μεντοι πολλακις ...). In that this weighing was the comparison of old Attic 4drs with Alexandrian, we may have an indication of another context in which coin would be handled possibly by weight - money changing.

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Money-changing is an attractive, perhaps obvious, context for the frequent weighing of coins. The Greek world possessed an unwieldy number of mints. Most places specified the use of local coinage, and exceptions appear only to have been made for the few large, well-known coinages such as Attic or Alexandrian (as the Arcesine decree above). Though temples might be glad of donations in any coin, the result could be an embarrassing accumulation of local variants (cf. contributions especially in third-

Century Delos e.g. 161.B.19-21; but much earlier also fifth-century Athens IG I^2 310 leading up to an attempted total of ξενικον ἀργυριον συμμεικτον ἐπισημον σταθμον τουτο ... - (11.298-305): local coinage could be simply accounted and was not weighed). Though no problem for local trading (for which Aristotle's point about coinage facilitating matters applies), the operations of inter-state traders would be greatly inconvenienced by coin changes. As many such traders existed, it seems certain that money-changing was very widespread. The "international" coinages only travelled in their higher denominations ; for small local items traders would have to use local change.

Weighing would appear a simple and satisfactory method of effecting such change into small local coinage. We should suppose it to be comparative - traders' coin weighed against the local held by the money-changer. The general points about commercial weighing apply here, so that the overbalance principle is a satisfactory method of such comparative weighing: the customer is happy he has his due amount while the money-changer takes his profit from a separately-agreed rate (no doubt paid out of the smaller, therefore local, coinage involved).[88]

It should be admitted that this reconstruction is no more than hypothetical. No direct evidence attests to the activity of the small-scale money-changer. It is however nice to note that a rare word used of the money-changer, ὀβολοστάτης, appears to reflect, pejoratively, the fact that he weighed tiny coins. The term occurs in fifth-century Athens: Ar. Nub. 1155, and is clearly unsympathetic;[89] and also Antiphanes fr.168 (Kock CAF.ii) where the man announcing himself as ὀβολοστάτης is called ἄνθρωπος ἀνυπέρβλητος εἰς πονηρίαν. Unfortunately doubts have been cast on the necessary implication of weighing here: Schol. Aeschines I.39 explains the term as based on interest charged at 1 obol per mina, and this sense perhaps better fits Lysias fr.60 (Thalheim). A third explanation, relating the ὀβολο- to early spits, is attributed to Heracleides of Pontus by Orion Etym.[90] I am nevertheless inclined to retain the obol-weighing interpretation, as another word for money-changers again refers to the coins handled: κολλυβιστης.[91]

A more substantial objection to assuming money-changes involved weighing is the clear evidence of money changed by means of set exchange rates.[92] The subject is complex, and I have attempted a short survey

in Appendix C. I think it fair to recognise this procedure as the manner in which most money was changed, though the contexts can be distinguished from the more ordinary, small-scale transactions I envisage for weighing changing. First , the evidence for exchange rates is on a naturally official level; and states are in a position to fix and maintain the rates they operate. Second , the rates are used on well-known currencies: Attic converted to Aeginetan, or important local currencies. Third , rates are used for converting coins of different metals, especially where electrum is involved. Possibly further, fourthly, such large sums were involved and on both sides (money given and taken), that variations in individual coin weights would not be felt significant and so weighing be unnecessary. None of these considerations, I would suggest, need apply to the trader, arriving at a port with an odd handful of foreign coin and wanting to be able to make purchases locally.

It is clear that at this level there is little need to be concerned by the further objection that weighing even silver coin against other coin will not be able to take into account variations of silver content. If our trader has a recognisable coin, perhpas there will be a set and recognised exchange rate for it. Further the money-changer (if he knows enough about the silver content of minor coinages, which is unlikely) can adjust his price for changing the coin if he suspects its silver content to be poor.

The money-changer, in the situation I envisage his using weighing as a means of changing coin, is in fact operating rather as I have suggested the mint operated, or metal dealers. An important difference is now, however, that the operation involves a much wider public. Though the balance remains in the hands of a specialist (the money-changer), the weighing would be familiar to many travellers. The greater proportion will presumably have been in fact traders, including the metal delaers who were well acquainted with weighing. The possibility of a more general and higher class of traveller however remains. If many will have delegated the task of changing their money to their slave, or even have relied on local hospitality, several will have been forced to stand by and watch their money in the scales. No doubt this situation was what Zeno had in mind in refering to the frequent occasions on which he saw the Attic 4dr raise up a finer-looking Alexandrian. It is further interesting to

consider the inclusion of equivalences in the pages of written accounts of overseas travel by Greeks - thus Hdt. III.89 (equating the gold daric with the Euboean stater). Might this be of more than academic interest to his readers?

An objection to my account here of money-changing could well be that exchange rates were themselves but a reflection (and so a simplification for practical purposes) of weight differences. This I would accept with two qualifications: first the practical operation is of paramount concern where the extent of weighing is being considered, as in this chapter. If money-changers measured carefully weight differences and equivalences (as no doubt they did) to establish exchange rates, they did this independently of the actual exchange itself (most would probably accept the rate as established by others moreover). Secondly exchange rates can be seen to be in fact inaccurate reflections of actual coin ratios. Thus Tod II.140, fourth-century Delphi, describes the conversion of 10 drs Attic into 7 drs Aeginetan, but 4 drs Attic into 2 drs 4 ob Aeginetan; on the 10 : 7 ratio in the first case 4 drs Attic should have been slightly more (2.8 drs Aeginetan).[93] Practical considerations, available coin fractions, have clearly intervened. Compare also the equation by Herodotus at III.89 of the Euboean stater, approximately fixed around 8.50 gm, with the heavy gold daric, of around 8.35 gm.

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We can return therefore to the still remarkable fact that individual coins were not weighed in normal conditions. On the way to market Greeks stopped and counted their coins (Theophr. Char. 18.3 καὶ φέρων αὐτὸς τὸ ἀργύριον κατὰ στάδιον καθίζων ἀριθμεῖν πόσον ἐστίν). At market they could if necessary change their coin, for example at the fish-store (Ar. Vesp. 788ff), but weight was not involved. They carried their small coins in their mouths[94] yet were apparently oblivious to the serious effect this could have on their accuracy.[95] Despite the list of qualifications for ancient coins (discussed above), no requirement of dryness, nor even of cleanness (and accumulated dirt on deep-struck coins could appreciably affect their weight), is mentioned.

Generally, within a currency area, coins were accepted at their face value and were not individually weighed. Remarkably they could be assumed to be accurate enough for use as weights in weighing (see now

below VIII.2). Such faith in the mint was not justified for individual coins; but it may be excused by the lack of any convention to check their weights. Without smaller (independent) weight units it is any way difficult to see how such a check could be made except against another coin. For travellers outside and between currency areas, coin changing probably did involve weighing, but this was comparative, and the coin was treated as bullion, not as individual coin, unless it was of an internationally accepted type and a set exchange rate could be used.

1. (4) Official involvement.

In earlier sections reference has frequently been made to various officials as those solely or mainly concerned with weighing. This seems to be a fair general statement of the overall picture, for by considering together officials in public or temple contexts most examples of attested weighing will be covered. Of course this is in part an accident of the surviving evidence which is largely official in origin; however, consideration of non-official involvement in preceding sections has shown how unlikely is any significant degree of weighing by such people. In what follows I shall proceed through the various aspects of official involvement with weights and weighing. The first is included for completeness sake; it clearly does not impinge on the discussion of weighing.

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1. Safekeeping of actual weights, (measures), and balances. There is some evidence that selected official premises were used for the safekeeping of standard weights (and measures) and even for balances. The late second century B.C. Athens decree IG II^2 1013 (Pleket 14) lists sets of weights, which are instructed to be kept on the acropolis (ll. 54-56,57, possibly not for use), ἐν τῇ Σκιάδι (56f under a local public servant δημόσιος backed up by the prytanies and a strategos ll.40 & 45) ἐν Ἐλευσῖνι (l.57 again a δημόσιος, but backed by the high priest and the annual panegyris officials ll.40 & 48f), and ἐμ Πειραιεῖ (l.57 under a δημόσιος and the ἐπιμελητὴς τοῦ λιμένος ll.40 & 47). The major office would appear to be Skias, as weights kept there were to be used for reference by the "archons" (l.65). The same decree mentions a further set of weights kept in the mint (l.30 τὰ στάθμια τὰ ἐν τῷ ἀργυροκοπίῳ).[96]

Earlier evidence for Athens is not clear. A remarkable dozen bronze weights recur on accounts first of Hekatompedon then of Athena

through the first part of the fourth century B.C. (IG II^2 1388.46; 1407.41; 1412.27; 1423.10; 1425.193; 1428.119). They seem to be simply there for safekeeping (σταθμια χαλκα ν ΔΙΙ ν & ὁ δημος σηκωται ἐψ[ηφισατο: 1407.41); they are not apparently associated with the punches and dies for the gold coin series of the late fifth century.[97] A further ταλαντον σιδηρον (IG II^2 1425.380 - c.368 B.C.) may be identical with the ταλαντον σταθμον of earlier decrees (IG II^2 1424.a.288). Later in the fourth century τριμνον χαλκουν may be intended for τριμναιον IG II^2 1469.100 and 1471.51 (Athena 321/0 and 318/17 B.C.).

More generally it must be assumed that Athenian metronomoi and, possibly later, agoranomoi had their own weights with which to perform their duties (see chapter II.1.(1) sections III and V where I suggested those marked METPO- or ΑΓΟΡ-, but also those stamped, probably belonged to these officials). These they would have to keep in their own offices; one such set is recorded as passed on after each year of office (Hesperia 1968.73-76 222/1 B.C.).

Outside Athens the evidence for weight keeping is less clear. Again the general implications of stamping may be accepted.[98] At third century Delos we find special ξυληρα σταθμια being issued by the agoranomoi, who presumably kept control of them when not in use (ID 509; Pleket 10 1.2; a slight doubt surrounds whether these weights were actual or notional, at 1.38ff the agoranomoi have only balances and measures for charcoal). In the Andros treasury are inventoried σταθμα ταλαντον ἡμιταλαντον χαλκουν δεκαμνων λιθινον (IG XI(2) 203.B.98 : 269 B.C.).

Rather more evidence exists however for the public holding of balances. In third-century Delos inscription already noted the agoranomoi issue the balance for wood-selling (ID 569.39; and apparently refusal to do this would prevent sale). More than one balance was kept in the ἀγορανομιον as around the mid third century the ἱεροποιοι reveal that they used the smaller balance to weigh part of their inventory (IG XI(2) 287.B.142f). Again from late second-century B.C. Magnesia comes an inscription apparently showing that the state leased out balance(s) to traders who wanted to use it (them) at a small daily charge (Pleket 12). I am rather doubtful that one of the taxes (τὸ ταλαντον) from which Aisepos was exempted by sixth-century B.C. Cyzicus was for use of a balance (Pleket 21.5; SIG^3.4). State control of balances is of some interest to their general use; it

would seem most reasonable however to suppose that the balances involved were somehow special: size seems the most likely factor, in view of wood-weighing at Delos, and of the practical problems of transporting large balances ~~(Aristophanes' would-be fig seller Ar. Pax 1248-9 and the purple dye-sellers of [Arist] Mech §1)~~. It remains possible that insistence on the use of a state balance was either to safeguard against deception (cf [Arist.] Mech. §1), or, more typically, as an additional source of state revenue. It is not attested for Athens.

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2. Control of weights (and measures). It could be assumed that the enforcement of the use of standard (or correct) weights, and the checking that they were used in commerce (both to be considered further below in part 4), implied the actual checking of such weights as were used. This assumption must be qualified. The question of whether weights were in fact used greatly restricts in scope any such checking activity: and the evidence for general checking (such as Arist. Ath.Pol. 51.2, describing the functions of the metronomoi who τῶν μέτρων καὶ τῶν σταθμῶν ἐπιμελοῦνται πάντων ὅπως οἱ πωλοῦντες χρήσονται δικαίοις) should be recognised as ambiguous between checking actual weights and checking on the weights of items sold (such as the ὄρτοι of Ath.Pol. 51.3). Furthermore, the wide variation in extant weights, irrespective of stamping or δημοσιον legends, attests dubiously to any checking having taken place.[99] Decrees about coinage, as noted already, avoid the question of individual weight (and the careful description of the scrutiny procedure on AS. I.7180 mentions only coin type). It is not possible to check the effectiveness of the mid fifth-century Attic decree enforcing consistent use of Attic weights (and measures) along with coin.[100] Actual weights in circulation may indeed have been checked, but I wish here to note that the evidence is not decisive; explicit only is the procedure described as late as second century B.C. IG II^2 1013 especially 14-18 (cases of improper weights to be heard in Hekatombaion). The checks, if they took place, were far from complete or satisfactorily accurate.

Another important area of actual weight control lies in the supervision of weight- and coin production. This has already been mentioned. For weights we know of at least one official in charge of their production in late second century B.C. Athens - Διόδωρος (IG II^2 1013.39);

others need not have been as anonymous as they appear if they were also metronomoi (this seems possibly indicated by IG II^2 1013.51ff on the replacement of damaged standard weights). I have suggested that both weights and coins were probably made in the same place, the mint.[80] Weighing, I agreed, was essential to fix the sizes of moulds etc. used in the manufacturing process, and some checks on the finished products seem to have been made,[101] but there is no explicit evidence for this checking, and I incline to feel it was badly, or only very sporadically, done.

The only well attested control is the careful maintenance of the special sets of standard weights. It is only with their condition that IG II^2 1013 is concerned (e.g. at 51ff, and 56ff).

All elements of weight control discussed here involve no more than equivalence weighing. Nevertheless it is fair to point out that <u>two-way</u> equivalence is required, and that a proper balancing technique should be used.[102] That there is no evidence for Greeks possessing such a technique (or balances suitable for it) may begin to explain several of the variations in extant weights (and coins). Checking may therefore have been more extensive than the scepticism of my first paragraph gave credit.

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3. <u>Manipulation of weights, standards and systems</u>. Potentially, this field could prove to be the most sophisticated in terms both of understanding, and of using, weighing. Modern scholarship has been concerned since the nineteenth century to attribute such understanding to the ancient Greeks, and recent work (such as Lang <u>Agora X</u>) has sought even to build upon it. The greater part of this thesis has tended however to undermine any such possibilities. Three general points can be selected for comment here.

<u>First</u>, the evidence for early, and detailed, Greek interest in and manipulation of weight standards occurs in particular in later fourth-century B.C. accounts (by Aristotle, Androtion and others). As well as being anachronistic, these accounts of earlier metrological moves were made with hindsight. This enabled subsequent low coin weight units to be used to express the earlier pre-coinage weight standard changes. In fact no such units existed in the earlier period: thus explanations of the changes made then may be accurate descriptions but cannot reflect the

actual considerations of the earlier times. The more general caveats can be repeated here : that Greeks had no weights (no absolute, theoretically unending, series) in which to measure, other than whatever weights were at any time available; the process of standardisation and systematisation (which was necessary for such weights to be available) would take time; further it seems that low fractional coinage was never generally admitted as actual weights (as opposed to the standard στατηρ of which the fractional coin represented theoretical subdivision).

Secondly, manipulation of standards and systems can be distinguished from simple standardisation and systematisation. Greeks were conscious of these latter processes, and appear to have sought to enhance them; but there is no evidence to suggest they were involved in sophisticated manipulation till the later second century B.C. (towards the period of IG II^2 1013). Modern explanations for the origins of weight standards in terms of bimetalism, or for variations in standards in terms of the availability of materials, may possibly be an accurate statement of ancient conditions; but there is no reason to suppose they also reflect ancient thinking.[103]

Thirdly, I argued above that states played an important part in the development of weight standards and systems in Greece.[104] Their influence was felt through the institution of coinage with a set standard weight and, ultimately, systematic subdivisions. However it should be obvious that states did not introduce coinage in order to further the advancement of more general (or even coin) weight systems. Both the particular standard coin weight, and its wider effect, were incidental to the reasons for initially introducing coinage (payment of mercenaries; accountability of bullion etc.).

Although officials would clearly be closely concerned with decrees that affected weights and coin, their motivation was primarily other than metrological. The mid fifth-century Attic decree enforcing consistent weights and coin was primarily an imperialistic gesture. Further, such metrological interest as might be involved was initially of the simplest sort. The same mid fifth-century decree simply demanded consistency. Equally, it seems reasonable to suppose straightforward considerations of practicality lay behind such reforms as are said to have taken place in the earliest period of this weight system (achieving a means of interchanging with Aeginetan weights); just as it is likely that pressure from

commerce led to the recognition of secondary standards in the later second century B.C. (IG II^2 1013). By this date the basic coin standard was sufficiently established for Athenians to be reluctant to tamper with it: for the early period, and the development of Greek weight systems, no such established independent scale of weights existed. This situation is entirely confirmed by the general attitude of Greeks to weighing (as an immediate and comparative matter); and elements of precisely the same approach appear no less fundamental in the ancient theory, even into the fourth century B.C.

All the operations of Greek officials with weight standards and systems can be explained by reference simply to equalisation , internal consistency and, only very occasionally, the practical demands of the contexts in which weights were used.[105]

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4. Control of weighing or weighed items. This control was the basic responsibility of the metronomoi at Athens at least (Arist. Ath.Pol. 51.2 allowing either interpretation of the ambiguity noted in part 2); but weighing items on sale appears no less to have involved agoranomoi (Xen. Symp. II.20), and σιτοφύλακες (Ath.Pol. 51.3). On a wider scale, but similar, was the administration of such decrees concerning weights and their use as the mid fifth century Attic decree (ML 45: the officials responsible being ἄρχοντες τῶν Ἀθηναίων, Athenians, or, there being none of these, the local officials: §4). There seems no reason for not assuming similar practice throughout the Greek world.

I have already suggested that this sort of control of weights (in terms of weighed items) need not have involved either manufacturers or the general public. Moreover, while concern about traders' weights involved equivalence (two-way), the checking of items, purportedly of a certain weight, is essentially checking that they are at least of that weight. The overbalance principle is therefore most satisfactory, as in other aspects of commerce.

It is interesting to note finally here the extent to which states felt it important to issue regulations about weights (see list Appendix E, in particular the parody of the typical decree in Ar. Aves 1040-1 and the theoretical stipulation of one in Plato Leges 746D-747A). With these regulations should be contrasted the very small number of references to

dishonest weighing, and the lack of any reference to inaccurate weights.[106] The insistence on proper weights might appear closer to official propaganda than practical necessity in these decrees. There was no such pretence maintained for coinage.

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5. Administration of public works. It has already been noted that the greater number of instances of weighing (of commodities weighed and situations in which they might be weighed) is to be found in official building accounts. Outside such contexts, however, there are indications that weighing was very much more restricted. In earlier parts of this section it has been shown that aspects peculiar to public works (such as the bulk and type of materials involved, or the open-ended nature of many operations, requiring open-ended contracts based upon amounts of material used) must partially explain the increased amount of weighing such accounts contain. However the variation in which weighing is noted for pricing or simply omitted or alternative pricing systems given (by item, or capacity) as well as the ridiculous and superfluous detail (e.g. $1\frac{1}{2}$ stater δικελλαι at 1 dr. 2 ob per stater rather than a simple 2 dr per δικελλα), raise suspicions about the validity of several of the references. While many are beyond doubt accurate reports of procedure followed (e.g. especially contract work where inspection of weighing procedure is itself noted)some further explanation should be sought for the general detail.[107]

One solution would be simply to suspect the detail as a superficial attempt on the part of the officials to give the impression of their being very closely in control of the spending of public money. The pricing could be simply superficially expressed in weights. But then why choose weighing? and why use in many cases the sorts of weight units untypical of the state system? - real difficulties, quite apart from the unsatisfactory implications of this solution. A better explanation can be found in terms of the background of the officials themselves. They were not professional builders, and were more often than not totally inexperienced. If not themselves, then at least their staffs had general administrative experience; and it seems reasonable to think of the sort of precision other officials in other contexts were able to give. The detailed weights of official inventories offers an obvious parallel:

the building officials need only have been more concerned to appear (and why not also to be) as precise as possible to overstep the limits of what in normal circumstances would be weighed. Given that officials were determined to weigh, it is not remarkable that "commercial" weight units[168] were what they usually had to use except in contexts totally within their control. The use of such units does not however mean that commerce would normally have weighed at all: this would depend upon the situation requirements though general commerce tended (as shown in the earlier Sections of this chapter) to avoid the use of weighing.

It is not necessary therefore to cast total suspicion on the fact of weighing where officials have given weights in their accounts. My arguments have sought simply to use the context of giving public accounts as a special reason for such officials weighing. The types of weighing an official might be called upon in consequence to supervise can now be briefly listed and considered.

(1) Where transactions resembled normal commercial operations (a price agreed and an amount sold for it, or for multiples of it) the over-balancing principle was sufficient. Though contractors produced their material probably in standard sizes and building commissions purchased in similar units, the sale of surplus material by the commissioners would be of fragmentary pieces. We have no evidence of how the commercial world handled scrap;[169] but the officials seem to have insisted on a careful control and measured the scrap to be sold by weight (cf. Parthenon sales and also those later by the Naopoioi). This may be proven to have been a recognised commercial procedure (introducing measurement to at least part of the commercial world: see above VII.1.(2)), but I should interpret it as very much in line with the principle of inventory-making, while also reflecting the desire by officials to avoid charges of throwing away public goods.

(3) Contract work, and unit weight pricing, has been already argued to involve little more than open-ended measurement out of the basic unit weight. Surplus (as the last paragraph shows) was the responsibility of the purchasing commission; and there is very little evidence of contracts being ultimately priced in units less than what was the unit for pricing. One contract, that for binding the tympana of columns at Eleusis (IG II^2 1675 late fourth century), also involved officials in details of metal-

alloying technique.[110] I have suggested above that the ratios of different metals could not be achieved by weighing-out various amounts of one against another.

(4) Several further technical operations supervised by officials brought them, by virtue of the need to render an account, into even more sophisticated weighing techniques. Thus the various weight measurements and calculations made at stages in the process of making the new oin choe for Ἥρως Ἰατρος (late third-century Athens: IG II^2 839).[111] Subtraction weighing is found in the account of corn payment for Ios of the third century B.C. (IG XII(5) 1010.7 ἀποκατασταθέν). The need to measure weigh, rather than simply count, foreign coin in general accounts can be included here, thus IG I^2 310 (on p.143) ll.298-305 (Other Gods); 313/4 ll.56-7 (end fifth-century B.C. Eleusis). Accounting takes us properly well beyond the subject of weighing; so also the general listing of objects on many inventories, yet inventories are the clearest context for the measurement of weight in ancient Greece.

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6. Official (store and temple) inventories. The procedure of publishing lists of contents of stores or temples under official (or public) control became established throughout the Greek world. Several methods were used: from bare enumeration, description of distinctive items, to precise measurements of sizes, capacities and weights. The surviving inscriptions, which by virtue of the repetitive nature of such documents (at least as applied to temple contents) are reconstructable in extenso, are the major source for Greek weight measurement. They are further to be supplemented by literary references to the weights inscribed on objects in temples for which records have not survived (in particular early Delphi and Olympia).

Because of the sheer mass of this evidence it is hardly necessary to present it here in detail.[112] The weighing involved was invariably measuremental, weights being used in series - though variations can be detected between temple practices on such matters as whether to use silver coin weights for all materials or also to introduce higher weight units, either of the coin system or outside it. Though initially such weighing would be to establish the weight of formerly unknown items, it would subsequently only confirm such weights as had earlier been established.

There may be room for scepticism here as to the actual weighing in detail on each occasion; but weights are from time to time emended. This aspect, as also the general requirement for accuracy in inventory weighing will be pursued in chapter VIII.

The items weighed tend to be only the more precious materials (gold, silver, on rare occasions when it appears ivory, but infrequently bronze and iron). This does not necessarily tell against the conclusions reached about official building accounts, as few other articles in temples or stores would have their value expressed in weights (and this description of value is what I shall argue to be a basic point for inventory procedure).

What is perhaps most significant and relevant here in this chapter, is the amazing labour involved in the inventory weighing procedure; and the lack of any evidence that steps were taken to improve the tools it required. I shall attempt a reconciliation between inventory motivation and the overbalance (pointerless) Greek machines in the next chapter.

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A large range of official activities has been embraced in this section: mint control to ship-yard inventory, legislation to public works. All these contexts brought the officials into contact with weighing, and in many with the more sophisticated aspects of the operation: measurement of weight, precise equalisation of weights. Who and what sort of people were then involved in these activities?

The officials themselves at any one time were a small group of people. Many of them, especially at Athens, were amateurs, temporarily involved in administration. On the other hand I do not think it at all correct to infer that what Greek officials did and experienced, any Greek could understand. (1) Quite apart from varying qualifications for office,[113] not all the officials I have considered were temporary appointments. Many (such as Diodoros of IG II^2 1013.39, responsible for making weights) were professional specialists. (2) Where important appointments were temporary, the complexities of the official duties were such (irrespective of the minor problem of coming to terms with a weighing machine) as surely to require the continued presence in the office of permanent assistants. (3) In the case of weighing, a technical operation, it must be assumed that assistants (possibly even slaves) actually did the work. King

Arcesilas, on Rep.C.1, simply observes from his seat, and a similar activity should be assumed for officials described as supervising weighing operations. In effect I believe that the official weighing activities involved a smaller number of people (and these specialists) rather than the general "Greek in the street." For the most part those permanently involved would come from the lower (and illiterate) social levels. It is not therefore necessarily remarkable that the complaints of inventory assistants have not been preserved.

A further question is how public were the weighing operations performed by officials? Though accounts were published, and, as I have insisted, were very much meant to be read, only very rarely can the weighing operations behind them have been seen by more than the small number of people directly involved. It has been assumed that the public procedure described in Callias' decrees (ML 58 AB 434/3 B.C.) established a normal procedure of regular weighing and counting before witnesses (Linders Braueron (1972), p.51). In fact however the only regular system instituted here was the presentation of annual accounts of income and expenditure (A.25; B.20). Weighing was only specified for the present situation which was peculiar as several accounts were being combined in a single treasury for which a careful initial inventory was required. On this occasion the whole Athenian βουλη was expected to witness the weighing (ἀπαριθμεσασθον και ἀποστεσασθον τα χρεματα ἐναντιον τες βολ[ε]ις ἐμ πολει A.20f). Both the need to specify this procedure, and the extraordinary relevance of the whole βουλη on this occasion, suggest it was not usual: it would certainly be an inordinately boring operation as well as one which an assembled crowd could not properly "observe". The only parallel I can find is second-century Delos (ID 442.B.118ff) where the ἱεροποιοι and the ἐκκλησια are involved in the weighing of melted down votives (cf also 443.Bb.41ff). More usually a small group of witnesses are specified:-

Eleusis IG II^2 1675.26-29 for bronze contract: καὶ ἀποσταθήσει τῷ δεῖ παρόντι τῶν ἐπιστατῶν ἢ τῷ δημοσίῳ ἢ τῷ ἀρχιτέκτονι (4th.cent).

Delos IG XII(3)199.86-7 for iron working: stipulating the weight to be measured with the architect ἀποσταθμεναι μετα [του] ἀρχιτεκτονος (3rd.cent).

Oropos (Amphiaraon) IG VII 303. objects melted down to be weighed μετα πολεμαρχων και κατοπτων (3rd cent.).

Thespiae SEG I.132.23 an account specified before witnesses, though no weighing is explicitly mentioned: (? 2nd cent.).

In all of these officials are specifically named, but the public nature of the operations can be questioned as a general rule.[114]

The other activities of officials - checking commercially used weights and weighed amounts, and controlling the use of official balances in commerce (outside Athens at least), will have clearly impinged upon the commercial world. The sort of simple overbalance-weighing involved in these activities will not have been unusual in that context. Control of weights and balances could not affect the method of their use, nor alter their design (without pointers). The more specialised weighing (the equivalence-checking of weights, mint regulation, and usual inventory-taking) will have taken place in camera. It is this weighing which most strains the performance of Greek weighing machinery, and most contradicts the prevalent Greek attitude to weighing.

1. (5) Private Inventory and Account

While publications and the need for checks on the honesty of officials may have contributed (perhaps most significantly) to public account and inventory, there were also other reasons for such controls: valuation and checks against thefts and losses to outside parties. The importance of such additional considerations will be considered further in chapter VIII.3. They apply however to another area, the control of private fortunes and stores by individuals. Though there is virtually no evidence surviving of such private inventory and account, the area must clearly be envisaged as one in which weighing could have taken place. I shall include here also brief consideration of a method of store-keeping based on tare and gross weight. The context seems that of private enterprise, but the identification of the procedure is most uncertain.

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1. Private fortunes. The possession of great wealth inspired many moralising remarks: one that Xenophon attributed to Cyrus is relevant here (Xen.Cyr. VIII.2.21). While Cyrus gave away his excess wealth to friends, most people found them a burden:

τὰ μὲν αὐτῶν κατορρώττουσι, τὰ δὲ κατασήπουσι, τὰ δὲ ἀριθμοῦντες καὶ μετροῦντες καὶ ἱστάντες καὶ διαψύχοντες καὶ φυλάττοντες πράγματα ἔχουσι ---

This points to private inventory weighing. An actual example (borderline as the property belongs to a regent) is the second century B.C. digramma to officials in charge of store-rooms in Chalkis (Euboea, IG XII Supp. 644.4-6):

ὧν μετρον ἐστιν ἀναμετρησατωσαν ... ὧν δε στεθμος ἀναστατωσαν.

These instructions are tantalisingly vague, but when it be considered what might be weighed in private inventories, the context as a

whole for weighing largely collapses. Wealth by classical times was exclusively measured in money terms: this emerges passim from Aristophanes (see especially Plutus); Xenophon made the Armenian convert his revenue and stores into money for Cyrus' and his readers' benefit (Xen. Cyr. III.1.33 χρήματα ... εὖν τοῖς θησαυροῖς ἔστιν εἰς ἀργύριον λογισθέντα τάλαντα πλείω τῶν τρισχιλίων); and see more generally the Athenian practice of valuation for tax purposes of capital, goods, property, etc.[115] Money was normally counted, as even public accounts show passim. For private context see Theophr. Char. 18.3 καὶ φέρων αὐτὸς τὸ ἀργύριον κατὰ στάδιον καθίζων ἀριθμεῖν πόσον ἐστίν.

Extraordinary here could be the example of the Elean traitor, Xenias (Xen. Hell. III.2.27). He is said to have measured out his father's money (ἀργύριον) by the medimnos. Beyond the general context of Xenias' collecting a group of pro-Spartan sympathisers, subsequently defeated by Thrasydaios and the democratic Elean element, no elucidation is furnished by the frequent references in Pausanias.[116] The text in Xenophon includes a number of mistakes, and may have been meant to state simply that Xenias distributed money to his followers by this method.[117] Even as a means of distributing or of measuring, the implication is of a somewhat inaccurate (lavish or ham-fisted) way of dealing with the money. The example is therefore either a-typical of private inventory procedure, or (as I incline to believe) irrelevant.

The need to weigh for inventory purposes would seem (on the parallel of temple inventories) to apply only to objects of precious materials, or to lumps of such materials. As items of gold and silver were clearly possessed by private people it is possible that they would be checked and even inventoried. In the absence of any evidence it is difficult to estimate how widespread (if at all) such practice ever was. If the prevailing conception of wealth was in terms of money, it seems most likely that money (in the form of coin) would be amassed and hoarded deliberately; and such people as did this would be those most likely to be interested in checking and accounting it. Further the distribution of wealth in ancient Greece, in any case a poor country (Hdt. VII.102.1), was very uneven: the vast majority would not conceivably be in a position to weigh any items in their personal fortunes. Finally, widespread private inventory-weighing

(which like temple would be measuremental) is ruled out by the fact that there has been shown to be no concept of measuremental weighing in the general Greek attitude to the balance or to weighing.

The type of weighing involved in private inventory would be (as said) measuremental; weights could be public standard or private. In the absence of any convincing evidence, discussion of the possibilites of such weighing must be deferred. A similar solution can be found in the commercial context.

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2. Commercial stock-taking. It has been shown above that several commodities were handled commercially by weight.[113] Here I should like to consider the possibility of traders' weighing independently of external transactions, in the course of keeping control of their stocks. At the outset some form of day-to-day control would seem desirable — to assess profits and deduce pricing.

There is however no direct evidence of stock-taking in such a context, and it would seem furthermore difficult to insist that weighing was used even if stock-taking did take place. Such commodities as metals I have already suggested were handled in standard sizes; wool once weighed was stored in sacks or bundles (see Rep. C.1 Arcesilas); cheese and bread were made in unit sizes (even if these sizes corresponded to a maximum weight, or if the unit was subsequently cut for sale by weight); meat obviously would originate in a natural unit (and without refrigeration we need not be concerned with its storage over any period of time). All these commodities, though priced with reference to weight, would be more conveniently assessed, when stored in such units, by counting the number of units. Each trader would know, and be consistant in the use of, his own storage units. He could tell when a unit had been tampered with: but only to assess the loss in this sort of case might he be expected to resort to the tedious process of weighing. It seems to me likely that this process was restricted to the initial buying for stocking, and the subsequent sale.

In one area, however, weighing, rather than counting units, could be the simplest means of checking amounts in stock. Liquids or granular substances were frequently stored in opaque containers.

Though official seals might give some guarantee of the contents of specially-packed containers (especially wine-jars which indeed could be kept stoppered until sold close to drinking), many open containers were used that could not be so sealed, and indeed could be repeatedly refilled. One method of checking the contents of such a container is to weigh first the container empty, then to weigh it filled to a known and visible mark (with whatever the container is to be used to hold). In use, the amount contained at any time can be calculated by weighing the container and comparing this weight with the two initial figures (empty and full). In modern parlance the terms tare and gross weight are applied to the empty and full weights. A third weight can then be derived (subtracting actual from weight empty), which is the net weight at any time.

The evidence for some such procedure in ancient Greece is slight, but can I believe be admitted. Of the eight possible inscriptions on vases collected by Lang,[119] one appears to give two weights for a single amphora of the late fifth century B.C.: No. 71 - AM Δ MM and Δ Δ , which Lang reads as ἀμ(φορεύς) 12 μ(νᾶι) and 20 μ(νᾶι). The terms must be weights as the amphora is much too small to contain so many medimnoi or metretai. Lang takes the first weight as the weight empty (i.e. tare), the second as the weight of contents (i.e. net).[120] I see no reason for accepting this interpretation: the second weight is I believe the total weight when full (i.e. gross weight). First, the gross weight is required before the net weight can be derived (by subtracting tare from gross); the inscriptions on Greek vases show how operations proceeded by the most elementary stages,[121] and the omission of gross weight is virtually incredible here. Secondly, there is no need to assume that the commodity for which the vase was weighed was normally measured in weight (it could be granular or liquid and indeed would be more likely to be then measured by capacity). Thirdly, I suspect that Lang has been influenced here by her belief in an early corresponsion between weight and capacity measurement.[122] Such corresponsion is anachronistic until the late Roman period.

Despite the practical advantages of tare and gross markings the infrequency of identifiable examples shows that the procedure was not at all widespread. It is true that it involved quite sophisticated

weighing techniques - exact measurement and further calculation (subtraction weighing has however been noted on official accounting[123]). Apart from it, the evidence for weighing in commercial stocktaking is an unhelpful blank.

2. Other minor (possible but improbable) contexts for weighing

2. (6) The Greek Kitchen

The excavated Greek kitchens have yielded no archaeological evidence of weighing implements. Balances, parts of them, and weights are not listed in such comprehensive surveys as Sparkes JHS 82 (1962) 121-37. Recipes call for measures of capacity (as Ar. Pax 1144 three choinikes or beans, plus even more of wheat, to be eaten with figs; [Arist.] Prob. xx.35 926b.32-4 two kotylai of marjoram per amphoreus of must to produce sweet wine), but there is no evidence that weights were used. The Greek housewife, though well acquainted with capacity measures (especially of wine: Ar. Eccles.), does not appear to have used weights or balances at all.

2. (7) Medicine

One uncertain context for weighing is medicine: and the incertainty is largely a result of the difficulty of dating parts of the Hippocratic corpus. As far as I can see no weights and measures can explicitly be found in the earliest parts of this, the case-books etc. Yet there are indications that weight at least was an early concern. By the time of Galen (second century A.D.) the problem was one of standardisation of measures of weight and, more especially, capacity but there was apparently by that date no lack of local measures.[124] My research has produced only two references to weights in medical contexts. The first is little more than a mention; the second could well have rather wider application, though its interest is I believe rather later than the classical period of Greece.

Theophrastus H.P. 9.16.8 mentions a small dosage of hemlock and other herbs prescribed by Thrasyas of Mantineia as μικρον ὅσον ἐς δραχμης ἑλκην. Weight would seem to be the way of describing quantity in this context at least by the end of the fourth century B.C.[125]

Aristotle cites as examples of general and particular errors (ἁμαρτια either περι το καθολου or περι το καθ' ἑκαστον), the views that all heavy waters are unwholesome, and that a particular water is heavy (ἢ ὅτι παντα τα βαρυσταθμα ὑδατα φαυλα, ἢ ὅτι τοδι βαρυσταθμον NE. 1142a22). This clearly implies the existance in the later fourth century of a medical controversy over the medicinal properties of waters, involving their weights. There is considerable evidence for the controversy. The major accounts comprise the collection of references in Athenaeus II.40F-47A, and Vitruvius VIII.i-iv;[126] probably lost are treatises by Hippocrates Περι Ὑδατων (Athen. II.46B) and Theophrastus, of the same title, (Athen. II.41. E-F). Further references appear in the undatable [Arist.] Prob. IX.10, XXIII.passim: see below. The problem

is to fix the origin of the controversy, and to clarify the sense(s) in which the weight of water was registered.

The reference in Aristotle NE gives some credibility to the proper Hippocratic concern for the subject. Athenaeus' citation however indicates only relative weight: " ὕδωρ τὸ ταχέως θερμαινόμενον καὶ ψυχόμενον ἀεὶ κουφότερον " (Athen. II.46.B).[127] Aristotle's own example of the particular is open to the same observation: how is ὅτι τοδὶ βαρύσταθμον something about which one can have a mistaken opinion (ἁμαρτία ... ἐν τῷ βουλεύσασθαι) unless it is a relatively-defined concept? Subsequent references to the medicinal properties of water (or its physical properties) in fact tend to be no more explicit than the comparatives λεπτότερον or βαρύτερον, or the categorical (and apparently exegetical): quod est levissimum ... quaeque gravissimae (partes). General surveys of waters in Greece were apparently carried out by reference to individual accounts of individual sources (thus Vitruvius' lists VIII.iii.27), and there is no evidence of a controlled survey - till Athenaeus.

Athenaeus appears to have carried out the survey himself, and to have actually weighed at least some waters: σταθμήσας τὸ ἀπὸ τῆς ἐν Κορίνθῳ Πειρήνης καλουμένης ὕδωρ κουφότερον πάντων εὗρον τῶν κατὰ τὴν Ἑλλάδα (II.43.B). It is unreasonable to suppose he carried around a quantity of this water to compare with those from other springs; and in fact in another place, which has no alternative authority, he shows clearly he did measure-weigh a set amount. At II.42.A-B we read, incredibly, that the water near Mount Pangaeum weighs 96 drs. per kotyle in winter, but only 46 drs. per kotyle in summer. I have no doubt that the variation is proof of the wild inaccuracy of the standards (both kotyle and drachmae) available over the 6-month interval, but it is equally a very clear reference to measuremental weighing. Though Athenaeus, in the third century A.D., may then have in fact conducted this experiment (and his general survey also on similar lines), the lack of any such specific results, the comparative weight references, and the fact that ὅτι τοδὶ βαρύσταθμον was a matter of opinion, rule out I believe such measuremental weighing of water for the earlier period, certainty the fifth century-fourth century with which we are most concerned.

A fifth-century/fourth-century controversy about the medicinal value of heavy waters (ὅτι πάντα τὰ βαρύσταθμα ὕδατα φαῦλα) does nevertheless indicate that the weights of waters were compared, even if not actually measured. This is of interest, but the lack of measurements is probably indicative that there was no established use of weights or weighing in medical practice. The point approaches more closely the use of weighing in a general experimental context: to this I shall now briefly turn.[128] For general medical purposes it seems to have been sufficient, as late as the third century B.C., simply to specify proportions and leave to the reader to decide what units (and type of measure, be it weight or capacity) to use. Thus Philon § 32 on how to prepare drugs to preserve public health: ... παραμιχθέντος εἰς αὐτὴν ὀβολοῦ μὲν τοῦ πέμπτου μέρους, μήκωνος ὡς πεντεκαιδεκάτου.[129]

2. (8) "Scientific" Experiments

Several Greek scientific-philosophers who wrote about weighing balances, seem actually to have conducted experiments with them. It is true that much of the theory (discussed in chapter VI.1) is derived from the observation of other people weighing with balances.[130] Equally it may reasonably be argued that as the results of experiments seem on accasion fashioned more by theory than possible observation, so also the experiments themselves are likely to have been fabricated. This seems particularly true of Aristotle's proof that air has weight from the increased weight he claimed could be found of an inflated ἀσκός (De Caelo 311.b.9-10: see further below chapter VIII.1(1)1). Nevertheless, there are occasional details which lend some conviction to certain of the experiments involving weighing: the late fifth century was a period when experiments began to interest scientists;[131] and a practical context must be assumed for Archimedes analysis of Hieron's wreath in the mid third century B.C.

The significant aspect of this experimental weighing is that it can never be shown to have involved measurement, but was always purely comparative. At Arist. Caelo 311.b.3-4, a mina weight of lead and a talent weight of wood are used in an experiment which compares the two weighed against each other in air then in water. One suspects that the talent and mina are simply chosen as obviously disparate; the actual weight of wood is of course immaterial as it would always float while the lead sink! Accounts of Archimedes and Hieron's wreath that involve absolute weight measurement have already been shown[131] to belong to a late (and erroneous) tradition (I come to equalisation below). It might be wondered how Aristotle's experiment with the ἀσκός could be performed without first measuring its weight uninflated, then measuring it inflated. One solution is that he started with two equal weight

ἀσκοί then blew one up: though as noted one need not take the problem too seriously. He does not say how much more the inflated ἀσκός weighed!

The possibility of equalisation as a preliminary step in this experiment is slight. Similarly much of the work done by Archimedes on balance is hardly relevant to the practical use of a weighing machine: his interest was primarily theoretical, and focused on the centres of gravity (which he called balance points) of mathematical figures. Though "balance" is defined in the initial postulates to Equilib.I in a manner that applies to weighing machines as also more generally, such machines were too simple for his interest.[132] However in On Floating Bodies (e.g. I prop.5) he does note that a solid immersed in water (or any fluid) will displace water equal to its own weight; and this seems the best way to interpret his analysis of Hieron's wreath.

Comparative weighing, with the possibility of some form of equalisation[133] but with little likelihood of weights being used, seems the only sort of weighing used by scientific experiments. The result is similar to that observed for medicine: the scientists were of course not so specialised, and there is probably little reason to call them specialists at all in this survey of contexts of weighing.

2.(9) Greek Artillery

Greek artillery poses several problems for this enquiry, not least that of relevance. The most recent work published on the subject, Marsden,[134] maintains that within the classical period (before the end of the fourth century B.C.) Greeks weighed and marked stone shot for catapults. A more critical approach is I believe necessary to this aspect of his work, although in what follows I shall still rely on the main lines of the historical development of Greek artillery as established by Marsden.

At the outset a group of 422 sandstone (or limestone) "balls" from Kouklia (Old Paphos in Cyprus) must be considered.[135] These balls are unique, and form a separate part of the development of Greek artillery. They were found along with assorted weaponry in the siege mound built up against the city walls in the Persian siege of c.498 B.C.; and appear to lie on average 10 m. from the city walls (though some were found at isolated points beyond). They are roughly hemispherical in shape, relatively crudely finished yet certainly fashioned in some way; their diameters vary from 15 to 30 cms. No similar objects have been found in the excavated area inside the city walls, although a number of votive columns there could be capped by these hemispheres. The implication of the find places of the stones is that they were thrown at the besiegers as they attempted to scale the mound (as also the weaponry found with them); the range of 10 m. is not particularly impressive; and the hemispherical shape of the stones would appear well-suited to their being projected from a plank and see-saw arrangement. The flat part of the balls would enable them to rest relatively firmly on one end of a plank as defender(s) jumped down on the other. The idea is common in many circus tricks , in the Kouklia case it could count as primitive artillery.[136]

This interpretation is not proven, but it does appear highly likely. However several further observations are possible: most important the unusual shape of the Kouklia "balls" is not only unique, but totally

unnecessary for the method of projection envisaged. Any stone with a flat side would serve equally well. It is surely unreasonable to suppose the defenders, resorting to a novel form of attacking the Persians at this desperate moment, would trouble to round the stones before projection. The reason for their shape, and therefore the proper identification of the original function of these "balls", must be other than their ultimate use. I have already suggested column tops, alternatively gate or wall decorations inside the town. It is no argument against this that none were found inside the city walls, as it is probable that the defenders continued projecting these objects until all were used up. I could now add their one advantage over stones: namely their relatively consistant weight (so range), and also their relative lightness (because of their shape) in comparison with square stones with the same flat area.

No evidence exists of this method of projection, nor of subsequent repeated variations. Whoever thought it up, found it either unsatisfactory, or, as seems equally likely, did not survive to hand on the idea. The next artillery for which there is evidence is more sophisticated, and its subsequent development well-attested. The Kouklia material, or rather the evidence of a rudimentary use of artillery in the siege of 498, cannot undermine Marsden's arguments (HD.48-56) for the origin of the Greek catapult proper in early fourth-century Syracuse (Diod. XIV.42.1: τὸ καταπέλτικον εὑρέθη). Beforehand, as Marsden shows, the only references in the fifth century are to stones being dropped by cranes onto the enemy.[137] Neither these stones, nor the Kouklia "balls", have any relation to the possible calibration of the eventual torsion catapults.

The first Greek catapults, invented by Dionysius I's engineers, were non-torsion, bolt-shooting devices resembling over-size bows. Torsion catapults, with springs of hair, seem to have been first developed for Philip II of Macedon by a Thessalian, Polyidus;[138] these again were primarily bolt-shooting.[139] Apart from an uncertain reference to the fact that Onomarchos threw stones at Philip in the Sacred War,[140] the earliest clear use of stone-throwing catapults is in Alexander's siege of Halicarnassos of 334 B.C.,[141] then Tyre 332 B.C.[142] The latter at least Marsden believes were certainly torsion catapults.[143] There now followed a period of experimentation before the next significant stage - the expression of a relationship between projectile and machine dimensions in calibration formulae.

Marsden argues a date of between 275-273 B.C. for this achievement.[144]

Two formulae are found, applying to different sorts of catapult and each accompanied by lists of machine dimensions. One applies to bolt-shooting euthytone catapults.[145] One basic dimension is given, the diameter of the holes through which the springs pass, D, expressed in "dactyls" (and the lists of other dimensions are set in terms of this unit, D); the bolt-projectile is simply measured by length (again in "dactyls") L :-

$$D = \frac{L}{9}$$

For stone throwing (palintone) catapults the same spring-hole-dimension is related to the weight, M, of the stone shot (measured in Attic minas):-

$$D = 1.1 \sqrt[3]{(100\ M)}.$$ [146]

It is necessary to examine the application of these formulae, and their historical development (in conceptual terms).

It is in the first place clear from the single variable machine dimension that these formulae assume standard proportions in the catapults to which they apply. This points to a restricted, artificially restricted, context for the development and application of the formulae. As this applies however more to the practical side of the question (machine construction) it need not concern us here.

Secondly these formulae give the optimum size of machine for a given projectile (or vice versa if they are rearranged L = 9D etc): such and such a size of catapult will shoot best an x-mina shot. Marsden has shown that this "best" is in practice better than a smaller machine with the same size shot, or the same machine with smaller shot, or a larger machine with the same size shot...[147] It is a significant feature of the catapult that there is such an optimum, and, considering the practical purpose of the machine, it is reasonable to express this optimum as maximum effective range. This would incidentally explain how such different formulae are applied to bolt-shooting catapults (where bolts have to be moving fast forwards to be effective) and to stone-throwing (where the sheer weight of falling stone adds greatly to its effectiveness). However, circumstances might very well affect what effect was desired (as stones used to break up a wall can only do so if projected towards it in the manner of bolts; on personnel they can simply be showered from above); and this

could explain why range does not occur in any artillery formulae.

The question of range is however important. If it cannot be expressed in formulae as the desired effect might vary with circumstances, it is perhaps surprising that no guide lines appear to have been written out: for example that a talant-catapult would be effective against personnel up to 400 yards.[148] The experience of artillerymen could perhaps be sufficient, or alternatively the performances were well-known.[149]

But what of variation in range? There is modern disagreement over whether this was achieved by varying the size or weight of projectile,[150] or by varying the angle of projection (Marsden).[151] The formulae, and the absence of computation data for variable weights, favour Marsden's interpretation. So do the conventional ways of referring to catapults by a single figure denoting their projectile size (3-cubit or one-talant: see further below). However the possibility of slightly varying range, by varying from a known basic size or weight should be left open. It should also be asked whether in fact variation in range was often attempted with ancient artillery. In most circumstances those in control of the machines could move them into a suitable position, and nearer than the maximum effective range would be foolhardy. Where special circumstances demanded special performances, modifications are attested to the basic machine itself (as Archimedes in 213-211 B.C. siege of Syracuse. Plut. Marc. 15).

The implication of this interpretation of the formulae and use of catapults (which follows Marsden in most, but the last point made) is that a single size of bolt, or weight of shot, was associated with a particular machine as that for which it was designed. The immediate advantages are predictability and also standardisation over several machines of equal sizes of projectiles (on their accuracy see following). Nevertheless the possibility of varying range in practice by varying the size of projectile cannot be excluded.

Though the formulae were not derived till the 270's B.C., as has been stated, it is nevertheless possible to show that some of the basic approach to artillery calibration (derived above from these formulae) was already there in the latter part of the fourth century. Thus Athenian records from the period 338-326 B.C. onwards refer to catapults in terms of the size of bolts for which they were designed: καταπάλτας διπήχεις and τριπήχεις (?) IG II^2 1467 B.ii.48-56 (Chalcotheke) also IG II^2 1475.B.30-5

(Acropolis 318/17 B.C.) and IG II^2 1487.B.84-90 (Erechtheum or Chalcothece 306/5 B.C. adding τετράπηχυν and τρισπίθαμον). These dimensions certainly refer to the bolts for which the catapults were suitable, and are not the dimensions of the machines themselves, as later practice shows.

However, though the idea of designing catapults for set sizes of bolts therefore preceded the derivation of the formula D = $^{L}/_{9}$ (and dimensions in terms of D), it is not possible to assume that these fourth-century catapults were constructed with much awareness of the ballistic and projectile difference between say the 2-cubit and 3-cubit bolt. This would be to ignore the years of experimentation necessary before the calibration formulae could be derived (an achievement needing heavy subsidies: Philon Bel.50).[152] Also the length of bolt is related to the construction of the catapult to shoot it for the very practical reason of fitting into the space provided (neither too short nor too long). Nevertheless, these caveats apart, it would seem unreasonable to ignore the fact that a degree of standardisation had been achieved by at least 326 B.C. - the 2-cubit and 3-cubit catapults are inventoried items not unique specimens - and that this standardisation was in terms of the length of bolt.

We reach finally the problem of weighed shot. As already noted, stone-throwing catapults required more sophisticated design and appear to have been introduced later than the simpler bolt-shooting type. The earliest references to them are in Alexander's campaigns of the 330's; and they are not described by any sort of specification. The same is true of the stone-throwing catapult listed alongside the specified bolt-shooting ones in the Attic inscription of 306/5 B.C. already noted: IG II^2 1487.B. 84-5

κα[- - - - κατα]
[πα]λτην πετροβολον και ὀξ[υβελη - -]
[τ]ετραπηχυν ἐντελη - - -

This special catapult (the maker, Bromios, is named) shot both 4-cubit bolts and stones. No size or weight of these stones is specified. Just as the development of stone-throwing catapults came later than that of bolt-shooting, so it seems reasonable to accept the specification of the shot of the stone-throwing catapults to be later. As far as I can see

this is first assigned to Demetrios' machines in late fourth-century sieges, although the authority is the rather later Diodorus.[153]

It seems therefore that by the end of the fourth century catapults were being calibrated by the weight of their shot. Confirmation for this is claimed by Marsden following Laurenzi, the excavator of a quantity of stones found in Rhodes apparently of this date and marked with weights. I shall discuss this (doubtful) argument below. Further marked stone balls have also been found in Cyprian Salamis: but their identification as artillery shot, and the interpretation of their markings is even more uncertain.

Shot for ancient artillery has been found at a number of sites, but presents difficulties for the extremely theoretical approach to the calibration and use of artillery argued by Marsden, and from which I have ventured to deviate in my account. I shall not include the Kouklia material of early fifth century which I argued above to be most unlikely shot. Marsden lists seven other groups:[154] Carthage 5,600 stone balls, some forming a series of standardisable weights, dated before the 146 B.C. destruction; Pergamon 961 stone balls (with no flat sides as the Carthaginian had) vaguely dated by Boehringer[155] to the late 4th–2nd cent. simply, that is, from the known use of the stone-throwing catapult; Numantia dated mid second century B.C.; Caesar's Gaul, dated first century B.C.; Babylon, date uncertain; a dozen shot from the Peiraeus, again with no indication of date, and identification doubtful; and finally Rhodes where Laurenzi discovered 353 blue crystalline limestone balls, carefully inscribed with letters (painted red) and dated by inference to the late fourth century B.C.[156] To this list should be provisionally added about 50 spherical sandstone or limestone balls from Salamis in Cyprus (found towards the top of Nicocreon's cenotaph (tomb 77) and so dated c. 311 B.C.). These balls approximate to standard sizes and bear inscriptions Δ, ΔΔ, ΔΔΔ, ΔΔΔΔ, ΔΙΙ, ΔΙΔ (engraved but not painted).[157]

This list (Marsden's supplemented by Salamis) is surprisingly short when one considers the length of use for the stone-throwing catapult (late fourth century BC to the introduction of the onager, probably fourth century A.D., if not beyond). Identification of shot is naturally a difficulty, and only the Rhodian and Salamis material appears to have been marked, but the suspicion arises that on many occasions, and certainly in extremis,

assorted stones were used as were to hand and fitted, somehow, the machinery.

Doubt about the relevance of the ideal ratio of the calibration formula are strengthened by the variation in the weights of identified shot. This was so considerable in the unmarked Carthage weights then even the identification of groups proved somewhat arbitrary, and indeed persuaded Von Röder[158] to abandon the reconstruction of standard Carthaginian calibres. Pergamon shot, again unmarked, apparently was easier to subdivide into ranges marking "calibres"; Boehringer noted variation as greater in the smaller and the larger weights, otherwise precision was "estaunlich gross"; this conclusion must be qualified by his tabulating <u>average</u> weights, and by the inaccuracy of the weighing machines that were used to weigh the shot excavated (± 100 gm.)[159]. Laurenzi's tabulation of the weights of the marked Rhodian groups shows, as far as it goes (higher weights are described as varying from some theoretical weight, so obscuring the overall inaccuracy further), a reasonably acceptable variation.[160] Marked 10-mina shot (of the order of 436 x 10 gm) vary 700 gm from maximum to minimum; 15-mina vary 800 gm; 20-mina vary 1000 gm; whereas 30-mina vary 12.5 <u>kg</u> to 13.5 <u>kg</u>. 20% variation, or ± 10%, in 10 minai, compares favourably with the ranges of marked Attic weights.[161] Marsden points out that extreme accuracy in artillery shooting can be a positive disadvantage in focusing shot on too small a target.[162] It seems however a nice point to decide where reasonable scatter (Rhodian "shot") ends and shooting blind (as with the miscellaneous Carthaginian material) might begin.[163]

Just as significant as the variation in the weights of calibres, is the variety of "calibres",[164] indicated by, for example, the Pergamon and Rhodian material. I cite from Marsden (HD.81 n2) for Pergamon (inferred from weights):-

10 M (?)	13 M (?)	15 M	18 M (?)	20 M	30 M	37½ M (?)
40 M	1 T	65 M (?)	90 M	105 M	2 T	3 T

and (83 nl) for Rhodes (all marked):-

5 M	10 M	15 M	20 M	25 M	30 M	40 M
50 M	1 T	1 T 10 M	I T 20 M	1 T 30 M	100 M	2 T 30 M
3 T	3 T 30 M	4 T 30 M	6 T	7 T	10 T	

Considering only the Pergamon shot (securely identified by its location in the Arsenal), it is clear that we should be unwise to apply Marsden's conclusion and infer over 10 different calibres of stone-throwers. Rather

these groups represent evidence of the use of variation in weight to vary range, as otherwise the weight groups are relatively clearly separated from each other.

Now we must consider the Rhodian material: is this correctly identified as shot and should it be dated to Demetrios' siege? A number of arguments incline me to the belief that it should be disregarded here.[165] (1) The marking is not only unique for shot, but it is absurdly well-done. The stones are blue crystalline limestone; carefully inscribed with letters for the weights; these letters picked out in red paint. Such care and permanency are surely out of place on shot, in a world where even prices are but cursorily scratched on merchandise and red dye expensive.[166] (2) The weights conform to too obvious a series; oddly, despite their variety, the series lacks the natural 2T weight. (3) The series runs too high. Marsden and Laurenzi are at variance over whether to include the 3T weight in with catapult shot or to group it with the other higher weights as simply large balls to be rolled down wooden runways onto besieging engines.[167] If the purpose of readily-visible markings was to facilitate choice of shot for particular calibre catapults, I fail to see why such care should be taken also for deciding what weight to roll onto the enemy. [(4) The series is possibly too long. The Pergamon shot can be collapsed into about half as many groups up to 3T. This point however is qualified to the extent of possible range variation by choice of shot weight.] (5) The date is most improbable. First, it is surely surprising to find the most developed calibration procedure right at the head of our evidence for weight calibration at all. Second, the stone-throwing catapults play a very minor role in the city's defence against Demetrios - only apparently in the night bombardment and against personnel, so small stones presumably.[168] Thirdly, there is no positive argument for dating to the late fourth century beyond association with Demetrios' siege, which seems at least to be sole grounds for Laurenzi's position.[169] Yet Rhodes was very closely associated with catapults in the late third century to judge from gifts after the 227 B.C. earthquake (Polyb. V.88.8; 89.9) and especially Rhodes' own donation to Sinope c.220 B.C. (Polyb. IV.56.3: 300T of prepared hair, 100 T of prepared sinew for catapult springs, plus 4 stone-throwers and men to operate them). If these balls are shot they could more plausibly belong to this later period.

Judgement should perhaps be withheld on the Rhodian "shot" till further parallels are found or their find-place checked. I have not yet been able to inspect them. Nevertheless I should be more prepared to regard them as commercial weights (their shape convenient for rolling on and off scales as they are heavy) than military shot.

This conclusion seems to apply no less to the Salamis material. Though not yet fully examined or published it is already possible to deduce from the presently available information that they are unlikely artillery shot, and certainly that they are not calibrated by their weights.[170] The legends Α, ΑΑ etc. ΑΙΙ, ΑΙΑ may seem close to numerals, but for the extraordinary ΑΙΑ (for which Roman XIX is of course not a valid parallel), and the fact that the legends do not conform proportionately to the sizes of the balls.[171] Provisionally I should note the fact that all combinations contain Α, and so suggest "δημοσιον" (which is the most commonly found abbreviation on weights),[172] repeated where necessary or simply emphasised. But the presence of commercial weights on a royal tomb seems difficult to explain.[173] Certainly there is no basis yet for inferences about sophisticated calibration techniques.

If the marked Rhodian or Salamis "shot" can therefore be discounted, there is little significant use of weighing in the context of Greek artillery. An ideal correlation between weight of shot and size (and dimensions) of catapult was set in formula c 270's B.C.; before this, as subsequently, stone-throwing catapults were designed for certain shot sizes or shapes but were probably used with greatly varying weights of shot (for purposeful scatter fire or in the absence of consistently prepared shot or to vary range). There is no evidence of any sophisticated attempts at coordinating range with weight or catapult size, and it is doubtful whether such correlation could usefully have been made.

I do not feel that there is any evidence of careful weight-marking on artillery shot. Attested calibres of stone-throwing machines are few, but only include round figures ½T, 1T, and 3T, in contrast with the many "calibres" postulated for the Pergamene and Rhodian shot above.[174] There is no other explicit evidence of weighing shot, or of using the wrong shot. Finally it should be noted that a distinction was made between bolt-throwing and stone-throwing catapults; but the bolts for the former were specified only by length, and not by weight though this would be as relevant as the weight of shot to projection.[175] There seems little justification for going on now to consider Greek ballistic theory.[176]

2. (10) Greek Athletics[177]

Weights played an important part in the execution of several events: long jumping (where the use of pairs of weights, halteres, is well attested,[178] discus throwing, and throwing the javelin. Surviving evidence is remarkably scanty, but there is no indication of measurement of the weights of these objects (halteres, discus, or javelin), nor indeed of official regulation of them at all. Extant specimens similarly exhibit great variations. I add references to the unofficial sport of weight-lifting.

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1. Halteres

Several halteres have survived, some inscribed as used in games, but few pairs are known. Apart from variation in shape[179] (developing from simple ingot type, early Sixth century, to cylindrical, Roman) and material (lead, stone, marble) these vary considerably in weight. The total range is around $2\frac{1}{4}$ to over 10 pounds (c 1.05 kg to over 4.6 kg) but the majority lie between 3 and 5 pounds.[180]

The variation between pairs is much less considerable. A fifth century lead pair of halteres from Athens (now in Copenhagen) weighed 1.610 kg and 1.480 kg.[181] Another stone sixth-century pair from Corinth (now in Athens) are said to weigh 2.018 kg each.[182] I have found no others.[183]

The importance of the weight of these halteres should not be over-exaggerated. Even their function seems misunderstood in antiquity: as a hardicap Lucian Anach. 27 or an aid Aristotle IA.705a.17. They were used also for training purposes (compare our dumb-bells). However modern experiment has shown conclusively that they can be used to increase the length of the long jump whether running or standing.[184] These trials

have revealed the important point that, in selecting weights to suit their objectives, the modern athletes chose different weights (in fact 5 lbs and 8 lbs). Clearly the size most helpful to distance (and least hindering, for example to speed of run) might vary with individual athlete's ability. Lack of standardisation of ancient halteres need not therefore be significant if athletes were able to provide their own equipment.[185]

The question of equivalence or variation in a pair of halteres is possibly similar. Such variation might be used to correct an individual's weakness on one leg (and halteres were visibly right- or left- handed in certain types); alternatively the variation may simply be the result of conditions of survival. Insufficient examples survive to corroborate the apparent 8% difference of the Copenhagen (Attic) pair as either unusual or usual (so evidence of imprecision).

For the purposes of this enquiry only two points can be profitably extracted from these halteres. (a) Those extant do not explicitly belong to identifiable weight systems. The Attic pair, for example, is roughly equivalent to the διστατερ weight.[186] However, the earliest example (from Eleusis, and inscribed by the victor, Epainetos) is much heavier at 1888 gm.[187] No halteres moreover are marked with their weights; and so there seems little reason to doubt that those used were selected because it was found by trial and error, they were satisfactory.

Secondly (b) the halteres possibly afford an indication of accuracy in equating weights (or they would if more were documented). Variation might be due to factors beyond our control and so, as noted already above, do not indicate permitted inaccuracy.[188]

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2 Diskoi

Diskoi show similar variation in both size and weight. Examples survive from 3 to 12 inches in diameter, and from 3 to over 15 pounds in weight.[189] The fullest analysis is given by Gardiner, who assembles fifteen assorted specimens.[190] Several explanations reduce the variation, but standardisation does not seem possible until late, Roman period. Thus (a) some diskoi, from their shape (sharp edges) and indeed weight, seem to be not intended for actual use, i.e. votive or dedicatory only (Gardiner's nos. 1, 9, 11).[191] Secondly (b) two classes of competition existed, for men and

for boys, and the diskos apparently varied, in size at least, for these classes: in Paus. I.35.5 the bones of Ajax' knee are described as being as big as the diskos of boy pentathletes (πενταθλου γὰρ παιδὸς εἶναί οἱ κατὰ δίσκον μάλιστα τὰ ἐπὶ τοῖς γόνασιν ὀστᾶ). Further (c) it is suggested that different festivals had different sizes and weights. The Olympic diskos seems to be thought particularly large: Phayllos' throw is described by Philostratos Heroic. p.291 fin, as with a diskos "twice the Olympian" - though the word used (διπλασιον) does not specify whether size or weight.

Extant diskoi however do not fall into recognisable groups either light and heavy (corresponding to (b) above), or local ((c)). The Olympian diskoi, probably actually used, weigh 2.945 (?) kg, 2.775 kg, 2.083 kg, 2.023 kg, 1.721 kg, 1.353 (?) kg, 1.268 kg.[192] Gardiner attempted to isolate weight groups, but without conviction.[193] Moreover the possibility of diskoi of wood, of similar dimensions but much lighter, cannot be entirely rejected.

The significance of the weight variation of these diskoi is again doubtful. A plate can be spun further than a circle of cardboard, but a wooden diskos further than a lump of marble. I should suggest two possible solutions: either competitors used one single diskos, which all threw in a particular year's event,[194] or competitors were allowed to choose their own design i.e. to optimise their performance. Some sort of standardisation would result from the latter in so far as people's ability would be roughly comparable (dividing boys from men by power). Weather conditions could well affect the sort of diskos used (a strong wind favouring the heavier), as direction (within the narrow stadium) was important as well as distance. It is not unlikely that weather conditions also dictated the style of throwing.[195]

Pausanias mentions (VI.19.3) three diskoi kept in the Sicyonian treasury at Olympia and connected with the pentathlon. His description requires note: ἐν τούτῳ τῷ θησαυρῷ δίσκοι τὸν ἀριθμὸν ἀνάκεινται τρεῖς, ὅσους ἐς τοῦ πενταθλου τὸ ἀγώνισμα ἐσκομίζουσι. This is normally taken to mean the 3 diskoi used in the pentathlon.[196] However these diskoi were offerings (ἀνάκεινται), and only their number is equivalent to the pentathlon practice (emphasis on τὸν ἀριθμόν and ὅσους). Besides the pentathlon diskoi are said to be brought to the competition

(ἐκκομίζουσι), not taken out of the treasury.

These three dedicationary diskoi were probably of brass as other items in the treasury, but they are not weighed (unlike Myron's θαλαμοι[197]). I cannot believe they played a practical part in the actual competition any more than the other notorious diskoi, associated variously with Lykurgus, Iphitos, and Terpander (Aristotle ap. Plut. Lyk .1; corrected by Sosibios FGH 595 F 3), inscribed with rules for competition (καθ' ὃν ἐδει τα Ὀλυμπια ἀγειν second century A.D. Phlegon FGH 257.F.1. § 4) or the Olympic Truce (second century A.D. Pausanias V.20.1). The ceremonial use of the diskos, as in this sort of context, may prove long-standing.[198]

It remains to note however that no absolute weight measurement is given, nor correspension with known weight standards apparent, in any extant diskoi or allusion to them.

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3. Javelin

No specifications are given of javelin dimensions, nor can they be deduced except from representations, as no javelins have survived. Nevertheless these dimensions are clearly relevant to the weight of the javelin (as also is its material) and so, as athletic javelin competition was simply a distance throw,[199] to the length of the throw in the athletic event. It can simply be noted that the athletic javelin was more or less the height of the athlete, about the thickness of a finger, and probably of light wood rather than heavy.[200] In competition (as outside cf. Xen. Anab.IV.2.28, showing further how variable a Greek javelin could be) it was thrown by means of a thong wound round the shaft near its centre (ἀγκύλη); and also, even if blunt-ended, it was capped with metal. Both modifications greatly assisted the distance the javelin could be thrown:[201] but about neither is there any evidence of official ruling.

Again I should suggest that details concerning the equipment used in this event would be left to the individual athlete.[202] On the analogy of artillery bolts,[203] the only likely specification would appear to have been that of length, rather than weight. But as already said there is no evidence for this.

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4. "Weight lifting"

Non-standardised weight lifting and throwing characterises what Gardiner called the sixth-century "age of strength".[204] Though a competitive element was clearly present, there were no rules nor standard-type equipment. In all cases the weight of the object involved was not measured in absolute units. Gardiner has collected some passages.[205]

- Hom. Il. 23.826-849. Patroclus' games include the throwing as far as possible of a σόλος αὐτοχοώνος, a lump or iron described simply as enough for 5-years' supply (1.833). The heroes compete with it and for it. A problem surrounds the use made of it by its former owner, Eetion (ὃν πρὶν μὲν βίπτασκε μέγα σθένος Ἠετίωνος 1.827): on what occasion?
- Philostratos Heroic. 291 end. Protesilaos throws a discus over 100 yards and one twice the size of the Olympic: size or weight is not specified by simple διπλάσιον, nor is it clear what idea Philostratos had of the Olympic size in the first place (see above s.v. Diskos).
- Inschrift. von Olympia 717. Sixth-century inscription recording the fact that Bybon threw the stone with one hand over his head. On a red sandstone block weighing 143.5 kg (315 lb).
- IG XIII.499 (Santorin). Sixth-century inscription recording the fact that Eumastos lifted the stone from the ground. On a black volcanic rock weight 480 kg.
- Aelian VH VII.22. Milo lifted a young bull each day till grown in order to train; but Titormus took a stone Milo could not move, carried it, and then threw it.

There are numerous other references to heroes hurling in battle stones two men could hardly lift, or such activites: Aelian VH VIII.18; Paus. VI.ii; Hom. Il. 5.302; 12.445, Od. 9.481,537; 10.121.

There is nothing extraordinary in interest in such individual feats. As well as noting the lack of measurement, we should conclude with the simple fact that there was no weight-lifting competition in Greek games. I should argue that even if such competition had occurred it would not be measured, with "record" weights lifted carried forward to succeeding games.

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Concluding note on Greek athletics

Two general conclusions can be drawn on this evidence. First, in general and in organised athletics, no measurement in absolute terms occurred of the weights of objects lifted or thrown. Secondly, there appear to have been no standardisation, nor consistency of such weights even if not measured.

These conclusions are supported by three features of Greek athletic competition that it is relevant to comment upon here.

(a) Competition was the prime object of organised games, with interest focused on who won. This could be observed for races, where competitors competed simultaneously, and was derived from markers in throwing or jumping events.[206] The evidence is both literary and pictorial: Statius Thebaid VI.679-712; but better Iliad 23.843 Ajax' throw καὶ ὑπέρβαλε σήματα πάντων; there are no references to the marking of javelin throws, nor (see below) of their measurement.

Athletic performances were not measured in absolute units as a general rule. There certainly were no "records", Olympic or otherwise, in the modern sense of measured best performance to date. This was not simply because the Greeks had no stop watches (as Tod supposed[207]), as the point applies to non-timed events, such as jumping and throwing, which could have been measured. We have indeed some records for such events (including one reference to measurement), but these are few, of memorable feats (rather than every competitor's performance), and of semi-historical individuals or absurdities: thus Phayllos' discus throw and long jump in the controversial epigram Anth.Pal. App.297,[208] or Protesilaos' throw, Philostr. Heroic.291 fin., aptly described as a "150-foot cast of an overweight discus by a fifteen-foot ghost".[209] It strikes me as unwarranted to draw a general practice of measuring practice jumps with the odd sandal[210] from Socrates' enquiry about how many of its own feet a flea might jump (Ar. Nub. 145ff; a further difficulty is that sandals were not feet).[211] Another inference, that κανόνες were used for long-jump measurement is equally to be suspected. This must involve a slight digression:

[1] Gardiner Greek Athletic Sports and Festivals (1910) 298 cites Pollux III.151. This passage, describing events in the pentathlon only mentions "measurement" in connection with the long jump, but ambiguously even then: τὸ δὲ μέτρον τοῦ πηδήματος κανών. I suggest "marker" here as reasonable at least as "measure". In neither case is actual measurement (in absolutes) involved. Gardiner does not notice the unnecessary reduplication, if measurement took place as he assumes, of both peg marking (attested on vases) and measurement.

[2] Gardiner, JHS 24 (1904) 180 fig.1, shows rods being laid down side

by side on a kelebe in the British Museum; and he has used this as confirmation of rod-measurement. The idea of measuring a jump in thicknesses of rods, which is what the picture shows, is however ridiculous. In fact two scenes are portrayed: preparations for jumping and for javelin throwing, for the latter the selection of a particular javelin.

[3] Harris, Greek Athletes and Athletics (1964) notes a Rhodian inscription as mentioning measuring rods in the context of jumping (undated inscr., G. Pugliese Carratelli Annuario ns 14/16 (1952/4) 289, no.65). The inscription is fragmentary, dealing with several events, and the κανών could equally be an umpire's staff in wrestling or a flagpole.

[4] Gardiner's view that javelins "served as measuring rods" is doubly insubstantial as there is no evidence for standardisation of javelin length nor of the use of rods to measure.

That throwing or jumping competitions were not normally measured (indeed there is no historical evidence for their having been measured at all!), is to my mind conclusively shown by the fact that no victor's diskos nor halter is inscribed with the distance thrown or jumped.

I must therefore disagree with the conclusions reached by Tod in his article on "Greek record keeping and record breaking" [207]. Although he rightly diagnosed the difficulty of translating "record" into Greek [212], and suggested ὑπερβολή and the key words εἷς, πρῶτος and μόνος, he seems then to have confused the two senses in which the word is used in modern English. The Greeks were not concerned in the Olympic "record", though they were indeed keen to record athletic victories. The difference is important, as modern athletics could well take note.

(b) It seems likely that athletes were expected to provide their own equipment for many organised competitions. All sorts of equipment are shown used in general training outside the actual competition event. Given the variation in such equipment (both illustrated and that still extant) it seems reasonable to suppose athletes retained their own in the competition itself. Competitors in any case provided their own equipment for chariot and horse racing. Only artillery was laid on by the organisers (third-century Ceos [Coresos] Syll.^{3} 958.37ff) [213]. I have argued against the interpretation of Paus. VI.19.3 that 3 diskoi for the

pentathlon were kept in the Sicyonian treasury. The only exception I can find is Homer Il.23.826ff - competition with, and for, a single σόλος αὐτοχοώνος provided by the organiser. There is no problem however in recognising this as a special case (and of course a standard!); and where halteres and diskoi appear to have been dedicated by victorious athletes who use them, there is no indication that these were their prizes rather than their own (lucky) equipment. Prizes in the form of equipment are very rare: apart from the σόλος αὐτοχοώνος, all I can find are third-century Ceos prizes for archery and javelin (Syll^{3}. 958.27ff); elsewhere prizes are oil, amphorae, tripods, money (Sybaris and Croton), hoplite equipment (Syracuse), but most commonly some sort of wreath.[214]

(c) It might appear odd on the face of it that such artificial aids to performance as jumping weights and throwing thongs were permitted (indeed were the general rule) in organised competition athletics. This point however ceases to be extraordinary if these competitions be viewed in the simplest possible form as competitions in events simply described as running, racing, throwing etc. with such matters as technique etc. left to the competitors' discretion. It is difficult to see otherwise why, for example, weights were used for the long jump; and similarly it is possible to explain why they were not standard: for if all used identical equipment there would be no point in having weights at all. A well-known incident provides a straightforward illustration of the sort of technical development I suggest accompanied these athletic competitions (and probably led to the use of weights). This is the accidental (?) dropping of his loin cloth by the Megarian runner Orsippos in Ol.15 720 B.C. (Anth.Pal. App.272). Pausanias (I.44.1) regarded the act intentional γνόντι ὡς ἀνδρὸς περιεζωσμένου δρομεῦν ῥᾴων ἐστὶν ἀνὴρ γυμνός. Resistance to follow this example may have been psychological, or possibly (as writers on Greek athletics seem shy to point out) realistic. Nudity was apparently only recently a general practice by Thucydides' day (Thuc. I.6.5-6).[215]

From these three observations, there is a basis of support for the suggestions I have made above on halteres, diskos, and javelin: that the dimensions, including weights, of these items were left to the athletes'

discretion. Individual performance would be variously improved I think by different adjustments to these items, and it is well within the concept of Greek competitive athletics to allow such (private) adjustments to be made.

2. (11) Rope Strength

There is no evidence that rope strength was expressed in terms of breaking/holding power measured in terms of weight. The reason for raising the point here is to discount the description Herodotus gives of Xerxes' second Hellespont bridges, the flax ropes in which, he says, were one talent weight per cubit length (VII.36[3]). The cables had been the weak point of the first bridges, and much is made of their use in the second. It would seem therefore at the outset that a correlation between strength and the unit weight length ratio existed. This is I believe unlikely and of no relevance to our inquiry.

In the first place, the context is non-Greek. Egyptians and Phoenician engineers constructed the first bridges, using papyrus and flax cable respectively (Hdt. VII.34); despite the fate of these particular individuals (35.3), it is surely likely others of the same nationalities took their places; the same materials, flax and papyrus, were used on the second bridges.

Secondly, the improvements in these second bridges were improvements of overall design. Boats were moored head-on to the current as opposed to at right angles to it. Both sorts of cable were used together (2 flax and 4 papyrus to each bridge), as opposed to one sort alone on each bridge. No changes were made in the cables themselves.

Thirdly, whatever the significance of the 1T weight per cubit, Herodotes does not understand it as a specification of strength. He is simply interested in comparing the two sorts of cable, and the flax is heavier. This is 1T per cubit. Of the papyrus we read nothing.

παχύτης μὲν ἡ αὐτὴ καὶ καλλονή, κατὰ λόγον δὲ ἐμβριθέστερα ἦν τὰ λίνεα, τοῦ τάλαντον ὁ πῆχυς εἶλκε.

Finally, of course, the weight is the actual weight of the cable, not its breaking strength. The "calculation" (κατὰ λόγον) performed to

arrive at the unit weight is interesting, and presumably derives from pricing. It would be interesting to know Herodotus' source on this occasion (probably Phoenician as Phoenicians built the first bridges with flax cables).[216] His interest however revealingly lay in the comparative (ἐμβριθέστερα).

Rope strength in terms of weight to break it might be thought of interest to most ancients whose livelihood, if not lives, depended upon it. Any sailor was as vulnerable as Xerxes' engineers. Yet there is no evidence of anything other than the material and dimensions - thickness - of rope being noted. The evidence has been discussed in some detail above.[217] Surprisingly I can find no reference to ropes breaking, apart from Xerxes' first bridges. The important ropes on ships (anchors) were thicker than usual, or made of twisted ox-hide.[218]

2. (12) Ship cargo and capacity

This heading is necessarily vague. Several quite distinct questions are involved, but discussion of them has been so confused by recent work on the subject that they cannot without excessive repetition now be considered apart. I should like to begin at least by stating the questions, then list relevant testimonia, and finally attempt to arrive at individual answers to the questions in the course of a general discussion.

The questions are (1) weighing of ship cargoes (what was weighed? why? by whom? etc); (2) reduction of measurement of ship cargo to single units (how often weight units? theory of equivalences, etc); (3) expressing ship cargo capacity (potential) in terms of weight; (4) describing shipping in general by a weight term (if at all true of ancient Greece)- the equivalent of our ships being of so many tons.

The following owes much to a recent, and largely admirable treatment of the subject by H. T. Wallinga in his article "Nautika I: the unit of capacity for ancient ships" Mnemosyne 17(1964)1-40. Wallinga was concerned basically to destroy the notion of the talent weight as a universal unit of capacity. He showed that talents were but one of several units for measuring cargoes, that volume measures were more usual (interestingly in the form of space taken up by containers rather than their contents), and that no system of equivalences operated in the Greek period. However, Wallinga's argument was not, as is mine, specifically concerned with weights and their use, and his work falls short of the more detailed analysis needed here. The passages he collected do not include the earliest and clearest reference to talent-capacity ((1) below), nor did he consider archaeological and other evidence outside such literary and epigraphic passages. Nevertheless what follows accepts the more important of his conclusions[219]

and cannot pursue the more interesting implications concerning stacking and packaging for transport by sea.

Evidence for weighing used in connection with ship cargo and capacity

A: Literary and epigraphic - (chronological order)

(1) Regulations for anchorage at/off Sounion 455/4 B.C. (SEG X.10 not mentioned by Wallinga). Though the inscription is interesting in general for mercantile practice, we are concerned here with lines 19-22.

ἀ]πο δ[ὲ] τον ἄλλον πλοιον δονα-
ι, ἐαν μεχρι χ]ιλιον ταλαντον ἀγε[ι], ἑπτα
ὀβολος, ἐαν] δε ὑπερ χιλια, ἑπτ' ὀβο[λο]ς
κατα τα χιλι]α

i.e. the charge for harbour use varies with weight (cargo or capacity? see below): ships pay seven obols per thousand talents. This part of the decree offers no problems (the other categories are less straightforward), but it might be fair to point out how small the "under 1000T" class is - contrast Wallinga's comments pp. 26, 36-40 and especially contrast Thasos, below No. (5), where cargoes "under 3000 T" are not envisaged at all.

(2) Assyrian river craft (on the Euphrates) described by Hdt. I.194.3 τὸ δὲ μέγιστον αὐτῶν καὶ πεντακισχιλίων ταλάντων γόμον ἔχει. Wallinga P.1; Casson Ships and Seamanship in the Ancient World (1971) [henceforth SSAW] 6 n.10 thinks in fact Hdt. has confused his information about two sorts of boats on this river: the coracle-type Quffa and the raft Kelek. (see also Wallinga p 10 n.4).

(3) Egyptian river craft (ἡ βᾶρις on Nile) Hdt. II.96.5 ἄγει ἐνια πολλὰς χιλιάδας ταλάντων.

It can be noted at this point that both Mesopotamian and Egyptian cargoes are invariably, where measured, measured in units of grain capacity gur (or Kor) and artabs. See A. Oppenheim "The Sea-faring merchants of Ur" JAOS 74(1954) 6-17; J. Nougayrol "Nouveaux textes accadiens de Ras-Shamra" CRAI (1960) 163-71 especially 165; Casson SSAW chapters 1-3; Wallinga p.10. This fact does not mean Hdt. must have converted the figures he was given into talents (as Wallinga p.10 "the most simple solution").

(4) Ceos decree about the export of ruddle (μιλτος) first half fourth century B.C. (IG II^2 1128; Tod II.162; Pleket 5; Wallinga discusses it on pp. 8-10). Those exporting ruddle are to pay 1ob. per talent to the owners of the ships they are using: ναῦλον δὲ τελεῖν ὀβολὸν τοῦ [τ]αλάντου ἑκάστου τοῖς ναυκλήροις το[ῦ]ς ἐργαζομένους 11.13-14. While noting that the text is too fragmentary to make clear whether the ships to be used are Cean or Athenian, Wallinga

does not indicate the degree of restoration, including the vital ταλάντου, necessary in this part of the text. Several points call for comment at this stage. (a) The use of ναῦλλος here is picturesque if rightly for transporting the ruddle and not passengers (compare Ar. Ran. 270 for crossing the Styx!) Moreover the specific wt/transport cost correlation here is unique as far as I can tell (even if the κασσίτερος of Delphi FdD. III(5).25.I.3-6 was costed by weight, it is not recorded as other than a bulk total amount, and was anyway carried over land from Kirrha to Delphi.)

(b) Μίλτος was generally handled by weight (see references above in ch. III); the use of weight terms here is not at all extraordinary (a point to be expanded below). However it was ~~expensive, and~~ usually sold by a much lower unit than the talent (viz. stater, 1/30th T; priced at 3ob per stater for example at fourth-century Eleusis IG II^2 1672.184)

(c) An ambiguity should be seen in the cost of transport expressed as "1ob per T": is this silver coin or weight of actual μίλτος? If coin, the cost represents approximately 1/100th its value: this is surely to be preferred as obols (fractions of drachmae) do not normally intrude in such commercial contexts where staters are more normal (i.e. using conclusions from chapter III). We should note that the traders have to pay, in addition, to the Cean authorities 1/50th πεντηκοστή (ll. 22f). [Further (d) Wallinga thought to explain the importance of weight here by the fact that μίλτος was particularly heavy (5 times that of water: Wallinga p. 9). This point can at the outset be discarded as entirely irrelevant.]

(5) Thasos harbour regulations third century B.C. (IG XII Suppl.348; Pleket 9; Wallinga P.6) ll.1-3.

πλ]οῖον μὴ [ἀ]νέλκειν ἐντὸς τῶν [ὁ]ρων τοῦ μὲν πρώτου ἐλάσ[σονα φόρ-
τον ἄγον τρ]ισχι[λ]ίων ταλάντων, τοῦ δὲ δευτέρο[υ] ἐλάσσονα ἄγο[ν]τα πεντα[κ]ισ-
χ[ιλίων] τα[λάντ]ων.

Part of the harbour is reserved for ships with cargoes over 3000T, and part for those over 5000T. The remainder of the decree concerns fines and disputes consequent on this ruling. Again several preliminary points can be made here. (a) The ruling is not tantamount to saying that ships of cargoes between 3000 and 5000T must use the first marker (as Wallinga p. 12). (b) Actual cargoes are the deciding factor not the sizes of ships. Wallinga makes the unwarranted transition in a single sentence: "it forbids ships carrying less than 3000 talents to use some part of the harbour and those of less than 5000 talents to use the other part, that is to say there were two basins - one reserved for ships of 3000-5000 talents and the other for the bigger ships" (my italics; Wallinga p.12). (c) This last observation surely rules out several interpretations offered to explain the harbour board's ruling: e.g. differing depths of the harbour (Forbes ap. Wallinga p.12 n.2). The inscription is not explicit on the point and it remains open to conjecture. I shall suggest it concerns convenience for unloading/tax payment. It remains remarkable however that evasion

of this ruling should be anticipated by the procedures that bulk larger in the inscriptions than the ruling itself! (d) The ruling is not to be taken as complete either for all ship cargoes (both Wallinga and Casson use the passage to indicate ships carrying under 3000T were not worth considering; but constrast the Sounion decree no.(1) above), or, more importantly, for all sorts of cargo. Only those weighing 3000T or more, and 5000T or more, are subject to the rule. I shall argue many other ships were possibly carrying cargoes measured in volume units (amphorae etc.): at least these are not (pace Wallinga p. 12) ruled out by this inscription (though the first - above (1)-is more decisive).

(6) Syracusia. Ship built for display by Hieron II of Syracuse, but sent off to Alexandria (more likely Ptolemy Euergetes 246-221 B.C. than Ptolemy Philadelphus 283-246 B.C. OGIS 56.17 see Casson SSAW p. 185, in n.6 dating c.240 B.C.) The ship was described by contemporary Moschion, whose account survives in Athenaeus (V. 206D-209B; text + translation: Casson SSAW 191-199). Two items in this account are relevant:

(6).1 loading of Syracusia on maiden voyage. (Athen. V. 209a; Wallinga page 24) σίτου δὲ ἐνεβάλλοντο εἰς τὴν ναῦν μυριάδας ἓξ, ταρίχων δὲ Σικελικῶν κεράμια μύρια, ἐρίων τάλαντα δισμύρια, καὶ ἕτερα δὲ φορτία δισμύρια.
The various commodities are thus measured in the usual units for their measurement, and no single unit is used for overall cargo. (a) Casson argues the grain measures to be modii rather than μέδιμνοι (SSAW 185-6 achieving a more reasonable total capacity). (b) The assumption is generally made that the 'miscellaneous cargo' was also measured in talants (Casson); Wallinga seems to recognise the caution necessary ("φορτία at a talent each . . . This would support my speculations about portable loads" Wallinga p. 24 and n.2). In fact no special weight unit is given for the φορτία (that would have been perhaps ἄλλα δὲ φορτία ἕτερα δισμύρια?); and if non-specific μυριοφόρος etc. are volume measures, the weight unit seems indeed perhaps unlikely. Alas Wallinga's caution wanes within the same paragraph: "a weight measure for the rest of the partially mixed cargo" (p. 24). (c) At least for the weighing of wool we can cite a multitude of parallels. It was not at all unusual; indeed was always measured in this way if at all.

(6).2 Small boats of the Syracusia. (Athen. V.208.F; Wallinga P.7) ἐφόλκια δ' ἦσαν αὐτῇ τὸ μὲν πρῶτον κέρκουρος τρισχίλια τάλαντα δέχεσθαι δυνάμενος· πᾶς δ' ἦν οὗτος ἐπίκωπος· μεθ' ὃν χίλια πεντακόσια βαστάζουσαι ἁλιάδες τε καὶ σκάφαι πλείους.

One boat of 3000T and several of 1500T - capacity. This will be seen as a unique reference to theoretical capacity. The boats in question would be used to ferry personnel, or as lifeboats, though they could serve to load and carry parts out to the parent ship.

B: Representations of ship loading and unloading

These have already been listed above in chapter I.1.(2) as they include representation of balances. Thus:-

C.1. The Arcesilas Vase mid sixth-century Laconian: showing probably wool weighed on board ship and then stacked below: no weights are used.

C.R.12 Sousse mosaic. Roman, showing probably metal bars unloaded to be weighed on shore (Wallinga 9.n.4 cites only this mosaic as evidence for what he has claimed the "necessary stage" of weighing for loading in ship transport.)

C: Tare and gross or net-weight inscriptions on vases

(not considered by Wallinga) This subject has been discussed separately above (VII.1.(5) part 2). The evidence for Greek use of these concepts is extremely slight. I hesitate therefore in adducing this evidence here: if weight were important for ship loading we should expect the weights of containers to be as important as their contents. No evidence shows containers weighed specifically for ship transport; none of the many amphorae found in wrecks bear any such marking. I believe the most likely context to be commercial store-keeping.

D: Theoretical equivalences capacity and weight measures

The theory, and practical tabulation of evidence as a result, is well attested in late Roman times. For Greece it is assumed by Mabel Lang (especially Agora X passim - and note suggested restoration on DM.70 [δ]πτακλ]άντ[ον μετρον] "since the water weight of a medimnos is exactly two talents" (p.55); but the step appears taken as early as Hesperia 25 (1956) 17 introducing tare inscriptions). Wallinga rightly, and hotly, disputes (against Benoît especially) such identifications as the talent and amphora ("unfounded and a pure anachronism" p.17). As this matter has also constituted an important (if negative) part of my whole thesis, I need not justify my support for Wallinga here!

These last two considerations will therefore be disregarded in the account that follows of ship loading and capacities.

This list is to my knowledge complete. There should be no doubt that τάλαντα, where cited, refer to weight rather than value (in silver coin). This ambiguity could exist but should be rejected here on grounds of likelihood. Cargoes of anything but the most expensive commodities would be too bulky if worth 3000T or 5000T-plus in silver coin (μιλτος @ 3ob per stater for example would be loaded to 1,200,000T weight on a ship carrying 3000T worth!). Besides it is inconceivable that Greeks would trust anything like such a valuable cargo to a single ship.

A simple observation from specific cargoes in the preceding lists is that named commodities weighed are precisely those we should expect to find weighed (as opposed to measured or priced in other units): thus μιλτος (4); the wool of the Arcesilus cup and of (6).1; even the metal bars of the Sousse (Roman) mosaic would not be out of place.[221] Comparable is the measurement in volume: corn to Athens in medimnoi;[222] wine in various containers (Thasos inscriptions Pleket.1 and 2) etc: both aspects exemplified by the multifarious cargo of the Syracusia (6).1.

If the discussion could rest on this simple statement there would be no problems. As it is I am inclined to return to this statement even when the other difficulties have been taken into account. These difficulties begin with measurements of unspecified cargoes, and undefined units of measurement.

Wallinga has satisfactorily shown that several Greek references to ships of undefined unit capacities are in fact references to measurement of container-volumes. This important conclusion applies to Thuc. VII. 25.6 νῶν μυριοφόρων ; Thuc. IV.118.5 ἐς πεντακόσια ἄγοντα μέτρα[223] ; Ktesias Indica.6 μυριοφόρου νεώς. Moreover the type of definition extends into the Roman period (embracing Heron's theoretical calculations of ship capacities). These definitions are of potential capacity, though no doubt based on actual cargoes or on the assumption of a container-cargo being carried. Alongside them we can now set the references listed above to similar classification of capacity in sums of weight: Herodotus' descriptions (2) and (3), and the smaller boats of the Syracusia (6).2.

The two methods of indicating capacity are comparable, and may plausibly be related to the commodity the individual writers had in mind as being carried - Thucydides thinking of corn shipments, Herodotus of people or stones. There is no reason as yet to demand the priority of one system of defining shipping over the other. Certainly it is not necessary to follow Wallinga's argument that the volume-measurement is basic because it was more basic in the later period (Heron mentions volume but not weight).

A final stage is reached in these passages which necessarily subsume measurement by weight and volume under a single definition. Thus the Sounion decree (1), which covers apparently all shipping; similarly the Thasian (5); the ἑτέρα φορτία of (6).1 (given that

are measured in talents weight). To these instances could be added the Herodotean passages (2) and (3) if these are, as has been supposed, translations into weight terms of the usual Egyptian and Mesopotamian grain volume measurements (artab and gur). All these passages reduce the ship cargoes to weight measurements. The only comparable examples for reduction to volume measurements are Thuc. IV.118.5 the 500 μετρα (of peace proposals 423 B.C.; on which see above); and passages in the Lex Claudia of 218 B.C. (Livy. XXI.63.3 "ne quis senator cuive senator pater fuisset maritimam navem, quae plus trecentarum amphorarum esset, haberet" cited Wallinga as P.10 see pp.20-21).

These passages alone imply a preference for one form of measurement be it weight or volume. The preference might vary as between Sparta and Sounion/Thasos: but it seems to have been more widely a preference for a weight standard measurement in ancient Greece for the capacity of shipping.

It is not necessary to assume that such a preference, and its operation in practice as regards ship-loading and taxing (on which see below), implies any equivalence or correlation between such weights and the capacity measures in which much carried by sea was otherwise measured. As already argued there is no evidence for theoretical equivalances between measures of length, capacity and weight until late Roman times. The (slight) evidence for tare and gross or net weighing presents an alternative to capacity measurement; I suggested it was a preferable alternative in the stocktaking context above[224] and it could possibly be felt preferable for ship loading also (though this would be dangerous without also considering centre of gravity). Such an alternative can be used independently of other measurement (that might be preferable on other occasions).

This is in a sense to restate Wallinga's own doubts about any implication of overall metrological systematisation. His misgivings (p. 24) seem to have centred on (1) the variation in general practice (between weight- and volume- measurement) and (2) comparison with modern usage, where a unit such as the "ton" can vary depending on who used the unit and why (without any implication of correlation).[225]

The apparent instances of equivalence or correlation are unsatisfactory. We do not know what Herodotus' sources were, and so he need

not be responsible for the "translation" into terms acceptable to the Greeks. ἑτέρα φορτία of (6).1 are anyway doubtful. More significantly these, and the cargoes of the two decrees (1) and (5), are actual cargoes, and not theoretical potential capacity.

It could furthermore be doubted whether the harbour regulations we have are sufficiently complete. As Wallinga pointed out, most Thasian trade would surely be in wine, and (as the earlier Thasian inscriptions show) this had to be carried in certain containers. Fines (and so presumably other charges) were, at least in the fifth century, based on just these container units (ἕκτην κατ' ἀμφορέα ἕκα[στον ὀφελέτω] Pleket 1.5. - a coin sixth, not a dry measure) - The Thasian ruling no. (5) applies to ships with weighed cargoes, similarly the Sounion decree no. (1). Could it be suggested that not all shipping had weighed cargoes, and that these decrees do not imply that they did?

I do not really feel this point holds. The Sounion decree certainly reads as if all shipping can be subsumed under its classification of cargo by talent-weight. Nevertheless the difficulties raised over particular cargoes handled in non-weight units in the last paragraph can perhaps be avoided by breaking down the various operations (or operators) involved in the carrying of goods by sea. The difficulties arise from regulations concerning traders; their concerns do not necessarily overlap with the ship captains who would worry about the size of cargo carried on a particular ship and voyage, and its disposition in the ship in rather different practical detail from the trader concerned simply with the safe transport of as much as possible; further harbour officials, interested in extracting charges from shipping, would be concerned with as simple and general a method of assessing such charges, either by measuring cargo or more simply by a fixed rate on the likely size of the ship's cargo. This would then appear as an expression of potential capacity.

Clearly the harbour official's interest stands separate from those of trader and ship-captain, and I shall pursue it in what follows. The distinction between the other two is meant to be one of interest; it should apply irrespective of whether the two are in fact one and the same person. The evidence of loading practice and the relations between traders and ship captains is too fragmentary (and too complex) to be

pursued here. I shall leave open the possibility that the ship captain may have used systems of measurement other than the trader. As far as I can see it is unlikely: weight he could estimate best from how low in the water his ship was, but he should also have been no less concerned with centre of gravity affecting his stability. This he could not have calculated.[226] Nevertheless it seems very probable that the ship captain used his own containers and packaging systems on occasion. Thus grain carried on board in sacks or baskets, could and apparently was then poured out either loose or into larger containers.[227]

The most likely quarter, to which the standard measurement of ship capacities in terms of weight can be attributed, is the official harbour administration. Harbour officials were faced in the first place (and for state policy, apparently the most important) with the extraction of charges from shipping. This, as we know both from these two sources (1) and (5) as from general practice, was calculated upon the amount of cargo carried either as a rate ((1) and (5)) or as a proportion (ἑκατοστή, πεντηκοστή ..). More consideration of how this proportion in particular instances, but also the rate itself, might be calculated, must lead to the conclusion that weighing was the simplest procedure available: weighing that is of the total cargo (amphorae as well as their contents). The reasons I should give here are basically: (a) universality: whatever was carried in the ship could be weighed, not everything could be measured in a single other way; (b) suitability for the calculation of fractions (weight systems were very flexible in this respect because of the low units, at least theoretically, they involved); (c) the practicality of talant for porterage, and handling;[228] (d) impossibility of proper capacity-volume measurement (different packing capabilities of commodities, thicknesses of amphora and degree to which filled etc.).

A further point now can be made, arising from the combination of weight of cargo with docking position on the Thasian inscription (5). As already argued, considerations of water depth, ship length etc. are ruled out by the fact that the ships need not have been full. Now, as checks on the weight of cargo needed a great deal of porterage and access to weighing machines, is it not likely that these dock positions were fixed in relation to where (physically) both porters and machines were

organised? Not all weighing will have been conducted on board ships as on the Arcesilas Cup.

The following conclusions have therefore been reached:-
Firstly the commercial world of ancient Greece only weighed such commodities as they sold by weight. There is no suspicion of traders dealing with equivalences of weight units and volume units. The evidence (slight) for tare weight does not necessarily imply this.[229] We can therefore return to the simple statement made at the outset for the measurement of commodities carried by traders on ships.
Secondly, from the latter part of the preceding discussion, I suggest that some harbour officials weighed the whole of any cargo subject to tax in order to assess such tax. This weighing took no account of the commodities involved: jars were weighed with their contents: but no one suffered as a result.[230]
Thirdly, potential ship capacities were expressed by the ancient Greeks in whatever units were relevant to the commodity they imagined the ships as carrying. Thucydidean usage (capacity measures) must be preferred to Herodotean (talents weight) and certainly is backed up by subsequent practice (Roman). Ship capacity does not therefore qualify as a distinct context for weighing.

It may be interesting to note that the sizes of ancient ships are most usually expressed in linear terms. An exception to Ktesias Indica ὁ τὸ δὲ ξύλον ἔσων μυριοφόρου νεὼς ἴσον (describing the bamboo plant: Wallinga P.5). Some correllation between size and capacity clearly existed, but this could hardly be relevant in practice, where the bulk of items carried, their stackability, weight and centre of gravity of the whole ship, would determine how much could be taken safely on board. Although this factor can have concerned ancient sailors no less than modern, there is no evidence to show that the Greeks ever considered systematically the relation between weight and volume and its positioning in the ship.[231] Experience alone would indicate how full, and of what, a Greek ship could be loaded.[232]

2. (13) Kottabos

An arrangement comparable to a weighing balance was incorporated into the design of one variation of the game called κότταβοι κατακτοί. This version appears to have required banqueters to throw to overbalance a two-pan balance fixed at the top of a pole so that first one and then the other pan swung down to knock the top of a figurine positioned beneath it: κατακτοι δε ἐκληθησαν ἀπο του καταγειν και ἀυ παλιν ἀναγειν τον κοτταβον (Schol. Ar. Pax 1242 cf. Schol. Lucian Lexiphr.3).

The implication of an overbalance type of suspension is derived from the fact that the contrary swing is only achieved by a second throw (εἰπε το ἑτερον παλιν βαρυνοντες ... schol. Ar. Pax 1242); furthermore the overbalancing is sufficient to be decisive and leads to a noise as the pan hits the figurine's head (this can probably be transposed from another version described at Athen.XI.487.E ≡ XV.667.A και ψόφος ἐσται πάνυ πολύς). Significant is that the scholiast describes the action of this balanced kottabos as καθαπερ ἐπι τρυτάνης.[233]

Nevertheless this version of κότταβοι κατακτοί does not seem to have been at all common. Other versions, though they do not involve a balance, no less involved the idea of knocking something down: either a single bronze disk (called πλαστιγξ, cf. Athen.XIII.600.E) balanced at the top of a pole that had to be knocked off, or a cup floating in water that was to be sunk. In fact the first of these alternatives seems the simpler interpretation of Ar. Pax 1242-4.

The balance though it occurs in the context of the kottabos, and is clearly of the overbalance type when it does occur there, cannot be thought a prominent variant of the game, and may possibly be a rather late innovation especially as it only is detailed in scholiasts.[234]

2. (14) Apatouria

The weighing that took place during the Apatouria festival at Athens has already been discussed above chapter VI.3.(4), and here only a summary is necessary. It was comparative in the sense that a difference in weight seems the most conspicuous element of the ceremony (μεταγωγεῖν, and the restriction against over-weight : οὐκ ἐξὴν μεῖζον παρασχεῖν). Nevertheless it did involve also a fixed weight standard against which the sacrifical victims were weighed. There is no indication in the sources that this standard was an absolute amount, so many talents or minai: the scholiast to Ar. Ran. 798 simply mentions a σταθμὸς ὡρισμένος. While it is likely that the phratry fixed this standard, it is odd that no absolute amount is given; likely explanations are that phratries varied; or that the σταθμὸς ὡρισμένος was an ancient stone, its absolute weight immaterial; or that the essence of the ceremony was to find the victim underweight - this in effect defining whatever it failed to weigh. The evidence is insufficient to clear up these difficulties But, it is surely likely that such ceremonial would have substantial backing from long tradition by the time of the late fifth-century Aristophanes, and it is unlikely that the weighing was entirely symbolical right from the start. Thus the more attractive explanation is I feel that which relates the σταθμὸς ὡρισμένος to the sorts of ad hoc standards in the period before the introduction of systematic, absolute weights.[235] It is therefore important to note that the sort of weighing at this date was basically comparative.

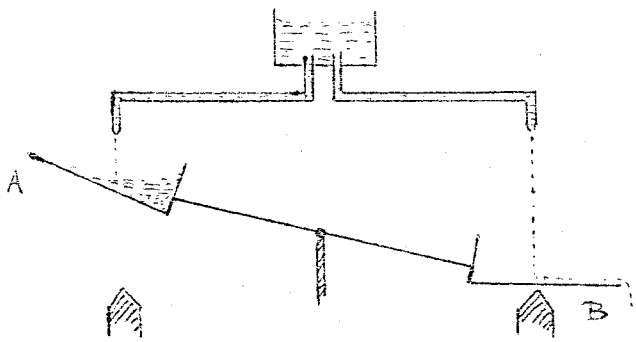
However the weighing at the Apatouria, even if it can be nicely fitted into this overall picture of the development of Greek weighing, cannot on its own point towards such a picture. The only direct implication is comparative weighing with a standard weight in a semi-religious context by the late fifth century. The suspicion that this might have become a purely ceremonial procedure must be allowed. But the balance used will presumably have been similar to those available at the time, and therefore

these conclusions should be compared with other evidence of temple weighing activity of the same period: the important context of inventory and accounts considered above in VII.1.(4).6.

A part of the Apatouria festival celebrated the shaving of the hair of ephebes. Called the κουρεῶτις , it involved the offering of the κούρειον . This ceremony was possibly distinct from that involving μεταγωγεῖν etc, but it suggests a possible parallel with the Egyptian custom of shaving children's hair. This was weighed against silver, and the silver given towards the keep of sacred animals: Hdt .II.65.4. The weighing of hair is mentioned at least twice in the Old Testament: II Samuel 14.26; Ezek.5.1. There is however no evidence that the Greeks weighed it till it was required for catapults (see VII.2.(9) and also references in chapter III). The small quantities in the Egyptian ceremony might well have been beyond the limits of Greek weighing machines, although hair is heavier than would be imagined (e.g. an uncrushed handful trimmed from a one-year-old child weighed, I discovered, as much as 1.23 gm.)[236].

2. (15) Water-Clocks

There is no evidence that the Greeks incorporated the balance into their water clocks. An extension of the principle of κόττυβοι κατακτοί can produce a rudimentary pendulum. See diagram: pans A and B at the ends of a beam supported from underneath: the pans are rigidly attached to the beam as scoops with open ends away from the beam, such that water dripping from two tubes into pans A and B will be held in A (the higher pan) and simply flow out of B. When sufficient water is accumulated in A, the balance will overtilt and the process resume with pan B. Mechanisms of this type are known from the middle ages and even approaching recent times; it may have been invented by the Sixth century A.D., to judge from a reference in Paulus Silentiarius (Anth.Pal.9.782):[237]



ὕδασι ἠελίοιο ταλαντεύουσι κελεύθους.

However even the most advanced Greek κλεψύδραι described by Vitruvius IX.viii.2-14 (Loeb) retain the idea of continuous flow of water from a single source either flowing out of a vessel (the earlier type) or into it (Ctesibios' variations).

2.(16) Personal weighing

The Greeks were not weight-watchers.

Greek art shows figures on the pans of balances in a variety of poses: standing, fighting, jumping (as I suggest for Rep.EE1 "The Boston relief"), and even swinging (Rep.E.4). Such scenes are however allegorical representations of moments of competition in people's lives, and the figures are not thought of as real people. Homer called them κῆρες; later artists in the Christian period felt free to represent souls in similar positions. This allegory has been shown to be backed up with a general corpus of literary references to the application of the balance to stages of human life.[238] Equally impractical in reference is Aeschylus' insertion of two chariots and two corpses into his scale, and his challenge for Euripides (and his family) to climb into the other at Ar. Ran. 1403-1410.

A more practical note, however, is struck by representation of Hector's corpse being weighed on a balance (Reps. H.1-2 being Greek mid fifth and early fourth cent.).[239] It does not matter here that Aeschylus or Lykophron misinterpreted Homer; these writers imagined, and apparently one depicted on stage, the weighing of the body against gold. Three points can be made. (1) The overbalance procedure of normal commerce is entirely suitable, for the context is basically a commercial one. Indeed the explanation I have given already for the suitability of the procedure is very much underlined in this case: Achilles will surely insist on seeing he has at least as much gold as Hector weighed: Priam on the other hand would not mind that little extra! (2) Secondly, the example should not be overworked; the occasion was hardly normal.[240] (3) The practical weighing could indeed be derived from the metaphorical comparison of a man's worth with gold or silver [cf. Theognis 77-8]. As weight was what determined the value of an amount of gold and silver, so it could be thought to express a man's value.

But not to measure it. The metaphor breaks down at this point; and

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though meat was sold by weight it patently was never as valuable as gold. There is no evidence that the Greeks were conscious of variations in human body weights, certainly they were not concerned to weigh themselves. The idea occurred first, it seems, to Pollux on reading a line of the fifth-century comic writer Crates (Poll.IX.53, Crates fr. 32 Kock CAF.1.p.130):-

> τὸ δὲ ἐν ταῖς Κράτητος Τάλαις "πρῶτα μὲν ταλαντιαῖος ὅσος ἐστ' αὐτῶν λέγε" ἄδηλον εἴτε τιμὴν εἴτε ῥοπὴν λέγει ...

Though Pollux goes on to cite examples of ταλαντιαῖος used clearly of weights, he must be wrong to hesitate over Crates. The prospect of a crowd of dwarfs (talent equiv. to 26 kg Hultsch GRM^2) becomes grotesque when their 3-talent houses are included (Isaios III.18,25). The reference is simply to the property qualifications at Athens.[242]

Conclusions

Personal weighing, considered last in the preceding list of largely negative contexts for practical weighing, is a good illustration of the sort of weighing carried out in ancient Greece. The bulk of the evidence is of comparative weighing, which can be transfered to an allegorical level as in this case. Also indicated however is an element of equivalence weighing, though compatible with the overbalancing technique. No instances of measurement are to be found. Much the same picture is the general result of this chapter as a whole. Here I shall briefly summarise the extent (in terms of people involved), and the types of weighing that have been found in practical use.

The general Greek public came across weighing in general commerce, but few commodities were weighed necessarily by weights and it seems that there was no requirement that anything of general interest had to be so sold. That states could charge for the use of balances might indicate few were in operation; this would be confirmed by the lack of surviving examples; however I have preferred to note the large numbers of weights that have survived, to suggest that balances were perhaps vulnerable to decomposition, or problems of identification, and to explain state balance-fees as for the use of special balances. However in general commerce there seems to be little reason to distinguish between weighing with or without weights given the overbalance technique. Bargaining for basic price, followed by a decisive and apparantly favourable tilt of the balance, could operate whatever the weights were, whether they were inaccurate or not, whether they were used or not. Amounts would be sold by multiples of single units (repeated weighings); items involving a specific amount of a certain more valuable material (e.g. iron) would, I suggest, be sold as unit items generally and only in special cases be priced with reference to their content (public works and large-scale contracts).

Even though the procedure I have argued for most commercial weighing

minimises the importance of accurate weights and weighing, there remains the possibility of fraud, and there is some evidence that it occurred. That complaints about weights and weighing in ancient Greece are so rare (restricted in effect to the sale of wool wet) is however to be contrasted with complaints about measures and pricing from the same people, and more generally with the clear widespread concern about weights in the trade of other contemporary and earlier cultures.[243] This is perhaps the most important single argument against any significant use of weights and weighing in general commerce.

Locally money could be changed quite simply by its face value. If the Greeks travelled they could be faced with money-changers with balances and a rather preciser repetition of the weighing procedure of general commerce. More likely however (especially if they were Athenian) set tables would exist for the changing and no weighing would take place. The occasional miser or hoarder could be interested to check his possessions. If he was sensible however these would be in coin, to be counted, and there is no evidence that Greeks ever doubted the values of their own coinage.

In other aspects of ordinary life weighing would only be noticed in the annual Apatouria festival at Athens, or the occasional game of kottabos at an avant-garde friend's house. In both the overbalancing element of the balance alone was involved. The general Greek public would continue reinforcing, and reinforced by, the attitude to weighing expressed in Greek literature.

Much in the commercial world was very similar. Regulations had to be observed and the official weights used where needed, but checks were the responsibility of others. Specialists, dealing in certain commodities, especially metals, were probably much more frequently concerned with weighing. For the most part they will have handled standard units of such materials irrespective of their absolute weight; in some cases, however, they will have been required to consider stocktaking techniques and may have used the measurement of tare weight as a means of doing this; and in others, dealing with public works officials, they were clearly compelled to exercise careful (and pedestrian) control on the weights of materials and pricing. This last however need not have involved measurement, so much as measuring-out standard units, for the public officials would have to pay for off-cuts that resulted.

International trading would clearly be complicated by the lack of consistent weight systems and standards if weights were indeed important. Nevertheless such trading seems to have flourished and only by the late second century B.C. to have reached the point of wanting to insist on its own independently consistent standards. There is no reason to suppose weight measurement was of concern to ship captains; as long as they were not too low in the water they would be satisfied; only officials seem concerned for tax purposes to have "rated" shipping by potential load.

State officials were however very much more closely concerned with weighing. Not only responsible for supervision of weights used commercially, for policy-making in terms of decrees and regulations covering both what weights were to be used and their use, for administering the leasing out of stateheld balances or special weights, for charging ship-taxes, but also officials were forced (by virtue of their public office) to demand careful weighing of items purchased for building, and (most important of all) to conduct detailed inventories of temples and stores. The aspects of weighing covered by officials would range from simple overbalance checking (e.g. of minimum weights) to careful measurement (for inventory) and further sophisticated subtraction-weighing techniques and accounting. Although recognising the amateur position of many such officials, I should prefer to suggest these activities largely conducted through more permanent assistants than that any Greek could be called upon to perform them. In any case the number of Greeks who held and had held such offices would, even if several times the number of officials at a given moment, still remain a very small proportion of the total public.

Further specialist activities involved consideration of weight. The manufacturing of coin, weights, or (doubtfully) of artillery involved no more than ensuring a certain weight standard was maintained. I have indicated simpler ways of subdividing such standards (especially for coinage), and feel sure these were followed, rather than complicated absolute weight measurement for which the basic units were absent, and which was intolerably inaccurate and impractical. Processes from cooking to metal alloys, requiring the mixing together of set ratios, could be accomplished by weighing, and in a practical manner: the type of weighing however would be by measuring out a number of equivalent units rather than by measurement. Similiar techniques (certainly none more sophisticated and nothing approaching

measurement) were used by philosophers for scientific work and by doctors.

With little evidence of weight measurement, this discussion of practical weighing in Greece has produced nothing to contradict the implications of the general Greek attitude to weighing derived in the last chapter. It remains to reconcile the remarkable inaccuracy of extant weights with both the lack of complaints about such inaccuracy from contemporary Greeks and with the apparent assertions of precision made by official accounts and inventories and implied by Greek fractional coinage.

chapter eight

THE RELEVANCE OF PRECISION AND ACCURACY TO THE POINT OF GREEK WEIGHING

Introductory

Two fundamental discrepancies in the evidence lie behind the problem of greek weighing in practice. The first is the mass of weights (and coins) and weight measurements compared not so much with absence of surviving weighing machines (surprising though this be) as with the lack of references to their use or misuse.[1] This discrepancy formed the basis for discussions of context and types of weighing (with or without weights; measuremental or not) in the last chapter. The second discrepancy has yet to be fully illustrated: it is between the high apparent precision of weighing in accounts and of the theoretical values of fractional coinage on the one hand, and on the other, (1) the wild inaccuracy of extant weights (especially commercial, and fractional coin), (2) the limited sensitivity of the types of weighing machine used by the Greeks, and (3) the lack of significant references to the preciseness or accuracy of weighing in ancient literature. The extent of this discrepancy needs no further exposition here; instead I shall attempt an explanation (if not a solution) to the difficulty the discrepancy poses.

The traditional approach has tended to ignore the problem and accept at face value the most precise statements of weight (e.g. the $1/8^{th}$ obol on inscriptions and in coin). On the assumption that these precise statements were also accurate, variations in extant weights are regarded as archaeological accidents or contemporary Greek mistakes. If no evidence of sufficiently precise machinery exists for such performance, it is, on the traditional line, still to be discovered. This view I reject in the face of the mass of contradictory evidence in detail (e.g. that only certain ccins have high accuracy) but also on the general grounds of Greek disinterest in precision or measured weight. This traditional approach ignores the indirect evidence, and makes no allowance for the different sorts of weighing procedure, especially their conceptual differences.

Another solution would be simply to reject as dishonest the more extravagant claims made by the Greeks in recording the results of their weighing. There may be some room for this view (especially in certain inventories), but it cannot account for such general procedures as the production of fractional coinages; nor is it an attractive solution on any level.

The explanation I propose consists in effect of three elements, of three different considerations. Firstly, it should be allowed that the basic Greek weighing method was comparative (distinguishing) and used unstable balances. Not only might this in fact increase the likelihood of higher performance results, but it introduces an important distinction between precision (simply the last weight added to overbalance, and this can be very small indeed) and accuracy (incorporated in the machine). This possibility of going well beyond limits of accuracy, without realising it, is a happier alternative to downright "dishonesty".

Secondly a necessary part of my conclusions on usual Greek weighing of this type is that it was not measuremental. Sets of weights are not as importantant as single, ad hoc standards. In this chapter we are in fact dealing with a relatively rare (specialised) facet of Greek weighing.

Thirdly a distinction should be made between absolute and acceptable accuracy. By this I do not mean to imply for example that the Greeks made weights as inaccurate "as they could get away with", but rather that contexts existed in which what we would call great variation was perfectly acceptable to Greeks whether they realised the variation or not. Albeit somewhat circular, this consideration has an obvious practical application. It relates further to a fundamental element, the point of weighing. By considering the point of weighing in different contexts it is possible to vary the emphasis, on the weighing or on the recording of a certain weight, on the measured amount or on the repeated constant unit, and which side the error might be expected to lie.

In these ways precise measurement of weight can be separated from accuracy; and, further, both disconnected from the basic concept of weighing. The discrepancies noted above exist, but were not valid in ancient Greece. This does not of course excuse discrepancies and inaccuracies in modern weighing of ancient Greek weights: there note for example the famous bronze weight (Barron Silver Coins Samos (1966), 7.n1); Olympia diskoi (Gardiner JHS 27 (1907), 7); and Pergamon catapult balls (Boehringer Alt. von Pergamon X (1937) 49).

Discussion of this subject poses problems of presentation. The potential of Greek balances has been considered above in chapter I with Appendix B on experiments; the accuracy of extant weights in chapter II and the problems of determining a useful idea of the accuracy of coins in the same chapter. From these two sources an approximation to the possible precision and accuracy of Greek weighing could conceivably be derived, but in fact the evidence is inadequate to lend much justification to such an approach.[2] In particular there is no evidence for particular sets of weights used consistently in individual contexts, nor is there any evidence of the degree of care taken by operators of Greek weighing machines. Clearly discussion at this point must be centred upon the precision and accuracy of Greek weighing in practice.

The latter part of this chapter is concerned with precision and accuracy and therefore of weight measurement. As already said, and as will in fact be subsequently reiterated, this was rarely the point of weighing in ancient Greece. The more usual use of weighing was to distinguish (comparatively) and for this weights were not necessary. Some, quite separate, attention should therefore be paid to the accuracy and sensitivity of weighing in these conditions. Hill asserted that "we are not justified in assuming that the Greeks cared about weights less than the least" of the fractional coins (0·05 gm).[3] While I am extremely sceptical about the Greeks having any awareness of such low weights (in fact reject entirely the possibility), and furthermore while I would resist the inference as drawn from fractional coins, I also challenge the overall assumption. Greek balances could, I believe, detect weight differences below the practical limits of weight measurement. The smallest Greek weights used for weighing may indicate the sensitivity of Greek balances; but this is not to say the smallest coins necessarily indicate such limits.

The first part of this chapter collects evidence of the performance of Greek balances in essentially non-measuremental terms. The emphasis is on sensitivity. Though the evidence is not as clear as could be hoped, it does give rough indications that this sensitivity was worse than the extravagant claims of attested and recorded weight measurement. These are considered in the second part of the chapter. After questioning their credibility, I attempt to separate precision from actual accuracy. By considering the relationship between precision and accuracy, I conclude by putting measuremental weighing in its proper place with regard to the reasons for Greek weighing as a whole.

1. The sensitivity of Greek weighing in practice

Further to the introductory remarks above, two aspects can here be distinguished: the maximum sensitivity achieved (the smallest detected weight differences) and insensitivity accepted or recognised (the order of weight difference regarded as immaterial or indicated as small). Evidence for the first aspect can be sought in the claims of Greek scientists, but it is difficult to avoid the suspicion that such claims are more often based on theory rather than practical weighing experiments. Coin weights must needs be considered for both aspects; as also certain indications of weight measurement, though this properly belongs to the next section. The conclusions that it is possible to reach here are unavoidably tentative, but nevertheless fall very well into line with both the potential of Greek balances, discussed in chapter I (and Appendix B. on experiments), and more general indications of the sensitivity of weighing, as indicated by chapter VI.

1. (1) Maximum sensitivity achieved.

1. Observed minimal weight differences.

A number of passages reveal observations of differences in weight, several of which appear at first sight to have been slight. Though a likely source therefore for infering the sensitivity of Greek weighing machines, these passages are tantalisingly circumscribed. (1) Problems of date and attribution. Thus one of the most productive sources, the pseudo-Aristotelian Problems, was put together late (as late as fifth century A.D.) even though drawing on earlier classical authors and especially picked from observations made by Aristotle. In several cases parallels for such observations permit their use as evidence of the earlier classical situation (and it is the observations, rather than the entertaining explanations characteristically offered in question form, that are relevant here). (2) The impossibility in most cases of determining the sizes of samples involved. (3) Occasional doubts whether the observation in question is genuine or based on theory. This suspicion is most relevant to the Aristotelian view that air has a weight, and that damp air is heavier than dry. Both are true, but there are grounds for thinking the latter at least to be based on observation (e.g. of dew) other than observation of a controlled weighing experiment.[4]

It has proved possible to group these references according to subject matter. Such an arrangement helps arguments for dating as well as for investigating the weights involved.

Passages, and arguments for the insensitivity of Greek scales are treated subsequently in the next section. The division is possibly arbitrary, but helps towards clarity in presentation. The present section however, in seeking to see how small a weight difference Greeks were able to detect, is aiming to find evidence for the maximum sensitivity of their weighing machines, not acceptable accuracy.

— — — — —

— (1) Arist. de Caelo. 311 b 3-4 ἐν μὲν ἀέρι βαρύτερον ἔσται τάλαντιαῖον ξύλον μολίβδου μναιαίου, ἐν δὲ ὕδατι κουφότερον "A talent of wood will be heavier than a mina of lead in air, but lighter in water." Considerable ingenuity would be needed to reconcile Aristotle's explanation here with that currently accepted, or to achieve consistency with a later observation in the same passage that an ἀσκός filled with air will rise to the top of water but not of air. The present example can yield a quantifiable result but of little value. Given that immersion of the wood in water affects its weight at all it must be a type of wood (unlike ebony etc.) lighter than water. It will therefore float, and should properly be registered as zero weight. The differences observed in this experiment are therefore 59 minas in the first weighing and 1 mina in the second.[5]

— (2) In the same paragraph occurs the most interesting example. De Caelo 311 b 9-10 everything has weight, even air: σημεῖον δ' ὅτι ἕλκει πλεῖον ὁ πεφυσημένος ἀσκὸς τοῦ κενοῦ, repeated at [Arist] Prob. XXV.13 939 a 33, again without any measurement of this difference. That an inflated bladder can weigh more than an empty one is true - not because of the air inside the inflated askos as Aristotle thought, but because of the greater amount of air inside a pressurized askos than its volume displaces. Moreover the weight difference, though slight, need not have been insignificant. The problem is to reconstruct Aristotles' experiment, or at least to consider the limits of the variables involved.

The most relevant factors are the pressure of air and the volume of the askos. ~~Heat, lowering the weight, from exhaled air if a pump was not used, would have become negligible by the time the askos was shut; and~~ The possibly lower weight of alcohol vapour (supposing an inebriated slave) would be cancelled out by the accompanying water vapour. Weight increase can, theoretically and adequately relevantly, be expressed by the formula

$$\delta W = (P-1)\ V \text{ gm.}$$

where P is pressure in units of atmospheric pressure (15 lbs. per sq.in), V is volume in litres.

The volume of the askos used for such an experiment cannot be ascertained. Pictorial representations show unlimited variations; but for the purposes of this study it might be reasonable to take as limits two container sizes indicated in Aristophanes. The 3-kotylai or so ἀσκός of

Ar. Thesm. 743 (with 733) is specifically a baby-size, and approximately 1 litre.[6] At the other extreme Strepsiades rates his creditor as making a container, capacity 6-choes (Ar. Nub. 1238 with the preceding line indicating an askos as understood)[7], that is, nearly 20 litres. Between these limits it is not easy to decide; a 10 litre askos of wine would strain its carrier and might therefore be a convenient guess; on the other hand, as balance sensitivity decreases with weight weighed, we need not feel restricted to any particular size in order to arrive at an expression of balance sensitivity.

Pressure is difficult to place even within likely limits. Aristotle did not realise that the weight difference he was detecting depended entirely on the pressure reached, so this is no reason to suppose he insisted on maximum pressure. Furthermore an askos is more rigid than a balloon and does not require the same pressurisation, or immediate closing, that is necessary for blowing up balloons. I shall, however, presume that Aristotle's askos (tied up with thong as most illustrated askoi are) was in fact closed before any pressure could escape. Was it inflated by a person or by a pump? A pump could conceivably exert rather more pressure. I am not certain on the availability of such a pump however, and, as said, doubt that Aristotle would have considered great pressure important. I shall therefore assume the pressure to be that achieved by a normal slave, blowing hard but not excessively so. My impression is that the pressure would be between 2 and 3 lbs. per. sq. in.[8], so outside limits could be $1/10^{th}$ to $1/5^{th}$ of atmospheric pressure (15 lbs. per sq.in.). For comparison, however, the effect of a pressure of 2 atmospheres (15 lbs. per. sq. in. registered), that could only be achieved with a pump, is included on the following table.

Pressure absol. (lbs sq.in.)	Pressure atmospheres	Increase in weight (in gm) at:-		
		1 litre volume	10 litres volume	20 litres volume
0	1	0	0	0
1½ lbs	1.1(+⅒th)	0.1 gm	1 gm	2 gm
3 lbs	1.2(+⅕th)	0.2 gm	2 gm	4 gm
15 lbs	2	1.0 gm	10 gm	20 gm

At the most reasonable interpretation - pressure (not straining) 1½ lbs; volume 10 litres - the difference in weight should indeed have been detectable

on Greek balances. Even with the smaller 1-litre askos, which is most unlikely, a sensitivity is indicated not far removed from that derived in chapter I and Appendix B for reconstructed Greek balances (around 0.2 gm). Aristotle's experiment here can be accepted.

— (3) A context already mentioned is that of variations in the heaviness of various sources of water (see above VII.2.(7)). These variations are expressed in comparisons contrasting different factors that might contribute to lightness or heaviness: there is also very late evidence of a general survey of water in a measuremental sense. This was necessary in the one recorded example, as samples were taken from the same place in summer and then in winter: Athen. II.42.B. Athenaeus himself seems to claim responsibility for the experiment which showed a kotyle of water from Mt. Pangaeum as weighing 96 drs in winter, but only 46 drs in summer.

A variation of this magnitude seems quite incredible. It clearly offers no evidence of particular sensitivity, but further raises grave suspicions about the care of the weighing involved, the consistency of weights and container-measures used. The last consideration is of major importance in any attempt to weigh similar volumes of different liquids comparatively as is also suggested by further observations to be mentioned below. Several points underline the extreme difficulty of Greeks' achieving any accuracy with such comparative weighing in practice. First, two containers must be used and their weights adjusted to be equivalent empty. This is not difficult, but more awkward is, second, that their capacities should be exactly equal (1 cc. water variation, which is very little in a κοτύλη of 275 cc. approx., incorporates a theoretical 1 gm. error). This is perhaps checkable by re-weighing, but, thirdly, clear marks of level should exist to ensure that the capacities are properly observed. Greek vessels, of opaque materials, would have to be filled to the brim and it is seriously to be doubted that, even if weighing began with equal capacities, this situation lasted as the pans of a balance tilted.

With these discouraging comments, I shall briefly consider four further observations made by Greeks on water-weights.

The simplest observation is of the difference in weight between fresh and salt water: λεπτότερον γὰρ τὸ πότιμον τοῦ ἁλμυροῦ [Arist] Prob. XXIII.8 (932 b 8f) with variants ποτάμιον, ῥεῦστα τὰ

ποτιμα; θαλάττη; and βαρύτερον for "heavier" in other passages of the same book: 10 (932b25), 14 (933a15), 22 (934a8), 38 (935b18), and alongside other factors in 20 (933b21), 30 (934b23ff).

These other factors are heat, cf. also Prob. XI.10 (βαρύτερον ὑδωρ [τὸ ψυχρόν] 900a6); and aeration (this latter only in Prob XXIII.30 of the two passages noted above) of water surface and of fresher waters in general.

The truth of these observations, and the order of weight differences involved, depend upon the conditions (experiments or natural occurrences) from which they were made. Salt water weighs more than unsalted water in that salt weighs more than water (see next section (4)). The degree by which salt water is heavier depends upon the concentration of salt in the water and the size of sample compared. Taking a constant capacity unit of 250 cc (close to the κοτυλη of approx. 275 cc) and comparing a saturated solution of salt water with fresh, the weight difference appears to lie in the region of 30 gm. [or 12%].

Heated or aerated water should weigh no more than an equal volume of cold water. The observations appear therefore false. However it is possible to make sense of the heated water point, if by heating is meant boiling. 250 cc. of water boiled for 2 minutes was found to lose more than 50 gm weight; the process could be prolonged or shortened. No indication of sensitivity is provided. Further, aerated water can be produced by blowing through a straw into water; supposing the container to be full to the brim for the measured amount, such blowing will displace some water and the result appear lighter. In both these cases however the observations are derived from comparing unequal volumes of water.

Somewhat more advanced is the observation, ascribed to Hippocrates, that water which heats and cools quickly is always lighter in weight (Athen. II.46.B). It would seem reasonable to suppose that samples were heated to boiling point in the absence of Greek thermometers[9]; and further experimentation with salt and fresh water samples can be inferred from both 46B and earlier 42C. The truth of the observation lies in the fact that the boiling point of salt-water is higher. There is no way in which the Greeks could have known this absolutely. Salt-water has already been shown to be detectably heavier.

— (4) Water is compared by weight with other substances. Thus salt (αἱ ἅλες) is heavier than water [Arist] Prob. XXI.5 (927a37) and oil lighter (ibid) XXIII.38 (935b22). Note however should be taken that in each case the context demands comparison with water.[10] Secondly, despite awareness of variation in water-weight, the writer is not concerned to specify what sort of water is heavier/lighter beyond that which is obvious from his context.

The actual differences, suggested by a brief experiment, again using capacities of c. 1 kotyle for comparison, are far from minimal (though considerable variation could be obtained with different sorts of salt and its humidity). Oil was about 20% lighter, salt nearly 30% heavier, than water. There is no indication that [Arist]'s observations were based simply on the fact that salt sinks in water while oil floats: the theory behind the use of such readily observed facts was not apparently available to the Greeks (see chapter VI.2).

— (5) In [Arist] Prob XXVI.33 (944a10ff), and cf. 42 (945a16 καὶ ἐκ πνεύματος κουφοῦ ὑγρὸν βαρύ), explanations are advanced that rest upon the fact that damp air is heavy. This is an occasion where it is very far from clear whether theory (and the clearly recognised fact that water was heavier than air) is responsible for the "fact", or actual weighing. I strongly doubt any actual weighing here, and for three reasons: the fact is a major feature of the explanation, and these explanations tend to be theoretical;[11] the observation is not signed enough as a practical experiment; the practical difficulties of the experiment are enormous. Further the weight difference in any practicable volume of air is negligible.

— (6) Another set of variations concern bread and its materials. The first I shall mention is closely comparable to water variation, though it observes a paradoxical situation: salt bread lighter than non-salted [Arist] Prob XXI.5 (927a35ff) διὰ τί οἱ ἄναλοι ἄρτοι πλείονα σταθμὸν ἔχουσιν τῶν ἡλισμένων, τῶν ἄλλων αὐτοῖς ἴσων ὑπαρχόντων ;
Despite this careful statement one factor is not allowed to be constant, namely humidity. As it is the evaporation of water through salt that is given as the explanation, the weight difference is properly accounted for by this increased water-content in non-salted loaves.

Somehow inserted into this point is another observation: day old[12] loaves are lighter than hot ones (at 927b2f), the explanation being because

they are colder. Though the humidity point is also relevant, it is only implied. In theory another paradox is produced here, as hot is generally lighter than cold (again contrast water example above).

The paradoxical nature of the loaf-weights is some confirmation of the weight variations being actually observed in practice. There is moreover reason to believe these variations known as early as the first half of the fourth century, for they surely are the proper explanation of what the Agoranomoi are looking for in weighing τὰ κάτω (sc. ἄρτου) πρὸς τὰ ἄνω (Xen. Symp. II.20).[13]

Experiment (with theatrical variation) showed again that the difference need not be inconsiderable. However it is impossible to derive any absolute indication of sensitivity given the variable factors involved (size loaf, amount of salt and/or water content, degree of staleness etc.), which cannot be determined. Using brown bread, weighed first when fresh then again some time later, a 15% loss of weight was detected.

Three further references to grain are less interesting. The extraordinary claim that a mixture of liquid and barley-meal is lighter than its two constituents Prob. XXI.18 (929a25ff) bears suspicious marks of being fabricated from the apparent decrease in overall volume on mixing (and note that a lessened mixture is in the writer's mind (a28)). The other two passages can be reduced to the observation that barley-flour is lighter than that made from wheat Prob. I.37 (863a34ff); XXI. 26 (929b35ff). Presumably similar volumes are compared; and, though explanation is surrendered to φύσει in the latter passage, the former reveals that the barley was thought to be more moist. I have not been able to mount an experiment to assess the latter assertion, barley-flour not being obtainable.

— (7) Wool was recognised as heavier if wet by the end of the fifth century (ex Ar. Ran. 1386-7 in scholiast), and the mid fourth-century Erythrae decree (Pleket 4.9ff) explicitly forbids its sale wet. The possible difference is considerable; varying greatly with the degree of wetness, but easily over 100%.

Other commodities (such as rope and possibly sails) which are measured in weight units would be subject to the same variation. But no comparable interdictions are to be found, and indeed there is no evidence that they were actually sold by weight.

2. Inferences from weight measurement

Inferences of sensitivity can be drawn from the evidence of weight measurement that will be considered in further detail in the next section (VIII.2). Four points can be made here however:-

First the smallest units in which sums are weighed are likely to have been the smallest units operators observed made a difference to the tilting of the balance. They should therefore indicate the sensitivity of the balance in use on any occasion whether or not the unit itself is accurate in absolute terms. I shall again examine these small units below in VIII. 2.(1) for their relevance to precision and accuracy: they varied greatly from one context (commodity, official board, date and state) to another, and such variation will be argued to reflect variations in regard for accuracy as opposed to preciseness. Here it is sufficient to list the lowest units in the more significant contexts.

Attic inscriptions contain the best documented references to low weights. In each case gold is weighed to these limits:-

5c. $\frac{1}{2}$ ob. [Parthenon inventory : 4 dr.; Other Gods: gold dust.]
early 4c. $\frac{1}{4}$ ob. [Athena e.g. IG II^2 1415.12]
later 4c. $\frac{1}{4}$ ob. [e.g. IG II^2 1517 passim] and ?? $\frac{1}{8}$ ob [IG II^2 1485.3]

This $\frac{1}{8}$ ob of the Athena inventory (after 307/6 and also restored on 1486.2) presents an immediate difficulty. The entry is fragmentary, recording, it is supposed, gold crowns and their weights - σ]τεθμον : ΓΔΔΔΓΗΙΧ[: στεφα- . X appears on the unusual Attic drachma weight BW.6, incised on one side ΓΗΙΧ : I have given reasons above[14] for suspecting Lang's reading as $\frac{1}{8}$ obol. Otherwise X only appears on accounts, where it is not common.[15] It stands of course for chalkous, a bronze coin equivalent in value to $\frac{1}{8}$ obol. It is difficult to understand how it can therefore represent a silver weight.

I shall consider below the strong probability that actual (silver) coins were used as weights; but there is no means of proving on most occasions that special actual weights (that were not coins) were not used, as here therefore for the chalkous.[16] There was a silver coin of the order of $\frac{1}{8}$ obol, and there is no ancient evidence for the other names, ἡμιτεταρτημορίον or ἡμιτριτημορίον, now given to it.[17] X may therefore be used simple because its value (χαλκους) was equivalent to the silver

coin the weight represented.

The virtual uniqueness of X should however allow consideration of possible alternative explanations. (1) That X is an error for ↄC or ¾ obol. However the more likely order for this weight is in fact Cↄ . (2) That the text continues with a further X, i.e. X[X] or ¼ obol. Such a variant for ↄ is not easy, but compare the only other instances of "X"s intruding into silver weights which occur at Oropos and Boeotia in the next century where 3 chalkoi and 9 chalkoi correspond to ¼ obol and ¾ obol respectively on the 12 chalkoi to obol weight system employed there.[18]

The evidence from outside Athens can more briefly be listed. Delos in the Athenian period did not weigh to less than ½ obol[19]; in the later period Delian officials weigh only to the ½ drachma. In Oropos (Amphiaraon) and Thebes (Cabiri) silver (and in the latter case also gold) appears in third-century accounts weighed as noted above to ¼ obols (3 chalkoi etc.).[20] Second-century Imbros weighed either gold or silver also to the ¼ obol. Delphi possibly weighed gold to the ½ obol in the fourth century; whereas Epidaurus, if it weighed gold at all, weighed it in Attic silver weights to the obol. Generally speaking therefore the Athenian weighing seems to offer the clearest indication of the lowest units felt practicable in such weighing.

The absolute values of the Attic weight unit limits are in the order of the following:[21] obol over 0.7 gm., ½ obol just under 0.2 gm., ⅓ obol close to 0.1 gm. It is important to recognise that accuracy in the expression of these units is not relevant, nor was it measurable by virtue of the very fact that these units were the lowest used. I have maintained that these units indicate the sensitivity of balances used; the units I believe were used because it was observed that they could make a difference to the overbalancing of a balance. In practice the sensitivity of balances (measured in terms of the weight difference needed to overbalance them) varies with the load involved (see Appendix B on experiments). ~~But there is no need to suppose~~ The Greeks ~~were~~ could surely be aware of this, and ~~I believe the~~ so the lowest units used reflect such weights as were able to overbalance the balance at ~~the most favourable loading. They~~ respective loadings (see following) and therefore properly indicate the maximum sensitivity of the balances. That on increasingly frequent occasions[22] weighing was in fact conducted to higher units than those listed above may indicate an increasing awareness of the inaccuracy inherent in supposing the preciseness of such low weight units valid: this will be

discussed in the following section; alternatively their balances were simply less sensitive.

Here it is possible to conclude with the inference that the generally accepted limit to the sensitivity of Greek balances was in the region of 0.2 gm (the $\frac{1}{4}$ obol). The possibility of an 0.1 gm sensitivity should be recognised, but it is sufficiently unique (and doubtful) to be for all intents and purposes disregarded.[23] 0.2 gm sensitivity applies to the most sensitive balances, others were clearly less sensitive: possibly those used by the Delian officials did not in fact register differences reliably under 2 gms (3 obols). I should now compare the limits of sensitivity obtained from experiments with simulated Greek balances: for (9)(a)II, 0.2 gm was indicated, for (8)(a), 2 gm. (See Appendix B). Compare also the askos experiment above VIII.1(1).1(2).

Secondly should be noted the extraordinary fact that sensitivity recorded appears to increase with higher weights.[24] A table can be drawn up of the more precise weights measured on Athenian inscriptions (invariably of gold and silver items inventoried). If sensitivity is expressed in terms of the smallest unit over the total weight measured ("one part in so many"), it can be seen to improve by a factor of 3 or 4 in high weights from the fifth to the fourth century. Further, at all dates such sensitivity is greater for heavier weights. (Table on following page).

It is most unlikely that these conclusions can possibly be valid in fact. Several considerations can be presented as a comment upon them. (a) The argument above, of the lowest weights used being those reflecting the limit of balance sensitivity, could be qualified. The lowest weights, it could be argued, are simply the lowest actual weights available, whereas balances were in fact sensitive to lower weight differences. I reject this possibility - because of the patent inaccuracy of such low weights in any case; because experiments I conducted do not suggest such low weights to be far removed from the likely sensitivity of the balances used by Greeks; and because more reasonable explanations can be adduced for the recorded increased sensitivity at higher weights being only apparent.

Thus (b) doubts can be raised about the validity of weighing to, say, within an obol at 2043 drs 4 ob. on IG II^2 1440B. Overbalancing the gold πρωτος ζυγος in question might on one occasion be achieved by adding the

TABLE

Sensitivity indicated by the most precise weights recorded of gold and silver on central Athenian accounts

weight range	gold 5th cent.	silver 5th cent.	gold 4th cent.	silver 4th cent.
1100–6000drs	1638dr 3ob SEG X.215 ie.l:3277 (on base 3ob) and 1:2200–12000 in whole range on 3ob base	–	2043dr 4ob IG ii^2.1440B ie.l:12262 (on obol base) and 1:6600–36000 overall on ob. base	1382dr 2ob Hekatompedon 1:8293 on obol base 1:6600–36000 overall
c.1000dr	–	–	–	1004dr 1ob Hekatompedon ie.l:6025 (on obol base) or more generally c.l:6000
100–900drs	307dr 1ob Eleusis ie.l:1843 (on obol base); 1:600–5400 overall on ob. base.	643dr 2ob Pronaia ie.l:3860 (on obol base); 1:600–5400 overall on ob. base.	272dr 3½ob Hekatompedon ie.l:3271 (on ½ob base) or 1:1200–10800 in whole range on ½ob. base.	–
under 100drs	30dr 5½ob Other Gods ie.l:371 (on ½ob base); up to 1:1200 in range on 1/2ob base.	–	40dr 3/4ob Athena ie.l:967 (on 3/4ob base); up to 1:2400 in range on 3/4ob base.	50dr 3ob Parthenon ie.l:101 (on 3ob, ½dr base); up to 1:200 in range on 3ob (½dr) base.
under 10drs	7dr 2½ob Parthenon ie.l:89 on ½ob base and up to 1:120 in range	–	1¾ ob Athena ie.l:7 on quarter ob. base, and to 1:240 overall	8dr 3ob Hekatompedon ie.l:17 (on ½dr, 3ob base); and up to 1:20 overall

[note: the entry of 86dr 1½ ob on the late fourth-century Athena inventory IG ii^{2}1485.3 has not been included in this table: see text for reasons to suspect the eighth obol as a weight].

the final obol over 2043 drs 3 ob, but it is most unlikely on the next occasion. I am not convinced that it is possible to assume that the Greeks knew what they were doing with adding small weights at this overall magnitude; it is certainly doubtful whether they checked the recorded weights for even the inventory being conducted - they do not appear to have checked their actual weights.[25] Subsequent notes of discrepancies possibly rectify this situation (and see also VIII.2.(3)). But wider doubts apply to the point of recording the weights involved (see VIII.3).

Further (c) it is not always clear whether a high weight is made up of several lesser weighings added together - even where the total weight is expressed as a single entry in an inventory.[26]

Thirdly because of these qualifications, firmer conclusions can be drawn from the practice of weighing, by noting in particular the variations of attested discrepancies (see further evidence in VIII.2.(3) below). Around 2000 drs corrections made indicate weighing no more sensitive than to $\frac{1}{2}$ dr or 3 ob. i.e. c.1 : 4000 (IG II^2 1440.B: mid fourth-century Treasurers of Athena). Around 100 drs. corrections again indicate a reluctance to note differences of less than $\frac{1}{2}$ dr. or 3 ob.: i.e c. 1:200 (IG XI(2)161.B. 107-114, early third-century Delos). The actual weight differences noted especially in the latter context show an inaccuracy of up to 1:15 (the fifth stephanos): as not weighed at the same time (nor necessarily even with the same weights) this is no evidence for sensitivity. So I add to the preceding table the following as evidence of no more than average sensitivity, though possibly with better authority -

Weight	Silver 4th cent.	Silver 3rd cent.
c. 2000 dr.	weighed to within 3 ob. i.e. 1:4000	-
c. 100	-	Weighed to within 3 ob. i.e. 1:200

Fourthly, an indication of the sensitivity of Greek balances in practice could be derived from apparent awareness on the part of Greeks that this varied with the size of balance used. The experiments I have conducted with Greek-type balances show indeed a significant variation in performance depending on size.[27] Unfortunately the Greek evidence is somewhat contradictory; at best obscure.

In chapter I.2.(1) discussing the evidence for the sizes of Greek balances, I cited the passages from Delian accounts where the smaller commercial balance was used. On one of these occasions (IG XI(2) 287.B.142ff) an attempt at precision is indicated by the specification of "full weight coin" as weights, and the far from round figure given (of 5,329 dr$_3$). However if the smaller (and theoretically the more accurate) balance was used for accuracy, it is remarkably inaccurate, being hardly less than 3' in beam. I suggested that in fact the bulk of the items involved (76 broken vases and a massive 2 kg silver rhyton) may have necessitated a larger than usual balance: the officials specifying that they used the smaller of the larger types available. Whether I am right in identifying three possible balances being manipulated at Delos (1', 3' and 6' say), it seems nevertheless clear that different balances were being selected for different weighing operations; and it is a reasonable inference from the designation of balance used that the officials selected their balances with a view to optimal results. Either the balance used on these occasions was indeed smaller than usually used, and so more accurate; or the balance was larger, and chosen for other reasons than accuracy – broken vases can indeed hardly have been so important;[28] but even in this latter case it was chosen with a view to retaining some degree of accuracy as the specification of "smaller" implies.

The sort of differences of performance between 1', 3' and 6' beams of similar construction can be seen from the experiments in Appendix B. Compare respectively the figures in exp. (9)a.II, (8)a, and (7)a. If the Delians were aware of the variation in performance between the balance sizes available (as I should argue), then they could presumably detect this variation: this is not to make any extravagant claims. ~~A~~ simple experiment, demonstrates that. ~~comparing 2p with 2d pieces on 3' then 1' beams, will quickly indicate how straigirtforward the detection could be: the difference is not registered on the larger balance.~~ There is no way of quantifying the sensitivity

variation however except by assuming the results of the experiments I conducted with reconstructed Greek balances. These experiments are themselves therefore fuller evidence of the performance figures we are seeking to establish than the present argument.

The contradictory evidence should not be forgotten. [Arist] Mech §1 opens with an explanation of why large balances are more accurate than small (848b1 - 850a2 Διὰ τίνα αἰτίαν ἀκριβέστερά ἐστι τὰ ζυγὰ τὰ μείζω τῶν ἐλαττόνων ;). I have discussed this passage elsewhere[29]; speed of movement seems to be the least awkward interpretation, and must apply to overbalancing balances. The observation introduces nevertheless a note of caution into the inferences being drawn from the Delian references: were the Delian officials possibly only influenced by consideration of the bulk of the materials they were weighing? But why then the smaller balance? Was their own machine perhaps temporarily out of action? Accidents are nowhere mentioned, though weighing 5 mina vases on a thin wood beam would be tempting providence.[30]

3. Inferences from coin weights

A note is required here to repeat my doubts about the relevance of coin weights. I have already indicated elsewhere that I do not accept the smallest theoretical weights of fractional coins as evidence of the possible sensitivity of Greek weighing. The variation of such coins would be better evidence of insensitivity (so see again following section); but, as the variation shows, these coins were valued on a theoretical assumption of weight, and were not checked or controlled. Similarly the high accuracy with which certain coins were produced is unlikely to be evidence of sensitive weighing techniques. The limits are below those credible for Greek two-pan balances: though numismatists have not been deterred from inferences of sensitivity as low as 0.05 gm (Hill as cited in introduction above[31]). Wallace suggested 0.03 gm for Euboean coins and for some 0.01 gm[32]. Such accuracy can be obtained by simpler reproduction techniques, which also are more practicable in the production of the large numbers of coins required.[33]

1. (2) Acceptable insensitivity

A number of miscellaneous passages can conveniently be assembled here. The more important evidence would appear to lie in the variations of coin and weights: this will be discussed subsequently.

1. Miscellaneous indications

The purple-dye sellers described by [Arist] Mech. § 1 (849b35ff) successfully deceived their customers by weighting their balance beams and by eccentric suspension.[34] The sort of errors achieved in an experiment that simulated these principles were of the order of 56 gm in 1 kg, 130 gm in 2 kg , 260 gm in 4 kg. (see Appendix B on experiments: no. (5)). There is however virtually no limit to the degree of error that could be involved, and this experiment simply illustrated the degree that could be introduced. It is remarkable that no Greeks apparently thought of, or recognised, this deceit till [Arist.] in the third century B.C. Equally however its use cannot seriously be entertained as illustrating the degree of inaccuracy Greeks might be prepared to tolerate!

The drachma was apparently thought to be a small weight. A dose of hemlock etc. prescribed by Thrasyas of Mantineia ap. Theophr. HP 9.16.8 ὥστε εὔσυγκον εἶναι σκεύασμα καὶ μικρὸν ὄγκον εἰς δραχμῆς δόσιν. The Loeb translation "of conveniently small size" seems correct: the convenience is for consumption, but the drachma weight is here revealingly regarded as small.

That money-changers were on occasion called ὀβολοστάται as a pejorative expression, might indicate that to weigh obols was particularly niggardly, akin to hair-splitting. For evidence and discussion see above in VII.1.(3); it must be admitted that interpretation of the word as referring to weighing obols is not without difficulties. Accepting this interpretation, however, suggests that weighing around, or under, 0.7 gm. was somewhat unusual (or beneath concern) in fifth and fourth-century Athens (taking 4.2 gm dr.).[35]

An indication of acceptable inaccuracy could be seen in the variations permitted for athletic equipment. I have argued above however that athletes

may have been allowed to choose their own equipment without its standard being controlled (see VII.2.(10)). Variations in diskoi are therefore not necessarily valid evidence. Long-jump weights (halteres) ideally should balance however, and without considering any general absolute control it is revealing that the only pair whose weights are well documented vary by 8%.[36] Clearly however these weights were acceptable to the athlete who used them, and it is not necessary that anything more than "feel" was used in their equalisation during manufacture. This variation is, I feel, unlikely to be any reflection of the sensitivity or accuracy of weighing.

2. Weight variations in coins and weights

The variations of Greek coins would appear a direct source for evidence of the acceptable inaccuracy of Greek weighing. The value of coins was after all determined by the theoretical weight of precious metal they contained. I have further shown above that coins were generally accepted at their face value without checks upon their individual weights (VII.1.(3)).

This point is however two-edged, as it also removes the possibility that Greek coins were often, or generally, subjected to weight checks, the insensitivity of which they might (by being accepted as of "correct" weight) illustrate. The problem is first therefore to identify occasions where coins were actually weighed and checked individually. In earlier discussion,[37] I ruled out money-changing (where weighing was comparative and treated the coins to be changed as bullion rather than individual coin), and also the general manufacturing process (which I suggested involved probably simpler and more practical techniques than weighing). Only three contexts seem to be available: (1) the mint controls; (2) the setting of exchange rates by money-changers (or again mint officials); (3) the possible separate checks on coin for special uses such as weighing. These must be considered separately.

(1) The mint control would clearly be extremely tedious if applied to all coins, and if it consisted in measuring the precise weights of coins. Modification of both these points can be suspected and as a result the possibility removed that variation in any individual Greek coin necessarily reflects the inadequacy of a weight control.

The operation of a mint can usefully be compared to the baking trade,[38] where a minimum weight was required, and where the bakers would attempt to minimise the amount over this weight within the practical limits of his

baking process. Similarly it could be argued that the requirement on the mint was to produce units of silver of at least a certain weight, while the administration of the mint would wish to prevent these units going overweight by too much. Given the number of coins produced, a manufacturing process had to be (and was) designed that approached the minimum requirement as closely as possible. Once this had been designed, and clearly weight equalisation played an important part here, it is not necessary to assume weighing was further involved.[39]

However, let us suppose (though there is no evidence) that checks were made on finished coin just as they were made on the baker's produce. Even in this situation the possibility that these checks were spot-checks (on some, but far from all, coins) cannot be ruled out.

Furthermore it seems to me probable that such checks were only to ensure that coins were not underweight. To measure their weight precisely would be extremely time-consuming and should properly have been cut out by the design of the manufacturing process. On the other hand a simple over-balance check against the minimum standard required would be a practical way of satisfying the basic requirement for the coin produced. Given simply the possibility of such a one-way check, the variation of individual coins must be doubted as evidence of the inaccuracy of a check at this stage.

(2) Clearly once outside the mint no overall check of Greek coins could be made as they would then quickly be dispersed. The only people who could perhaps take a professional interest in the general weights of dispersed coin are the money-changers, who operated by means of set exchange-rates. To a certain extent even they need not have worried about individual coins, as the exchange rates would apply both to the coin they gave out and also to that which they received in any exchange governed by such rates.[40] Yet it is reasonable to suppose that the rates reflected ratios between the actual weights of respective coin; and that in particular they were established with such actual ratios in mind. Nevertheless even this position cannot be taken far: the rates were independent of charges, with which money-changers could easily absorb the sort of variation in actual coin weights of which they could have been aware but unconcerned. Secondly, rates for changing individual or small coin were extremely inaccurate - in part because of the practical problem of lack of proper fractions to make up a full amount (thus for 4 drs. Attic, 2 drs. 4 ob. Aeginetan were

offered where the rate should have been 2 drs 4 $\frac{4}{5}$ ob. (2.8 drs): Tod II.140 Delphi fourth century) - but in part from a wilder inaccuracy than that generally indicated by the coins of a single mint that we are here considering (thus the equation of an 8.50 gm Euboean stater with 8.35 gm gold Daric in Hdt. III.89).

Allowing, however, that either of the two sources so far considered checked the individual weights of coin, it is important to note that this can have been no more than an equivalence check. No smaller units existed for measurement. Furthermore with unstable balances such checks are not easily (or convincingly) made, as any degree of error results in the same overbalanced beam position.

(3) On occasion coins were used as weights for certain inventory weight measurements.[41] The implication must be that those who used coins in this manner felt that they were sufficiently accurate as weights. The coin weight variations can therefore be used as evidence for acceptable inaccuracy in weighing if only it can further be established that this use of coin was based upon special confirmation, and by weighing, that the coins used were sufficiently accurate. I suspect, however, that the justification for the use of coins in this context was in fact based on nothing more than the generally-held view that coins weighed what their value was supposed to represent, and the belief that expressions of weight in small units were more accurate. This confusion of preciseness with precision is discussed further in the concluding section in this chapter and arose from the point of weighing in these contexts. In fact it was a sad miscalculation, because the variation in the weights of the small coins used would be greatly magnified when large numbers of such coins were needed in weighing heavy objects.

My view here is founded firstly on the general lack of evidence for actual weighing of individual coins (already noted above); but it could obviously be objected that those concerned to use coins as weights had a special interest in checking their weight. Secondly however I should raise the question of why coins were used as weights and advertised as so used. The implication would appear to be that the officials were calling attention to their use of what were generally felt to be satisfactory weights. Again no special checking is involved. Thirdly the practical problem of such possible checking, where both over- and under- weight coins would have to

be discarded, would be enormous. Fourthly, accuracy does not seem to have been of as great a concern to those conducting the inventory as precision: the resultant error of using large numbers of coins as weights was frequently greater than an individual coin unit itself. Yet this did not put an end to the practice, though it is true that such error might not have been realised.

Interest in this last case arises from the use of coins to weigh and in the resultant inaccuracy of the operation, rather than in the variations of the coins themselves.[42] These variations may illustrate the degree of inaccuracy generally acceptable to Greek weighing; but I do not believe that any such inference is necessarily justified. Alongside the considerations mentioned here, must further be included the problems of deciding how now to express variations, and how to recognise extant coins in good enough condition for their present weights to be relevant to this enquiry. This was generally discussed above in chapter II along with the problems of analysing the larger weights.

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Rather similar conclusions apply to the variations in larger actual weights as reached here for coins. There is little evidence of these weights being checked,[43] though there is a legitimate presumption that checks were made both on actual weights and on the weights of items offered for sale.[44] More relevant however is the use to which such weights were most generally put. This I have argued to be virtually exclusively the measuring-out of unit amounts, and only very rarely the measurement of weight. In the former, and more general case, the absolute accuracy of the weight would tend to be of lesser significance since the price would be arrived at by bargaining; only a minimum weight guarantee sufficed both for the actual weight and for its use in overbalancing weighing technique. It would be in the trader's interests to ensure his weight was not too much to his disadvantage. The leeway allowed here does not reflect the sensitivity of weighing so much as the value of the commodities handled, and the manner in which weighing was used. The values would tend in general commerce to be low; so the margin of over-weighing allowed could be high.

Use of weights in weight measurement however naturally demands absolute accuracy as well as internal consistency. The difficulty of establishing sets of actual weights in sufficiently precise contexts is an

important qualification on the implication of inaccuracy that might be derived from the mass of totally disconnected weights surviving. Nevertheless it is indicative of particular set-inconsistency that there is no apparent absolute accuracy in weights specially marked for one reason or another and therefore belonging to close, if not precise, set contexts.

1. (3) Conclusions

The weight variations of coins and actual weights remain nevertheless significant. They appear to be well within the sensitivity of Greek weighing technique yet no preciser control was exercised over them, nor, significantly were complaints ever made about them. I have argued that they are not evidence for the sort of inaccuracy Greeks might accept in the contexts in which they were used. Their existence and use therefore must be explained in terms of the general Greek disinterest in accurate absolute weight measurement. This may be related to the Greek lack of naturally-occurring absolute weights (grains or seeds; which were also, incidentally of very low values); but such absolutes were in use in areas with which the Greeks had contact, and the proper explanation remains the Greek lack of interest.

Outside the field of weight measurement, there are intimations that the Greeks used their balance to distinguish quite small weight differences. No evidence explicitly confirms the sort of results obtained by my experiments which attempted to simulate Greek balances, but the general indications are compatible with such results. These suggest a limit of around 0.2 gm. for minimum weight difference detection: compare reference to an obol being a small weight (c. 0.7 gm.) and the fact that the lowest coin unit the Greeks seem to have felt confident about using in weighing was the $\frac{1}{4}$ obol (just under the limit of 0.2 gm.). Doubts surrounding the use of such units must be proved in what follows - doubts about the absolute accuracy of the units being immaterial to the present point. This limit applies to (as it is derived from) the overbalance technique of weighing (with unstable balances). The application of such techniques is most suited to weight distinctions.

Comparison in order to determine difference is the aspect of weighing fundamental to the general Greek attitude to the balance. It is moreover the only aspect of weighing the Greeks ever regarded as precise. This seems the correct inference from Plato Protag. 356.A ὥσπερ ἀγαθὸς ἱστάναι ἄνθρωπος (for the hedonistic calculus) and Herodas 2.90 ταυτα τριτάνη Μινως οὐκ ἂν δικαζων βελτιον δίητησε. A contrast can be drawn with Plut. Mor. 723 b-c μονον οὐ μέτροις τισι καὶ σταθμοις ἀκριβῶς την τροφην διανεμοντα[45]; accurate equalisation, and accurate measurement of weight (for which I can find no references at all) belongs to the later (Roman) period.

2. Precision and accuracy in weight measurement

Reference has already been made to the discrepancy between the accuracy implied by the precision of weighing on certain Greek inscriptions and that which can be inferred from the balance and weights they actually used.[46] This potential has further been somewhat qualified by the evidence assembled in the first part of this chapter.

The minimum weight units are clearly the starting poing for consideration of the outrageous claims that appear to be being made, 2.(1). Their justification, or credibility, must then be examined, 2.(2); and particular sources for control or check are discrepancies noted on contemporary inscriptions, 2.(3), and some indications of the actual weights being used, 2.(4). Though most weights are measured in such low weight units, a number are recorded in higher units. These can be regarded as a more realistic appreciation of the limited accuracy of Greek weighing technique and apparatus, 2.(5). However there is little evidence to justify the assumption that the Greeks realised this in fact: this point will be pursued further in the concluding section.

The limitations of the available evidence to be discussed here should be repeated. The evidence is largely Athenian, and it is only measurement of weight that is recorded. This is further restricted to weighing by public officials. I do not however feel that this need be a distortion of the general picture of weighing throughout the Greek world, nor that the contexts and types of weighing are significantly wider.

2.(1) Lowest weight units: implications for accuracy and precision

I have considered above the lowest units used for weighing as evidence of the order of sensitivity Greeks appear to have felt their balances had (VIII.1.(1)); I noted however that there was considerable variation in whether weighing was actually conducted in these lowest units (as also the variation in what units were lowest in different contexts). The possible implications for accuracy in such variation will now be pursued here. The discussion must centre on the Attic evidence.

I shall begin by considering the clear difference that exists between the precision with which weights were recorded at Athens for gold and silver in the same period as these minimum weights. While by far the greater number of weights that are not round figures of drachmae, are $\frac{1}{2}$ drs (3 obols), the distribution of other obol weights (and $\frac{1}{2}$ obols etc.) varies between gold and silver. This can be roughly indicated by the table on the following page.

The reasons for this difference should be examined. In the first place it cannot be supposed that different weights (in absolute terms) were used for gold and silver. This occurred at several Greek sites (e.g. Boeotian Oropos and Thebes, Miletus, more rarely Delphi, questionably Delos) and on occasion at Athens. In these cases gold coins indicate the different unit used. It was not normal practice at Athens however, where there was no normal gold coinage.[47] Secondly it is doubtful that the more precise weighing of gold resulted simply from its greater value (as, for example, wood was only weighed in talents). Silver was accounted to lower units than ever gold was weighed.[48] Moreover the difference in precision between gold and silver weighing occurs only in the lower weights. There is no comparable difference in the high weights though, on the analogy of the lower weights, rounder figures for silver might have been expected if it was simply a matter of relative value.

Apart from the total of Pheidias' statue, for which the gold is said to have weighed 6 T 1618 drs 1 ob. but was in fact probably summed from partial weighings,[49] no gold weights in the fifth century above 307 drs 1 ob.[50] contain single obols, still less fractions of obols. Here the variation

TABLE

Frequency and range of contexts for low weight units in the weighing of gold and silver on Athenian accounts

	gold			silver		
	5th.c.	400–342/1	340–c.300	5th.c.	400–342/1	340–c.300
upper wt. M or T	T	–	–	T(M)	T	–
5ob	x (1)	x	x	–	x	x
4ob	x (1)	x	x	–	x	x
3ob	x (10)	x	x	x	x	x
2ob	x (4)	x	x	x	x	x
obol	x (4)	x	x	–	x	x
½ob	–	?[1]	x	–	–	–[3]
1½ob	–	x	x	–	–	x[3]
2½ob	x (1)	x	x	–	–	–[3]
3½ob	–	x	x	–	–	x[3]
4½ob	–	x	x	–	–	–[3]
5½ob	x (1)	x	x	–	–	(x)[3]
¼ob	–	–	–	–	–	–
¾ob	–	x	x	–	–	–
other ¼ frs	–	x	x	–	–	?[4]
T or Ↄ	–	T(Ↄ)[2]	T	–	–	?

sources 5th.c.: IG.i^2, all fifth-century inscriptions

400–342/1: IG.ii^2 1370–1454 (Athena); 1633–1651 (Delos).

340–c.300: IG.ii^2 1455–1492 (Athena); 1493–1531 (Athena and Brauron); 1532–1539 (Aesculapius); 1540–1552 (Eleusis); 1652–3 (Delos).

notes [1] IG.ii^2 1421.15 gives only ---]C.

[2] IG.ii^2 1425.32,127 have ...IIↃ twice after a drachma figure; it seems unclear whether 2½ob or 2¼ob is meant.

[3] These ½obs silver appear on Eleusis accounts IG.ii^2 1544.22 (1½ob), 23, 24 (3½ob); 1542.7 (5½ob in a mixed silver and gold section).

[4] IG.ii^2 1544.43 has --]πυρου ἀπυρωτικ σταθμον HHIIIII CT which is probably in fact gold; and 1527.17 is entirely restored at the relevant part -]π[λ]ατυτερον ἀργυρουν σταθ : ICT---

between high and low weights of gold would seem to lie in the performance of the machine used to measure weight (or in its operation). The variation between the precision with which low gold and silver weights are measured should I believe be explained in a similar way.

Referring to the earlier discussion of the procedure of weighing and the sensitivity of the balance, two factors are relevant: the care (and perseverence) to arrive at closest to counterbalance weight,[51] and the size of machine chosen for a particular weighing. The variation applies only to the lower weights, and a limit of a 1000 drs is suggested by the evidence. Above this figure both metals, gold and silver, are measured with comparable preciseness. The greater precision of gold-weights below c. 1000 drs cannot be explained by supposing a smaller, more accurate machine was used for these weighings.

The use of different sorts of balances is not attested in Athens, but could be presumed from the practice elsewhere.[52] If any sense is to be made of the weights of Greek coins, variable balances could be supposed: though I do not in fact feel that any sense need be made of these weights. More relevantly the use of separate, more accurate and smaller balances for gold seems a reasonable procedure: gold is more valuable. However, since it is uncertain (and will be discussed further below) to what extent interest in accuracy dictated modifications to weighing procedure, the higher value of gold can at best be suggested as a contributory factor to its being weighed in a specially accurate manner. Alternatively, it could be suggested, gold objects tended to be smaller and so a smaller (and incidentally a more accurate) balance might be used as a matter more of convenience than for considerations of accuracy.

Nevertheless I suggest the use of different balances as a possible explanation for the differences in precision (in terms of lowest weight units) with which gold and silver were weighed. The increasing precision for gold through the fourth century (with the unlikely 1/8th obol of IG II^2 1485.3) could be attributed to the improvement or modification of the balance, or to the use of smaller balances over the period.

2.(2) The credibility of official weighing in general (but with especial reference to these lower weight units).

The accounts from which the evidence of minimum weights has been taken are of the Athenian temple treasuries of the fifth and fourth centuries. Something can be inferred of the procedure that attended the presentation of these accounts, and further reasons deduced from other similar inventory-series outside Athens to throw some doubts on the figures they contain - even in Greek terms of reference.

It the first place must be emphasised the closed nature of the whole operation. Officials who served as ταμιαι (or ἱερομνημονες etc.) for a short period of time were called upon to present accounts of the objects in their custody and to declare what changes had occurred since their predecessors. Invariably such declarations take the form of a statement of items "received and handed on", with additional items more usually added in a separate entry than included within the existing. Naturally presentation of identical entries was preferable, both to avoid awkward explanations and to avoid the large amount of work weighing (or measuring) would involve. Some side-steps were legitimised as declaring certain articles ἄστατα or simply reporting an inscribed weight on an object hung on the wall which it would not be necessary to reweigh.[53]

It can therefore be asked what evidence there is of control of the procedure that led to the presentation of these documents - what evidence, that is, of actual weighing carried out at all and what evidence of its supervision by people other than the officials who would be responsible for inaccuracies were they detected. Neither can be substantially supported at all.[54] Evidence of actual weighing, if it does not lie in the usual formulae of weight recording (object described "weight so and so"; or "weighing so much"; or "we weighed it as..."), should be sought first in mention of discrepancies. These are extremely rare and revealingly restricted to only one or two inscriptions, or rather to one or two boards of officials prepared to question their predecessors, or forced (by removals or some such event) to make special mention of reweighing. Simple variations, not marked as discrepancies, may be evidence of tact - or carelessness. Details are

sometimes proof of weighing: thus for example where the weight of a τριποδίσκος is given both with and without its chain at IG II^2 1534.93f; or again the subsequent weight entry for an item formerly unweighed, as Lysander's crown (IG II^2 1386.3 and 1388.33). Actual weighing is also indicated by noteable variations in the formulae indicating in effect a particular weighing procedure followed: thus the claim in third-century Delos to have weighed against coin or the smaller Agoranomion balance: IG XI(2) 287 B 142f or the specification of weighing ἐναντίον τῆς βολῆς on Callias A.20-21 (ML.58). Such references however are so rare as to cast moredoubts on other occasions where no specific description is given than to establish any significant conviction of actual weighing procedure. After all what reason for mentioning weighing so specifically on such occasions if it was normal procedure?

The Callias decree leads on to a further check on the credibility of inventoried weights in that on that occasion at least there was public control of weighing. This question has been discussed above (VII.1.(4) end) and I concluded that there were few clear instances of public weighing. It would be difficult indeed to imagine how an assembled crowd could properly check a weighing operation.[55]

Proof of weighing could also be derived from the variation in technique (small and large balances) inferred earlier from my analysis of the minimum weights of gold and silver. This is tentative. More striking is the contrast between these minimum weight units and those illustrated by contemporary coinage and contemporary accounting of silver. This contrast is both in terms of the minimum units themselves (which are very much lower in coin and account), and in terms of the frequency of occurrence of the various fractional units. The low or fractional weight units show a much greater tendency to rounder figures (especially ½dr. or 3 ob.), whereas a wider scatter can be established for the other sources. The weight units were, I suggest, dictated by the exigencies of the weighing operation, whereas other factors demanded the fractions on coin and account without the practical limitation of weighing. This argument is an extension in a sense of that already implied when it was pointed out that the subdivisions of Greek coinage are more optimistic than even Greek attempts at weighing.

Comparison in what follows should be made to the earlier table on weighed gold and silver showing the fractions and their occurrence.[56] First, coinage: the Attic series is not particularly controversial. In the fifth century it consisted of 4 dr., 2 dr., dr., 3 ob., 2 ob., $1\frac{1}{2}$ ob., ob., and $\frac{1}{2}$ ob. (no silver of this period appears weighed to units lower than 2 ob.); whereas in the fourth century were added $\frac{3}{4}$ ob., $\frac{3}{8}$ ob., $\frac{1}{4}$ ob., $\frac{1}{8}$ ob. I have no evidence collected to date however of the relative frequency of these various fractions. It might however be reasonable to link them to the most immediate demands made on the Attic mint for small coinage viz. the requirements of state pay.[57]

Secondly the accounting of silver. This penetrates much more widely across sections of Athenian life - prices, pay, taxes than the inventories and special public accounts in which the evidence of weighing has so far been found. Yet despite the more general level of use, no unfamiliarity seems expressed, or difficulty experienced, with large unwieldy sums devolving to small minimum units. Precision in this sort of sense is greatly advanced over weighed sums: but more relevant here is the lower limit to accounts and the spread of fractions.

The evidence can be crudely collected under headings, or types of context; and the widespread use of the various fractions then can be expressed by the number of contexts in which it appears.[58] It is to be noted that these figures are not of absolute frequency (of occurrence); if every sum accounted was to be entered, 3 obol would again rank the most common fraction of a drachma. This would however overexaggerate the contexts in which this fraction most often occurs.

See following page for table of small drachma fractions accounted in fifth and fourth-century Athens.

Two significant facts emerge from these figures. (1) Of the drachma-fractions, 3 obol is not the most widely found, but rather 1 obol, possibly 4 obol and 2 obol. (2) The $\frac{1}{2}$ obol is at least as widely found as the 3 obol. Moreover this picture is not materially affected by considering only sums actually paid in money (as opposed to theoretical calculations of percentages, interest etc.): for example Eleusis Ca.460, IG I^2 6 (≡ SEG X. 6.90) the ἱεροποιός is paid per day ἡε]μιοβε[λιον. Towards the end of the fourth century the $\frac{1}{8}$ obol chalkous appears in accounts, and is

easily assimilated alongside the other entries (e.g. IG II^2 1672.2,113, 226 etc. ca. 330 B.C. Eleusis) just as the silver or bronze coins offered no problems in practical handling.[59] The virtual absence of ½ obols from the Attic Stelai (exceptions being VI.119 and Pritchett's restoration at I.11) is not a significant qualification to my argument here: the roundness of present auction prices could be evoked, as also the fact that the sales-tax was a stepped tax (rather than percentage), based on arbitrarily chosen 1 ob., 3 ob., 1 dr. units.[60] In these accounts the scatter of drachma-fractions in fact confirms the contrast I am arguing with weights –

1 ob. (19 occasions); 2 ob. (13); 3 ob. (13); 4 ob. (5); 5 ob. (2).

TABLE
Contexts for the accounting of small drachma fractions in Athens

5th century	¼ob	½ob	¾ob	1ob	2ob	3ob	4ob	5ob	6ob	7ob	8ob
Official sources fines; taxes; rates of pay; doles	–	3	–	4	2	2	3	1	–	1	1
Accounts AQL; Demes; Tamiai of Athena; Logistai; AS; Tamiai of Other Gods; Rhamnos in SEG X 210	2	6	1	7	5	6	7	5	–	–	–
Building accounts Eight different, plus IG i^2 388 (? Parthenon door) and 390a	–	4	–	9	6	4	5	3	–	–	–
Total (out of 21 contexts)	2	13	1	20	13	12	15	9	–	1	1

4th century	¼ob	½ob	¾ob	1ob	2ob	3ob	4ob	5ob	6ob	7ob	8ob
Official sources religious; harbour taxes	–	1	–	2	–	–	–	–	–	–	–
Accounts Athena; Poletai; Navy lists; Delos	3	4	2	2	3	3	4	4	–	–	–
Building accounts Eleusis	1	1	1	1	1	1	1	1	–	–	–
Total (out of 7 contexts)	4	6	3	5	4	4	5	5	–	–	–

2. (3) Discrepancies as evidence of checks on accuracy and as indicators of likely accuracy.

It is possible to proceed now to further controls on the accuracy of this weighing. Of the two sources of evidence available, discrepancies and references to weights used, both somewhat undermine the impression of accuracy given by the precision in which these recorded weights are expressed. The evidence of discrepancies has of course already been used in discussion of sensitivity above.[61]

The notices of discrepancies I have collected are as follows (for Athens and Delos) :-

Athens: noted explicitly as discrepancies:-

c.350 BC. Treasurers of Athena. IG II^2 1440.B. (fragmentary)

(a) various objects (gold certainly and possibly silver or plated also) 11.29-40 discrepancies (ταυτηι or ταυταις ἐνδεει) noted of under one drachma (Ⅰ[---] i.e. 1 or more obols, 1.30), and of 12 drs. (ΔΗΗ 1.33).

(b) gold Nikai. 11.40-45: restorations possible from long series of inscriptions relating to these (A.M. Woodward Ἀρχ.Ἐφ. 1937. 159-170 "The Golden Nikai of Athena" especially p.166, for restorations IG II^2 1440.B, and tabulation on p.171). Restored weights and discrepancy from earlier weights as follows:-

πρῶτος ῥυμος	---- 2043 drs 4 ob	ταυτοις ἐνδεει ; [ⅠⅠⅠⅠ]....5 ob
δεύτερος "	---- 1947 drs 1½ ob	[ταυτοις ἐνδε]ει ; ⅠⅠⅠ[Ⅰ]C ...4½ ob
τρίτος "	---- 1939 drs 3 ob	[οὐδεν ἐνδεει] .....nil
τέταρτος "	---- 1893 drs 4 ob	[ταυτοις ἐνδ]ει ; ⅠⅠ ; ....2 ob

c.330 B.C. Treasurers of Athena. IG II^2 1463.15ff. (fragmentary)

Discrepancies probably on gold objects are over 1 dr on a sum weighed in round numbers of hundred drachmae (--]ΗΗ ταυτηι ἐνδεει ; Η[--, 1.15); and also of 5 ob (1.18); 20 drs 2 ob (ΔΔⅡ, 1.19); 5 drs 4½ ob (1.20); 3 or more drs (Ρ]ΗΗΗ, 1.21); 6 drs 1 + ob. (ΠΗⅠ[·], 1.22).

Athens: some other variations in weights not explicitly noted as such:-

Hekatompedon Nike (τριτος ῥυμος in above list): 1937 drs IG I^2 369.9-12 [426/5-407/6] but 1939 drs 3 ob. by IG II^2 1388.21 [398/7]. Gold. (See table Woodward p.171 for other variations in these Nikai.)

Hekatompedon κυρχησιον ἀργυρουν Διος πολιους: 200 drs. IG I^2 262ff. (item 8) but 199 drs by IG II^2 1382.13 (ca. 400 B.C.). Silver.

Opisthodomos θυμιατηριον χρυσ. δραχμ. : 2940 drs (IG II^2 1396.18), but 2800 drs (IG II^2 1398.7).

Athena χρυσιον ἐπιτηκτον δραγυριον : 4drs 4ob (IG II^2 1425.100), 4 drs 3ob (1428.113), 4drs 2½ob (1429.34). Inventories 371/0 - 351/0.

Parthenon κερας ἀργυρου : [··]ΡΗΗΔΔΗΗ (IG I^2 276.8: 434/3 BC), but ΤΤXXXΗΗΗΠΗ[Η](IG I^2 280.77: 422/1 BC).

Delos: noted as discrepancies:-

IG XI(2)161.B.107-114 account 280/79 B.C.: listing gold στεφανοι ἐν τῳ νεῳ οὗ τα ἑπτα. Several notes as weighing other than inscribed. List of weights with calculated discrepancies where occur is as follows:-

5th	Crown	weighed	122drs,	marked	113drs 3ob,	thus	8drs 3ob	heavier
6th	..	..	65drs	..	63drs	..	2drs	heavier
10th	..	..	96drs	..	92drs 3ob	..	3drs 3ob	heavier
11th	..	..	68drs	..	66drs 4ob	..	1dr 2ob	heavier
13th	..	..	83drs 3ob	..	82drs 5ob	..	4ob	heavier
15th	..	..	84drs 3ob	..	82drs 3ob	..	1dr	heavier
19th	..	..	82drs 3ob	..	82drs 2ob	..	1ob	heavier
20th	..	..	101drs 3ob	..	100drs	..	1dr 3ob	heavier

If these notices are to indicate anything beyond that the objects were reweighed, it must be assumed that the true weights were unchanged. Woodward notes the variation for the gold Nikai but could offer no explanation;[62] however, even if no circumstances can be cited, the assumption is vulnerable to comparison with the account of Croesos' gold lion at Delphi: ἐλκων σταθμον ἑβδομον ἡμιταλαντον· ἀπετακη γαρ αὐτου τεταρτον ἡμιταλαντον (Hdt.1.50.3).[63] Secondly there is no reason to suppose the corrected weight necessarily resulted from a more accurate weighing than that which gave rise to the earlier weight. Insofar as there is an explicit statement to the effect that the new weight does involve a discrepancy with the old, it is likely that more care was taken, but by no means certain that even this care resulted in greater accuracy.

Nevertheless there is room to make certain deductions from the figures cited. Firstly, the very high discrepancies are noteable: 12 drs (IG II^2 1440.B.33); 20 drs. 2 ob. (IG II^2 1463); 140 drs (II^2 1396.18-1398.7) and possibly over 400 drs (I^2 276.8; 280.77). While most vulnerable to suspicion of a physical alteration in the weights of objects weighed, these examples might equally indicate just how far out on occasion the weighing procedure used could go. The sums involved seem to be quite large, yet they are not particularly heavier than items weighed correct to single obols on other occasions. Secondly, the tendency to "round off" weights in corrected weighing is no less apparent than that to take them to smaller units. Examples of the latter procedure, which would be normally expected

if discrepancies show increased accuracy, occur in the weighing of the gold Nikai (IG II^2 1440.B.40-45) - where the first ῥυμος is corrected from 2044 drs 3 ob to 2043 drs 4 ob; the second from 1948 drs to 1947 drs 1½ ob; the fourth from 1894 drs to 1893 drs 4 ob (only the third ῥυμος is not similarly corrected and that remains unchanged at 1939 drs 3 ob). The same process can be detected in earlier Athena accounts - the third ῥυμος began for example at 1937 drs (IG I^2 369.9-12) in the fifth century; 200 drs (I^2 262 item 8) becomes 199 drs (II^2 1382.13); and see also the gradual complication of the χρυσιον ἐπιτηκτον σπαργυριον from 4 drs 4 ob (II^2 1425. 100) to 4 drs 2½ ob (II^2 1429.34) between 371/0 and 351/0 B.C. On the other hand the Delian procedure points in quite the opposite direction and all corrections made in the early third-century account cited are to round drachmae or half-drachmae from smaller obol units.[64] As no fixed proportion of increase attends these revised figures it is difficult to explain the need for revision in terms of underweight coinage used for the weighing; however, as the use of coinage in this context is known for Delos,[65] that only drachmae and half-drachmae were used might appear a reasonable conclusion.

This evidence can be correlated with the weights themselves discussed earlier. It confirms that fourth-century Athenian officials were attempting to weigh to smaller units than fifth-century. Because the third-century Delian corrections are of earlier Athenian accounts, the question of how reasonable were these earlier attempts must seriously now be faced. I am inclined to interpret Delian procedure (use of dr. and half-dr. rather than smaller units) as evidence of an increased awareness of the limitations of available weighing techniques. This conclusion is anyway reinforced by the unlikelihood of the fifth/fourth-century Athenian account precision being practically possible.[66]

A discrepancy of a more complicated nature appears in the course of a late third-century account of Ἥρως Ἰατρος IG II^2 839. This will be discussed at the conclusion of the next section.[67]

2.(4) Identifiable weights as indicators of likely accuracy.

Reference to the weights used for weighing recorded on inscriptions is rare. Special temple weights may have been kept for this purpose: but it is not possible to identify any particular set from the large series of surviving temple weights (as the Olympian for example). Those listed in inventories seem not to be kept and listed for use.

More promising however are indications of the use of coins as weights. This practice has already been envisaged.[68] The explicit reference for mid third-century Delos (IG XI(2)287.B.142ff silver coin) allows comparison to be made with many other occasions of weighing there πρὸς ἀργύριον or in ἀργυρίου δραχμάς, some of which belong to the earlier fourth century B.C.[69] The general interchangeability of weighed drachmae of silver and counted coin drachmae on Athenian accounts reinforces this assumption, and takes us back even further into the fifth century, though the clearest Athenian example is the third-century account of Ἥρως Ἰατρός (IG II^2 840: to be discussed following).[70] Probably the Attic drachmae and obols for weighing silver at Epidaurus (fourth century)[71] are also coins (though no 4-drs are used). Consistent with this practice is further the use of gold coin to weigh gold objects: second-century Delos ID 442.B.120ff; third-century Troizene IG IV.750.16-17 (gold weighed, or counted?, in χρυσοῖ, silver in Alexandrian drachmae); third-century Thebes IG VII 2420,2424 (gold in χρυσίς and obols; silver in drachmae and obols).[72]

Here we are not concerned to establish any general practice (and I feel there is unlikely to have, in fact, been one), but to pursue the possibility of estimating the accuracy where identifiable weights, as coins, are used. If in the cases listed above coins were clearly used as weights, it is possible to consider the accuracy of the coins and so approach the accuracy of the weighing itself. Several problems, however, now arise. Firstly, the possibility that special coins were used: IG XI(2)287.B.142f mentions the coins as Attic and "of full weight" ὁλοσχερεῖς. The whole argument is in danger of circularity, for how was this "full weight" checked? I discussed the term, and the control of coinage, above in VII.1.(3) and reached a compromise conclusion that ὁλοσχερεῖς of individual coins might in practice[73] be decided by consideration of general condition rather than

by actual weighing. A second difficulty is to decide what size coins were used. The totals, expressed in drachmae, could be weighed with assorted coins of drachmae: 2 dr-, 4 dr-, even 10 dr- weights. There is no way of deciding this matter, and it affects the estimate of inaccuracy which can only be made by multiplication of the possible error of individual coins used.[74] This leads clearly to a third difficulty which is that probability would suggest that over large numbers of coin the individual plus or minus errors of coins would more frequently be cancelled out than exaggerated.

Although it is indicative of the sort of level of accuracy in such weighing contexts that coins were used, the individual accuracy of which was far from high,[75] I do not feel it justifiable to attempt to quantify the actual resultant overall accuracy. The 5329 drs. of IG XI(2)287.B.142f could be 266 drs. out by simply assuming drachma coin to be used, and noting the limits of Greek balances as 0.2 gm., or 1/20th of the 4.2 gm. drachma (5%). Consideration of the actual variation of "acceptable" coin would make the possible error much higher. It is clearly wrong to suppose the Greeks could not have noticed this resultant inaccuracy: they clearly could. Further it would be wrong to suppose such inaccuracy necessarily ever was obtained. Nevertheless, it is relevant to conclude by pointing out that their weighing procedure (using small coins, the individual accuracy of which they could not, and apparently were not concerned to, check rigorously), did not rule out the possibility of such outrageous inaccuracy in practice.

One occasion could be cited on which the inaccuracy of the procedure can possibly be detected. In the course of melting down silver offerings, making payments for work done, and remaking a silver vase, the officials of Ἥρως Ἰατρος in the late third century seem to conceal a loss of 1 dr. (IG II^2 839). The account has been described above in chapter IV[76] and its general shape strongly suggests coin weights were used for weighing. In all, four weighings were involved; out of a total of 234 drs, 85 drs 3 ob are at one stage or another in coin (but of these 18 drs began and ended as coin), and the largest single weighing (both of the silver and of the finished vase) was of 183 drs 3 ob. The other weighings were of 116 drs and 100 drs. Thus the 1 dr lost could be considered the inaccuracy of weighing overall 583 drs (183 drs 3 ob (x 2) + 116 drs + 100 drs). As a reflection of the cancelling-out of individual coin errors, this clearly is a much better result than the 5% error derived from consideration of

the limiting factor in weighing individual drachma coins. In the figures cited, however, I have omitted the puzzling "ἀπουσία" of 12 drachmae. Restricting the loss to 1 drachma is to presuppose that ἀπουσία represents the weighing of the silver after melting down and before being made into the vase. A less charitable alternative is possible that it should be added to the 1 drachma loss and that the overall operation introduced a discrepancy of 13 drs. I am inclined to favour this as an expression of the sort of inaccuracy involved.

While weighing with coin was probably more accurate than the use of commercial weights, it was still inaccurate, and, more importantly, involved degrees of inaccuracy that it was within the capabilities of ancient Greeks to detect. Why then were coins used in such contexts as weights? I suggest this was because of the higher precision possible rather than with the use of larger (commercial) weight units. Given the relative difficulty of detecting small discrepancies in individual coin weights, it is possible to understand how they could be used with confidence by Greeks in large numbers. This further explains how the really extravagantly-precise weights (with $\frac{1}{2}$ obols in hundreds of drachmae) came to be recorded. What is perhaps less easily understood is that so many inventory weights were preserved without complaint or alteration from one account to the next - for this (to be pursued below VIII.3) the suspicion that not all such inventories actually involved careful weighing is correctly awakened.

2.(5) The use of high weight units (alone and in combination with smaller units).

Discussion to this point has been centred on the lower weight units mentioned in accounts: drachmae, obols and their fractions. Even in the weighing of gold and silver, however, large units (as opposed to large numbers of these smaller units) occur; and the use of these larger units is virtually standard for the weighing of other commodities. The evidence has been collected in chapter III, which see for references for the summary recapitulation here.[77]

It seems standard practice for weights over 6000 drachmae of gold and silver to be expressed in talents: see note in chapter IV for Athens (exception the temporary lapse in the Pronaï inventory IG I^2 232.7 ≡ SEG X 184: ΜΓΡ[---]). It was the practice, naturally, also in Delos under Athens. Whereas drachmae were used in Athens for lower sums right up to 6000, other states frequently used intermediary high units: Peloponnese used talents and minai before staters (probably fifth century, IG V(1) 1:ML 67, and probably weighed); Delos Libera used talents, ½ talents, minai before drachmae (exceptional a silver bowl weighing 9572 drs that might possibly elsewhere be weighed in talents and drachmae but the weight variation, in this case, would be very revealing![78]); and Delphi used talents, ½ talents and minai (gold only and no drachmae on these inventories).[79] The variant lower units for gold (Darics, χρυσοῖ etc) should of course be read here as equivalent to low drachma units, both are coin weights.

Other commodities were virtually always weighed in higher units. Exceptions noted are (1) ivory ἐλέφας (Athens, fifth-century Parthenon: IG I^2 352.24-6 ≡ ML 59: talents and drachmae): but contrast its weight in minai on the open commercial market;[80] (2) dye πορφύρα (Athens, religious context early third century: IG II^2 659.27 drachmae) but again handled on the commercial level in terms of minai and ½ minai (Delos libera, slightly later date: IG XI(2) 159.23; 203.73); (3) the doubtful onyx, surely a metal ring surrounding the stone, of IG II^2 1388.63;[81] (4) the gold alloy? χαλκοκρας of IG II^2 1424.a.95f, 1425.91; and finally (5) the problematic δαΐς and δαΐδες (Athens, mid fourth century: IG II^2 1184.15f, and Thebes (Cabiri) in second/first century B.C.[82]).

These exceptions are not significant. I have argued earlier that they derive from religious contexts, and conform to the weighing procedure most common in such contexts - weighing gold and silver for inventory purposes. Change to other weights can plausibly be seen as unnecessary and also awkward. At least three of the exceptions are in any case of doubtful interpretation: all are directly at variance with established commercial (or general) practice outside the official religious contexts in which they appear (on this argument compare talents of ξυλα with the weighing of δαΐς).

Just as coin names for the lower weight units reflect the use of coins as weights, it is possible that the higher units similarly indicate the actual weights used. The most problematic aspect of this argument is the fact that no talent weights have yet been identified (as opposed to staters and minai)[83]: yet the talent weight unit is the least doubtful of the higher units - it is the only unit into which gold and silver weighing in drachmae ascends at Athens; it is used solely for several commodities (the most common being ξυλα); and such descriptions as Herodotus' of Delphi treasure seem to describe virtually the procedure of weighing.[84] Talent and half talent weights are mentioned moreover inventories.[85]

Obviously the use of larger weight units would greatly simplify the weighing procedure where small weight units (as coins) were used as a basis. A single talent weight would take the place of thousands of smaller ones. Furthermore an increase in accuracy might be argued to lie in thus avoiding the danger of multiplication of the minor weight errors in individual coins. As already shown however in the last section, the Greeks were not aware of such a danger; their use of talent units cannot therefore in this case have been to avoid it. At most the combination of high with low weight units would seem to be a simplification of weight measurement with only low units. It was applied only to such materials as were measured in the low units as a normal rule.

Nevertheless the use of high weight units in general is relevant to the present discussion of precision and accuracy. Most obvious is the immediate application of the variability of extant weights to the accuracy of declared weighed amounts on contemporary Greek accounts. Overall this accuracy is not impressive[86]; from 4- to 14-drachmae variation seems to have

been acceptable for Attic minai weights, to take a convenient example, i.e. 4% to 14% . This point however can only be applied to comparisons of unassigned weights from one context to another; within any particular context a consistent weight and more accurate weight series could have been used. In this case the possible accuracy can be much higher - possibly as high as a half drachma, 0.5%.[87] The possible accuracy of such a series cannot be established (through the impossibility of associating weights in such a series). Such groups of weights that do clearly hang together (e.g. the Olympia series) do not really confirm the possibility of greater accuracy allowed here.

An attempt has already been made to infer the contexts of groups of Attic weights and none can be readily assigned to the officials whose accounts are preserved as temple inventories or building accounts: see chapter II. Furthermore the distribution of Attic weights does not tally with the weight units commonly found in these accounts (especially true of fractions of the mina, and especially of the thirds of mina which cannot be argued to be simply expressed in drachmae). Also, as said, no talent weights survive at all. These facts make particularly awkward the correlation attempted here: are we to infer authorities used special weights, now lost, and of possibly higher accuracy? or are we to suppose they used weights available from those in general circulation? I incline to the latter hypothesis, as these general weights were thought good enough to be stamped on occasion (and without apparent regard to accuracy) δημοσιον . In this case the impression of considerable inaccuracy should be correct - and especially for the highest talent weight where even a group variation of 5% (which is a fairly low projection of the figures derived from extant weights[88]) represents a 300-drachma range (or 3 minai)! Contrast the gold for Pheidias' statue of Athena σταθμον ΓΤΧΓΗΔΓΗΗΙ or 1 T 1618 drs 1 ob! (representing a claim of one part in 45,709 or less than 0.003%).

The sort of variation that existed within a single set of weights (as opposed to a whole group) remains uncertain (as no recognised sets are identifiable) and should be allowed to have been rather less wild. It is however reasonable to regard precision as most compatible with likely accuracy in cases where only high weight units are used. The combinations of high with low (as in the Pheidian gold example) should not obscure the many occasions on which only high units make up a weighed amount. From the

evidence of chapter III the units are found combined as follows:-

- Talents only and half talents
- Talents and minai (also Egyptian talents and minai) and $\frac{1}{2}$ mn, $\frac{1}{4}$ mn, $\frac{1}{8}$ mn
- Talants and staters and $\frac{1}{2}$staters
- Staters only
- Minai only and $\frac{1}{2}$minai.

The limiting case clearly lies in the combination of talents with mina-fractions. First note that this is never more than one part in 480 ($\frac{1}{8}$ minai with talents for ἐλεφας in third-century Delos) - this is exceptional (and for an exceptionally valuable commodity); only one example of $\frac{1}{4}$minai with talents, or 1 part in 240, has been found (σίδαρος in fourth-century Epidauros accounts); and $\frac{1}{2}$minai are restricted to again third-century Delos (for χαλκος). The greater part of examples of talents and minai are examples of whole minai, often in round numbers (though I have not systematically collected these figures). On the other side, it is worth noting the use of half-talents (rather than 30 minai[89] or 15 staters) in Herodotus' account of the Delphi inventory, as also third-century Delos (for μολυβδος); and also the fact that staters are not used alongside minai.[90]

These facts do I think add up to a considerable area of reasonable weighing practice in which precision was compatible with likely accuracy. Contemporary balances were certainly able to make and register the sorts of units involved here. The assumption that some weight sets (in individual contexts) were of higher than general accuracy is reasonable, and increases the compatibility.

Conclusions and the point of weighing

The discrepancy between precision and accuracy has been found highest where low weight units were used as a basis for measurement. Higher units used alone are likely to have involved less inaccuracy. The question is therefore generated of what determined the units with which weights were expressed on different occasions: in particular whether the use of higher units reflected a greater awareness of possible limitations on accuracy, and why in certain contexts weights were measured with a precision that went wildly beyond such limitations. Consideration of several partially relevant factors will lead ultimately to an explanation in terms of the point of weighing.

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That there existed set weights for set commodities may be an explanation of Greek weight units, and in particular of their origins (see chapter V). It does not however explain how these set weights were what they were, large or small, or their absolute values; nor does it show why the Greeks should have subsequently adhered to these weight units when more general and standardised systems had been introduced.

Value of commodity. Generally speaking (as already noted on several occasions above) only the most valuable commodities are measured in the smaller units (gold and silver - with a possible extension, in this sense, to ivory); and on the other extreme the cheapest commodity, timber, is measured only in the largest unit, talents. However there is no gradual transition from one extreme to another , though the value of many commodities might exhibit such a gradation. Furthermore there is evidence of alternative, more realistic, handling even of the more valuable commodities: thus ivory ἐλέφας handled in minai (FdD III.5.25. IIA. 5-13), or gold handled in numbered sheets πέταλα (Erechtheum account IG I^2 374.282‡, 289‡), or silver content indicated by the capacity of the mixing bowl made of it

(Hdt. I.51.2 Delphi - in contrast to the gold crater, weight 8½ T 12 minai).

The bulk of the commodity involved should directly affect the sort of unit in which it is measured: however, small quantities of the commodities in question, from time to time noted in accounts, are not weighed in smaller units, but are not weighed at all; they are either totally unspecified or are measured in some other way (number most normally, but also length etc.). Alternative, or non-existant, specification is a very significant feature of all Greek accounting and I cannot illustrate this point fully here. For examples: Delos: items that are weighed but also occur unspecified - λιβανωτος, μιλτος, κηρος, μολυβδος, ξυλα, πορφυρα, ῥητινος, σιδηρος; and are weighed but also occur numbered - ἐλεφας (tusks numbered), ξυλα, σιδηρος (objects numbered) [all from IG XI(2)]; and one fourth-Century Eleusis account IG II^2 1672 alone shows ἡλοι priced by weight, or by number, or unspecified; κολλα by weight or unspecified; μιλτος by weight or unspecified; ξυλα by weight, by length, by number, or unspecified.

The unit of pricing. Normally commodities are entered at weights in units equal to or above the unit of pricing: exceptions however can be noted, again third-Century Delos: ἐλεφας priced per talent, but the actual weight being 1 T 32 minai ½ mina ⅛ mina - a difficult and perplexing sum (IG XI(2) 203.71) - hardly eased by a possibly more usual mina unit of pricing (found on IG XI(2)287.118 and 163.7). Equally σιδηρος, priced per mina, but purchased in units down to the ¼ mina. (IG XI(2)287.116; 444.B.105). Nevertheless unit of pricing seems more often than not to be equivalent to the minimum unit of weighing and was probably based on circumstantial factors such as handling, value, bulk, and the amounts required.[91] In no case can the unit of pricing be said necessarily to reflect any limit felt to exist on the accuracy of weight measurement.

Association in a particular context could account for a consistency in weight procedure and obscure the effect of other factors. This has been suggested for ἐλεφας in the Parthenon account which otherwise is concerned to weigh mainly gold and silver. The Athena Promachos account, weighing κατιτερος, κηρος, and χαλκος in round numbers of talents (SEG X 243 = IG I^2 338),[92] offers no counter-argument as talents are normally used for gold and silver - but the later (still fifth-Century) Athena-Hephaistos inscription IG I^2 371 weighs κατιτερος in talents, ½ talents, minai and ½ minai (III.5-8). It may be difficult to decide that these boards of

officials are sufficiently cohesive to make possible the counter-argument of variable practice here. It might however seem likely for at least third-century Delian temple officials to have weighed gold and silver in small units [+ talents] as well as other commodities in higher units [+ talents] - see the variations on 161.B inventories. But even on these inscriptions, the variable weighing procedures correspond to the various sections of the composite surviving accounts. Even if the same officials were responsible for all sections, their weighing was conducted in circumstances that varied in, and were dictated by, each section individually.

The origins of such particular conventions are not thus explained, nor are they necessarily interesting. Much more significant are generic contexts, such as inventory or commercial practice, to which correspond not only the general use of high or low weight units, but also different types of weighing (comparative or measuremental), and further differences in the point of weighing being involved at all. These contexts have been considered in detail where in chapter VII; the conclusions drawn there can now be reconsidered in the light of the present discussion.

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The most general context for weighing in ancient Greece was that of general commerce, in which the ideal and primary function of weighing was to measure-out quantities of commodities sold. The use of an actual weight was immaterial to such an operation where multiples of a consistent unit could be as readily multiples of a stone (or of a bag of commodity involved) as of a known standard weight. Pricing must be assumed to have been by bargaining (even where expressed in terms of weight units); and, though the standardisation of weights would help by allowing comparison of price from one occasion (or trader) to another, the only requirement on the particular occasion was the consistent counter-weight used. The absolute accuracy of a weight used would therefore be unimportant: and it should not be surprising in fact that extant commercial weights vary as much as they do. As most trading would be of commodities of relatively low value, and in fairly large bulk, it is easy to see how the basic commercial weight units tended to be large.

There is no requirement for such weighing operations to have been performed accurately. I have argued at length in the preceding chapters that an overbalancing technique was used, and explained its practical

advantages in commerce: speed, decisivenes, but above all psychological suitability. The buyer bought more than the amount represented by whatever was being used as a counter-weight. Even if this excess was small (and Greek balances constructed on the unstable principle would minimise such excess), the general principle is eloquent testimony to the irrelevance of accuracy (as earlier argued for precision) in most Greek commerce.

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Certain aspects of commerce possibly involved weight measurement, and though specialised they should be considered here: contract work based on unit price measurement, purchase of scrap materials (as opposed to sale of manufactured items), and possibly stocktaking. Where these activities involved traders and only traders, the weights involved will have been their own. No evidence exists to check their accuracy, nor the precision with which they were used, nor indeed to illustrate that they were actually used (the inference is drawn from the lack of internationally standardised weight systems, and from the fact of independent commercial systems established by the late second century B.C. : IG II^2 1013). In general I would suppose the weights involved to be those of naturally-determined units - the ingot of metal, plank of wood, sack of wool, and in fact probably to have been handled in such units rather than involve the unnecessary element of weight.

The better attested areas of contract-work pricing clearly did involve standard weights. The element of measurement can however be qualified. (a) Most open-ended contracts appear to have been priced in units corresponding to the probable size in which the materials were actually handled, and I have argued that off-cuts and waste belonged to the purchaser. Thus the measurement could be simple measuring-out of unit multiples of the material as it was needed, rather than measurement of what was used. The limits on precision in this case would be practical (no use in odd pieces of sawn-off wood, or half-used metal dumps), and in no way reflect contemporary considerations of accuracy. I am assuming of course that the material involved would be purchased in a form that would not make such wastage outrageously extravagant: thus, where a little gold was required, it could be bought in sheets rather than lumps (as in the Erechtheum a/c). (b) A further qualification on the measurement in contract work is that it is recorded (and was demanded) by public officials. Insofar as weight measurement

and its detailed recording, seems peculiar to official accounting, its use here could very well be entirely due to official involvement and the measurement should be properly treated as an extension of such official involvement, which I shall reach below.

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Coinage in general was not handled by weight, nor was attention explicitly paid to individual coin weight by either officials (in decrees etc.) or private persons. The paradox seems genuine between on the one hand the value of coin being determined by its theoretical weight of precious metal, the use of coins in certain contexts as weights, and the general preparedness to count coins into accounts involving also weighed amounts, and on the other this apparent disregard for individual coin weight. That the operative side was the latter is confirmed by the variation in coin weights (especially of the fractional coins - which further stretch the limits of the capabilities of weighing machines available to the Greeks) and practical consideration of the difficulty in checking such weights. It could be suggested that the Greeks took on trust the correct weight of newly-minted coin, influenced perhaps by the use of such manufacturing techniques as I have described that might enable higher precision and accuracy than could be obtained from weighing. Nevertheless the results of such techniques could not be tested (and as coin weights show were not always as satisfactory as could be hoped). The paradox is probably best resolved by emphasising the value-token element in the use of coinage when this use became general. As long as coins were accepted at face-value (as all Greek coins were within their particular state), possible variation in weight was immaterial. The only significant (absolute) weight unit in coinage need then be the basic stater, and fractions can be said to describe rather than properly measure subdivision of this. It is not significant that the smaller coins tended not to travel: as, once outside the area of minting, the value of a coin would revert to its silver (bullion) content (exceptional cases being certain well-known coinages) and this would (in practical terms) be best carried in large units. On the other hand the preparedness of certain officials to weigh to fractional coins is noticeable, and should warn against the assumption that Greeks were generally aware of how inaccurate these could be.

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Money-changing could naturally be expected to operate with the low weight units of coinage, yet I have shown above that the operation need not be much different from weighing in general commerce. Coins would be changed for coins by straight comparative procedure (overbalancing is not inappropriate as the context is one of sale), with the charge taken from one or the other sum. More normally in fact money-changing on any significant scale was performed by set rates with no weighing involved. The point of weighing would be where uncommon coins were to be exchanged, and because it was a satisfactory and practical method of handling metals whose amount was best indicated by weight. There is no implication here that weighing was a particularly precise means of measurement.

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Weight accuracy would appear to be demanded in certain manufacturing processes - coin and weight manufacture, the making of alloys and, more remotely, of artillery balls. At most however equivalence is required, not measurement. In most cases the degree of accuracy was not high (artillery and weight manufacture especially), but as it is most unlikely that the manufacturing processes themselves involved weighing, the responsibility for such inaccuracy falls to the officials concerned to regulate them (see below) and the relevance of any such accuracy is determined by the contexts for which the items produced were intended. Thus it can be repeated that the weights of coins were not generally considered relevant to check; that commerce did not demand particularly accurate weights; and that, to cover all examples above, it is a positive disadvantage for artillery balls to be of identical weight.

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I have argued above that the fundamental context for measuremental weighing in ancient Greece was that of public inventory, and by extension from this, public accounting. This is moreover the only significant source for extravagant claims of precision discussed in this chapter: it comprises the last (and most important) context for consideration here. This use of weighing is limited. The only objects weighed in general (from which occasional broader weighing can be seen as an extension) were those of valuable materials, in effect gold and silver. These materials are moreover conventionally described in terms of weight units in which they also independently occur as value units, viz. coinage. This measurement of

inventoried gold and silver can therefore be viewed not so much as measurement of weight as measurement in the normally accepted way, in terms of coin units which (as it happens) are weight units. Such a restatement is not tautologous, as we are considering why these objects are weighed.

Why next are they measured? Two reasons can be usefully considered. First, for valuation purposes. This is an extension of the point made about conventions of weighing in the last paragraph. In an emergency the state might wish to use the reserves of temple deposits, as Athens in the late fifth century. Political foresight would require figures of available resources (thus Pericles 432/1, Thuc. II.13.3-5). A second reason is the check inventories provide against losses, theft or misappropriation. Compare the public supervision of weighing stipulated by the first Callias decree (ML 58.A.18-21) as also the general formulae and practice of inventories themselves, attesting to the checking by officials invariably that they hand over as much as they received on entering office.

Both motives would demand some degree of precision in the weight measurement involved but there are good reasons for doubting the attempt at precision in practice, and so to suggest that the basic motive in inventories was more one of identification and description than of measurement. These reasons are: (1) the well-founded doubt that weighing in practice preceded the drawing up of all inventories, and the impression that many were simply copied from earlier ones. In discussing this above (VIII.2.(2)) it was important to discover if weights had any basis in practice and I agreed that they surely did. Here however it is possible to take the other implication: that weighing in practice was not always necessary undermines the validity of the preciseness of the weights in question. So to further arguments: (2) the openly-admitted non-weighing of objects that would normally be weighed - inscribed weight, hung on wall so inconvenient to weigh "ἀστάτα" ; and (3) the ignoring of inaccuracies (as Ἥρως Ἰατρος : IG II^2 839), unannounced corrections if these are not just mistakes of scribes, and the absence of repercussions consequent upon such notices of discrepancies as Delos third century IG XI(2)161.B.107-114. Plus finally (4), the amount of valuable, weighable material that is simply enumerated as described. All these arguments point to description being more generally important than measurement, and to the inference that sufficient accuracy in description for identification purposes was more important than precision in measurement for valuation.

If private inventory involved weighing it could be regarded as a special case of public inventory. The motivation would presumably be itemisation (against loss) or value description; the consideration of honesty would naturally be irrelevant, but so too the necessary observation of standard weight systems. There is no evidence to illustrate the precision or accuracy of this somewhat hypothetical practice. As argued above I suspect such people as might be concerned to inventory their possessions would be more likely to collect coin and so count it.

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In conclusion I should relate the precision, or better preciseness, of public inventories more closely to the conventional way of describing gold and silver than to the operation of weighing that it might appear to qualify. The origin of this convention lies in the adoption of coinage - that is, of units of precious metal as value tokens, and not in anything to do with the idea of weighing itself. There is no clear evidence for the Greeks having regarded weighing as a means of precise measurement; just as there is much to indicate that they did not basically regard it as a means of measurement at all. Where weight measurements, or rather amounts, are given, their function was in the first and last analysis descriptive. More commonly, however, weighing was used as a practical method of distinguishing. In this sense it was regarded not as particularly precise, but as decisive.

More generally it seems reasonable to conclude that the use to which the Greeks put weighing was compatible with their technology. Their balances were sensitive but were not most suitable for accurate measurement, nor were weights available sufficiently accurate for precision. The smallest weight, in the Greek way of thinking, would overbalance, not balance the scales. This idea, fundamental to the general Greek idea of the balance, had furthermore a practical commercial application.

chapter nine

THE UNIQUENESS OF GREEK WEIGHING

Introductory

The conclusions to this study of Greek weighing can be presented in the form of a comparison with contemporary or earlier cultures of the Ancient world. The Greek concept and use of weighing was unique; and this uniqueness raises a final question of the historical development of the practice. This I feel can be related to the general development of Greek society from the tenth to fifth century BC; direct influences on weighing practice itself should in particular be discounted.[1]

The bulk of this chapter consists of the separate analysis of weighing in various Near Eastern Cultures. With the exception of Egypt and the Greek Bronze Age these analyses are of subjects not hitherto fully studied. The limitations both of space and of my own knowledge (especially where languages are concerned) should therefore be stressed at the outset. The notes are fuller than elsewhere in this study.[2] Nevertheless the analyses are of sufficient depth to point the contrast I have drawn with the Greek approach to weighing. More importantly perhaps can be emphasised the way they illustrate how inferences can be drawn from different types of evidence for weighing. The picture of weighing drawn from Hebrew literature is especially interesting in this connection.[3]

I begin with ancient Egypt for which evidence of weighing can be found in all forms: actual balances and weights, pictorial representations, written records, and, importantly, an allegorical function in the Egyptian view of the afterlife. A connection is frequently suggested between this function of weighing in Egypt and indications of weighing in the beliefs concerning the after-life of bronze age Greece (Minoan but especially Mycenaean). Any such connection rests only on the most flimsy evidence, and (as I shall discuss later) has little relevance to the subsequent Greek attitude to the balance. The indications of weighing in the Greek Bronze Age are briefly listed in the last section of

this series of analyses. A major obstacle to interpretations (and general ideology) is the lack of any literature. This applies only in part to the other non-Greek cultures considered.

Asia Minor (the Hittites), Mesopotamia and Syria-Palestine (from which I have treated separately the Canaanite-Phoenician culture and the Hebrew) have through the Bronze and early Iron ages many common cultural features. These are generally thought to be Mesopotamian in origin, but the early Sumerian and Akkadian literature that is available (and forms the basis for this view) is too limited for anything but the broadest cultural reconstruction. Evidence for weighing procedure must in fact be sought only in the more developed societies of the later periods; and, while allowance can be made for variations in the sources available, it is clear that these societies evolved sufficient differences for their individual examination here. On the function of weighing there does appear to be consistency; and I shall note where possible its relation to commercial practice. It will also be convenient to review beliefs about justice, fate or the afterlife, contexts in which ~~the Greeks chose~~ people have chosen to call upon the metaphor of the balance.

Clearly what can be said on these matters is entirely dictated by the available evidence. The Hebrews are an important, as particularly articulate, source for the general attitude to weighing in literary contexts not immediately related to the physical use of the balance. This last on the other hand is most extensively illustrated by Mesopotamian documents of everyday (commercial and legal) life. The Hittite evidence modifies this extent, while indicating several obscure but interesting ritual contexts for weighing. It will prove however useless to speculate on the common Indo-European origins of the Hittites (sub culture) and Greeks. The Phoenicians, with neither literary or commercial documentation surviving, are a virtual blank that can only be relieved by Greek references and inferences from the earlier Canaanite picture (profusely illustrated at Ugarit).

As these analyses are linked to the question of the possible origins and development of Greek weighing, a wider comparative survey has been avoided. This could perhaps be attempted: thus scales in Sicel and Anglo-Saxon graves have been cited in a discussion of Mycenaean practice.[4] More generally the approach

of primitive societies to the problems of exchange units could be considered with a view to categorising the Greek solution; my concluding remarks lead naturally into the theory of primitive economics.[5] At a fundamental level the psychological studies on the concept of weighing as appreciated by children are also relevant.[6] Although it would be interesting to pursue these wider possibilities, their discussion is not properly justifiable within the context of this particular study of Greek weighing. The general subject of ancient metrology I have after all attempted to avoid by arguing the Greeks to be only marginally involved. I shall however briefly return to this last point in the final conclusions at the end of this chapter.

1. (1) Ancient Egypt

The Egyptian evidence for weighing comes especially from two particular sources: first, surviving balances and weights, models of them and pictorial representations; second, a central theological doctrine involving the explicit use of the balance (in the judgment of the dead). Both sources are unique for Egypt, and compensate for the comparative lack of documentation for everyday life (even of senior officials: the Egyptian peasant is not properly a historical figure). To a certain extent these sources are more helpful, as more directly answering the questions demanded by this survey (type of weighing and relations between literature and practice); but the difficulty of deriving any idea of more general, standard practice is a serious drawback with regard to comparisons with Greece.

Much work has already been done on weighing in Egypt, either directly or indirectly in the discussion of Egyptian religious beliefs and in the search for the origins of Greek weights and standards: the Greek connection in both cases is I believe tenuous and misleading. In what follows I shall rely most immediately on the work of Glanville, Skinner, and Brandon.[7]

The Egyptian balance[8] was explicitly designed for weight measurement, and below I shall show that this was how it invariably was used. Of the development of the balance aspects can be noted. (1) The development itself is a straightforward development towards increased accuracy. By the mid fourteenth century BC this was considerable, and seems the limit of weighing in open conditions that continued until the introduction of the glass case.[9] (2) An interest in such high accuracy is indicated by modification of cord suspension, first by a hollow tube[10] and second by the splayed tube-ends.[11] The effect of such modifications is minimal around the position of equivalence (or level). That this was of importance

is indicated (3) by the clear development of pointers to indicate the beam's level position (normally with a plumb-line attached in addition).

The operation of this balance is clear from representations. In all clear examples[12] it is used in conjunction with weights. The object to be weighed is placed on one scale which is supported while weights are added to the other until equalisation is reached.[13] At this point the weight is recorded,[14] and in many cases the Egyptian artist has taken pains to show the operations most concerned with the aspects of the balance that indicate this: the plummet and the lack of oscillation.[15] Further confirmation lies in the interesting fact that the Egyptian word for a balance and the verbs for to balance and to equate are virtually identical mh3(t).[16] Although the abundance of surviving weights might only be expected, it is particularly significant that sets of weights are indicated.[17] In this respect, as in the preceding, the measure mental function of weighing in ancient Egypt contrasts absolutely with that established generally for Greece.

The intricate problems of the numerous weight systems and standards that have been identified for ancient Egypt need not concern us in detail here.[18] Certain recognisable systems existed (such as 10 Kidet = 1 Deben)[19], and some weights were specifically related to particular commodities (the well-known Nub weights for gold being a clear example).[20] Yet there is no evidence for legal enforcement of certain weights, nor of official standardisation. The very variety of extant weights strongly suggests many people used their own sets, but there is little evidence upon which to develop any detailed analysis.

More relevant however to the present study is the general question of how widely the balance was actually used for weighing, and how generally true is the inference of measuremental weighing that has been drawn from the evidence so far considered.

Throughout it can be assumed that the balance was used by the Pharaohs and their officials for state accounting purposes. The only early representations are to this effect.[21] The remaining administration of early Egypt was similar to that of an estate, the Pharaoh simply distributing necessary commodities to his subjects who only had recourse to barter for independent trans-

actions of their own.[22] Under the New Kingdom Dyn XVIII this system was retained for such people (and works) directly under Pharaonic control;[23] but Glanville has argued[24] a change can now be detected whereby, after the expulsions of the Hyksos, the extent of this control was never so total as previously. Evidence can be cited of buying and selling by means of weighed units of metal. With this change, Glanville holds, the balance became an instrument used in everyday commerce.

Although the social change may be genuine, the inferences drawn by Glanville for the use of the balance appear to me to be unfounded. First, the lack of evidence for the early period should not be taken as so decisive against the more widespread use of the balance. The sources are naturally weighted in favour of high court officials or actual Pharaonic concern. It seems wrong to assume the rare glimpses behind the curtain of officialdom as exceptions to Glanville's hypothetical rule: thus the letters of Hekanekht from Memphis to his son in Thebes enclosing 24 Deben of copper indicate that already in Dyn XI, metals were handled as units of value in weighed amounts.[25] That the "Eloquent Peasant" refers to the practice of barter (a literary work of far from peasant origins dating towards 2000 BC) does not preclude the use of a balance,[26] and indeed this same Eloquent Peasant was very familiar with the balance which he handles metaphorically.[27]

From the New Kingdom period it can further be seen that even in Pharaonic control (and so lack of need for employees to be involved in commerce for their needs) weighing was closely experienced by these employees in that their rations were measured and weighed out.[28] This can plausibly be projected back for the earlier period. Nevertheless the New Kingdom evidence for a wider use of the balance in more general contexts than official accounting is clear. Central is the use of weighed units of metal as value tokens, a practice carried even into theoretical valuations and exchange rates as indicated by the lawsuit of Iri-Nofret in Dyn XIX.[29] A wall painting from Thebes of Dyn XVIII shows balances used in a harbour market scene; and if this dockside trading with Asiatics is not quite what Glanville called "private shopping" it nevertheless extends the contexts for weighing in some respects.[30] Rationing has already been mentioned, and extends the use of the balance

to many other commodities than metals (fish, porridge, meat). A religious custom (providing food for sacred animals) involved the weighing of human hair.[31] In general the extent of weighing can be presumed to have continued down to the fifth-century BC situation indicated on the Elephantine Papyri (see below at end of Hebrew section IX. 1. (5).[32]

Essential in all the occasions on which weighing was used and weight involved is that the weight was measured. Precise equivalence and the levelling of the balance are fundamental. This has been noted as entirely compatible, indeed also implied by the type of balance used and illustrated by the Egyptians. It can further be shown to be reflected in their allegorical and metaphorical references to the balance.

Least impressive is the metaphorical use of the balance (and quite generally the measuremental balance found little literary favour as will be seen further in the following sections). I have only found one clear reference, in the Eloquent Peasant's most eloquent appeal to the precision and levelness of justice. This I cite below where the contrast with the Greek picture of justice is made more conveniently.[33]

The most important non-practical context for the balance in ancient Egypt is clearly the part it played in Egyptian views of the afterlife, essentially in the judgment of the dead. Apart from being the context of a large number of Egyptian references (especially pictorial) to the balance[34], this subject is of wider relevance to our study of Greek weighing in that the Egyptian view here has been frequently used to explain aspects of Greek religious beliefs and iconography. Though there may be points of contact, and possible direct parallels with particular Greek cults such as the Orphic mystery cults[35], I am concerned to show the wider and more basic contrast between the Egyptian and the Greek views. This is the result of considering the timing of the judgment, the elements of the judgment itself, and its subsequent effect on an individual's life (or after-life). The contrast is best indicated by the manner in which the balance is used. An extended discussion is required as the Egyptian attitude was not static but underwent a development, and the late date of the final version must be shown. It probably reflects the influence in

fact of Greek beliefs. I believe that the fusion of these, basically incompatible, views of the balance is responsible for the illogicality of later Christian iconography: neither Greek nor Egyptian survived independently[36].

The Egyptian judgment of the dead is post mortem. This timing distinguishes Egyptian from the contemporary cultures of the Near East[37], but also contrasts strongly with the Greek picture of divine weighing that applies to the judging of when an individual was to die[38]. The Egyptians appear to have believed from early times that the moment of death was predetermined, but it generated itself no religious rationalisation. Though the decision was felt to be in the hands of a god, no details are preserved, nor were any worked out, as to how the moment of death was decided upon[39].

Many of the problems concerning the Egyptian judgment of the dead itself need not concern us here in detail, but the general picture must be stated. The date of introduction of the balance is uncertain, but had occurred by the end of the third millenium BC (c.2000 BC). Earlier evidence (Pyramid Texts and tomb paintings) shows the very different idea of judgment by a tribunal (the deceased adopting Rā or Osiris as his protagonist; which,may have depended upon the deceased's social status). By the start of the Middle Kingdom (the political turbulence of which period may be responsible for the changes coming to light[40]) two further elements are apparent alongside the earlier. The Precepts of Meri-Ka-Rē state clearly the earlier procedure of the tribunal:[41]

> It is woe when the accuser is one of knowledge...
>
> A man remains over after death, and his deeds are placed beside him in heaps.

There is no justification for taking these "heaps" to be two in number - of good and bad deeds respectively[42], and this idea only comes very much later (see Satmi below). Alongside the picture of the Precepts can however be found a cynical hedonism, as in the Song of the Harper (Dyn XI):-

"There is none who comes back from (over) there,
That he may tell their state,
That he may tell their needs
That he may still our hearts...
Make holiday, and weary not therein!
Behold, it is not given to a mantto take his property with him,
Behold, there is not one who departs who comes back again." [43]

And secondly, many references to weighing in a balance occur in the Middle Kingdom Coffin Texts. The picture unfortunately is unclear, but such phrases as "O Osiris N., this is the balance of Rɐ, in which he weighs Maāt" [44] can be compared to the Eloquent Peasant's comparison of justice with a balance "None shall equal thy scrupulousness. Does the hand-scales err? Does the stand-balance incline to one side?... Thy tongue is the plummet, thy heart is the weight..." [45] An early fourteenth-century BC representation of a standed balance incorporates two symbolical feathers of Maāt. [46] This evidence suggests an early version of the well-known situation (described in the Book of the Dead and discusses in what follows) of Maāt (truth) weighed against a man's heart. It cannot be suspected of being an operation to compare good deeds to bad. [47]

The Egyptians were typically loth to discard ideas of any sort, and through the course of the Middle Kingdom these variant accounts of judgment after death were assimilated into the composite picture that appears with the New Kingdom Book of the Dead. [48] Egyptologists have debated at length the details and implications of this account, and in particular whether the absolute and impersonal morality implied by the weighing scene is vitiated by the apparent ritualistic magic of the "Negative Confessions", the "Declarations of Innocence", or the prayer (ch. 30) asking the heart not to bear witness against the deceased. [49] These questions are not important for this study but involve one that is central to it, the precise use of the balance in this preliminary scene (ch. 30). There can be little doubt that this involves weighing with the aim of equivalence (and a level beam). The heart of the deceased is placed against some symbol of truth. [50] Anubis steadies the balance and examines the plummet. Thoth records and reads out the verdict. The balance has been seen, correctly, as used here because "the

Egyptians conceived of the decisive test as an automatic and impersonal weighing".[51] Considering the aim of the ritual as a whole, this weighing was meant to show that there was precise equivalence between what the deceased said and what was true - it was not the means of detecting a difference.

There is no detectable change in this picture as far as I can see until the story of Senosiris, son of Satmi. This is found in a second-century AD MS, but although it is conceivably of earlier date, no other versions survive to suggest this was ever as early as its dramatic date of the mid thirteenth century BC.[52] Apart from the remarkable interest shown by the story in the relation of social inequality on earth to that in the after-life, the interest in the story lies here in the account it gives of weighing. Conducted before Osiris, this consists of the weighing of good deeds against bad. It is therefore entirely different from that described in the Book of the Dead: the aim is for the good to outweigh the bad, and as a function of weighing this finally does appear compatible with the Greek.[53]

The Egyptian view of the afterlife in general, despite the variations both in detail and in system of judgment, follows a relatively consistent picture. Life after death is assumed but its nature depended in general terms on what the individual did about it while alive. Basic necessitites were to be provided by the living but could be obtained either at a person's own tomb[54] or if the deceased joins the followers of Horus (or is associated in other ways with Osiris) he can receive part of the more lavish and reliable offerings made to the god.[55] Brandon may well be right in seeing a causal link between the unreliability of the former source and the growth in popularity of the latter.[56] The relationship between the dead and the living is two way in another sense too. The dead could affect the life of the living by bearing witness against them or putting in a word in their favour to the gods;[57] and, as already discussed, the dead would be judged on the basis of their actions in life.[58] The nature of favourable judgement is well-attested,[59] but the fate of those convicted is not clear. It is certainly unpleasant.[60] In the sense that the individual might be able to affect the conditions of his life after death the Egyptian view contrasts strongly with the Mesopotamian. The moral aspects should be noted as again

a later development: formerly the judgment involved in the Book of the Dead was only for specially privileged candidates for joining the ranks of the Blessed. Comparable (but without a test) was entrance to Elysi__ before the fourth century BC.[61] It can therefore be doubted whether the discussion of Egyptian eschatology, from texts referring to the close assistants of divine Pharaohs, has much general bearing on,any validity for,the mass of less exalted Egyptians. In Egypt, however, unlike Greece, it is fair to argue that these people just did not count, and so to leave the problem.

The part played by the balance, to conclude, in central Egyptian eschatology was to demonstrate equivalence as impersonally and precisely as possible. Related was the (rarer) metaphorical use of the balance and weighing. Both are consistent with the actual practice of weighing in both particular and general everyday contexts: such weighing,and the balances with which it was performed,was exclusively measuremental. Thus all the sources for evidence of weighing in Ancient Egypt are consistent with each other;[62] and all greatly contrast the basic picture established for ancient Greece.

1. (2) The Hittites

The Hittites were an Indo-European people whose movement into Asia Minor is thought to have been part of the much wider migrations down the West side of the Black Sea, another branch of which reached Greece as the Achaeans.[63] This fact of a common cultural origin may be of significance when we come to consider certain obscure rituals that appear to have a counterpart in Greek thought of the very much later historical periods. Apart from their origins, however, there is very little evidence of much direct contact between the Hittites and the Greek world.[64] Essentially the whole direction of Hittite history was to the east. An Assyrian trading colony is attested at Kaniš even before the recently-arrived Hittites had themselves developed the art of writing.[65] From a similar source they developed their own cuneiform script in which most of the surviving material is written;[66] and their literature reveals an extensive overlay of Mesopotamian tradition.[67] Further Mesopotamian influence may be seen in social institutions as marriage[68] and more importantly in the Hittite Law Code which closely follows the form of the Babylonian and Middle Assyrian Codes and is about the most important single piece of evidence for the internal structure of Hittite society that survives.[69] The significance of this Law Code is however extremely uncertain: not only is its date disputed but the practicality of many of its stipulations, and in particular the fixed price table, somewhat doubtful.[70] Moreover no private Hittite documents survive against which the laws can be checked.[71] This fact, is an important qualification to the picture of the Hittites as presented by the surviving practical documents. These are mainly relating (as treaties or letters) to external relations with people to the East.[72] The reasons given here, however, for suspecting the extent of Mesopotamian influence in culture and practices of Asia Minor do justify a closer look for such aspects as might be independent of this eastern influence.[73]

As this survey concerns the Hittite use of weighing and their attitude to it, it will be convenient to describe briefly at the outset the apparatus they seem to have used. No archaeological evidence survives either of the Hittite balance or even of marked Hittite weights, and inferences have to be taken from the documentary evidence that for the most part will be considered in detail below for the light it shows on the Hittite practice. It appears however that the balance was similar to the general Mesopotamian type with two scale pans of indeterminate material[74] but without the sophistications, pointer or plummet, of Egyptian.[75] This balance could either be held in the hand ("up to the sun-god" usually and then on one occasion dashed to the ground)[76] or was, more rarely, freestanding.[77] Weights were used with this balance as can be inferred from treaties stipulating weighing according to certain weights,[78] but whether they were always used in conjunction with the balance will be considered in detail below, and must I believe be seriously doubted. That these weights were of either glass or lead is unlikely, and stone a more probable material - but with no surviving examples the question cannot be properly settled.[79]

It is equally impossible to reach conclusions on Hittite weight standards. Apparently several systems were in operation - of ritual, of court/administration, and of merchants (perhaps individual even?)[80] - but their interrelation is obscure if indeed it existed at all, and the absolute values of weights within these systems only very vaguely deducible and then in the context of court/administration only.[81] Naturally the importance of these standards is determined by their use both in terms of its extent and type, as weights are only relevant for measuremental weighing. Though certainly attested for the Hittites, the use of this type of weighing can be shown to have been very much less widespread than was the case in other Near East cultures. In particular the Hittites would appear to have operated (at least originally) a much less sophisticated weighing technique that did not rely on set weights. It is of some importance both for my general thesis about the Greek attitude to weighing and the specific question of its origins that the Hittite evidence be examined in some detail.

A glance at the Law Code, at the detailed prescriptions of certain ritual texts, or at the terms of tribute laid down in Hittite treaties, reveals immediately the practice of expressing amounts of a variety of commodities in something approaching a standardised system of weights. The problem is to evaluate the extent of this practice. In the first place, temple and court ritual, both apparently necessitating considerable use of the balance,[82] cannot stand as evidence that it was normally used for dealings involving the commodities concerned, which were often as commonplace as loaves of bread. That weight, however, should be considered important for ritual is nevertheless an indication of a familiarity with its assessment on the part of those involved in the ritual. Because of the closeness with which the King and his court were bound up with religious ritual,[83] this point is further confirmed by the involvement of the King with weighing in other contexts in which specified weighed amounts are recorded. Thus, tribute is assessed and paid in weighed amounts of silver gold and wood,[84] and there is a fair amount of evidence of private dealings of the Hittite King with foreigners and particularly via "merchants", in which similar amounts of (especially) silver are mentioned and shown to have been in practice involved.[85]

That these arrangements made with foreigners are in no way an indication of internal Hittite practice can be argued in part from the peculiar status of these Hittite "merchants". In the Law Code they are given special cover:-

I.1. If anyone kills a man or woman in a quarrel... he shall give four persons... and pledge his estate as security.

with I.5. If anyone kills a Hittite merchant[86] he shall give 100 minas of silver and pledge his estate as security. If (it happens) in the country of Luwiya or in the country of Pala, he shall give 100 minas of silver and replace his goods; if (it happens) in the Ḫatti land, he has (also) to make amends for the merchant himself.

In the first place, it is noticeable that only the premeditated murder of a "merchant" is covered by the Law. This is paralleled by the absence of a specific clause about premeditated murder in the Mesopotamian Laws; but it is not that the killing of a

"merchant" was particularly heinous rather than that in the "merchants'" case the law had to be spelled out.[88] There is an interesting parallel in the Ugaritic treaty with Carkemish and although the figures differ[89] it would appear that "merchants" trading between independent states were generally the close concern of the rulers of these states. The Ugaritic tablets reveal Hittite royal interest in quite trivial affairs of traders as Queen Puduḫepa's letter about the boat of an Ugaritic sailor that rammed a quai probably in Hittite territory.[90] The Hittite "merchants" of Ura figure prominently in international correspondence between Ugarit and the Hittite Court,[91] and the impression there is given that these and other "merchants" were special agents of the Hittite King himself.[92] Their social stature as such was high outside the Hittite Empire[93] and, if diplomacy be doubted, they fulfilled an important role in supplying the Court with the variety of imported material its ritual required,[94] and possibly also in collecting tribute.[95]

All these "merchants" are concerned with foreign trade;[96] and the lack of any reference to normal trading inside the Hittite Empire is a second reason for caution in inferring practices attested for foreign trading as generally accepted in daily Hittite business. The Law Code is far from being entirely or even mainly concerned with overseas or court activities. The detailed regulations concerning agricultural life are, but one example of the extent to which internal administration is covered by it.[97]

Yet there is no direct mention of internal trade, and most remarkably no mention of the fraudulent use of weights, measures and balances that is so prominent in the parallel Hebrew Code[98] and is a well-recognised crime in Mesopotamian legal and religious texts.[99] This silence is broken only by one very doubtful Hittite reference to an uneven balance in the handsof a merchant in the prayer of Kantusilis (Rev 12f) as translated by Otten "der Kaufman hält sie neben der Sonnengottheit und fälscht die Waage".[100] The content however is ritualistic and I shall argue below that some calculus of misfortune is involved rather than reference made either to a particular crime committed by Kantusilis himself or the mysterious "merchant". In fact I doubt whether any falsification is properly involved here at all, but the implications of an uneven

balance will be considered when I examine this and other references to weighing outside the direct commercial context. Even without this interpretation however the prayer does not alter the general picture being established of the restriction of experience with weighing. Kantusilis was, after all, a high official of the court,[101] and this would necessarily employ (for ritual purposes and the conduct of foreign trade) specialists, "merchants"?, skilled in the use of the balance.[102]

Even though no explicit reference to internal trading is made, evidence for a relatively widespread familiarity with the use of the balance might be inferred from the table of prices of common objects in the Law Code[103] and the implication throughout the Code that the ordinary people, down to villagers and slaves[104] might be able to pay the prices and penalties as they are expressed, namely in weighed units of silver. This inference, however, cannot be justified. Not only is the practicability of a fixed price table difficult to explain over the relatively long period that the Code was in force[105] but there are problems over how farmers might come to possess the silver required for both purchase and penalty,[106] over how the precise penalties might be enforced (for there is no provision of standard weights or penalty for misuse),[107] and over the apparent inconsistency of expressing meat prices, unlike other prices, in terms of sheep.[108] Even if the precise prices were not followed and the question of why then they were laid down at all left aside, it would appear that more difficulties remain than could be solved by the simple explanation of the stated prices as relating to actual payment in weighed amounts of silver.

The occurrence of silver prices and penalties in the Hittite Law Code can be paralleled by nearly all the Mesopotamian Law Codes to which the Hittite bears such a striking literary resemblance.[109] Even though there is some independent evidence that increasing use was made in Mesopotamia of actual weighed amounts of silver, the Mesopotamian law codes generally make allowances for the practical difficulties involved in the stipulation of a common fixed price/penalty. Sometimes alternative methods of payment are actually stated, sometimes a means of converting one medium into another is provided, or occasionally (it has been argued, consis-

tently) an attempt is made to relate the method of payment to the context, town or country determining whether silver or grain is laid down as the method of payment.[110] This last is also true of certain sections of the Hittite Law Code where payments are laid down in grain,[111] but the problem of silver prices and penalties is not solved by such minor concessions to practicality and is virtually total in the Hittite code apart from the extraordinary lapse into sheep prices in II.185(B) and 186.[112] This lapse raises in reverse exactly the same problems as the silver price stipulations themselves,as clearly others than sheepfarmers would wish to purchase meat. The difficulty is a real one and rises from the categorical nature of the Hittite code,with its complete omission of explicit mention of alternative methods of payment. Either the Code has no practical significance at all,or some way must be found of correcting this omission. The inference that silver prices were universally accessible is as unreasonable as its necessary corrollary that all Hittites could also pay for certain things in sheep and grain.[113]

Although it may be correct to regard the Hittite Law Code as largely a literary composition on the Mesopotamian model,[114] some practical relevance would appear indicated by the fact that the Code was frequently revised, and by the very detail of its one unique feature, the fixed "price-table". One interpretation,that avoids the practical difficulties mentioned above while still recognising the literary context of the Law Code, is that the "price-table" is not in fact a table of prices to be paid in the units (silver) specified, but a table of equivalences based on a unit base. The equivalence shekel-sheep can then explain how the Hittites were able to allow themselves the silver prices and penalties of their Mesopotamian model without practical inconvenience. The silver shekel weights on this view are simply theoretical, while the table itself fulfills the central purpose of indicating various ways in which penalties might be paid as well as also (incidentally?) laying down the rates of exchange in terms of barter. What could be more suitable for the agricultural communities with which the Code is largely concerned?[115] The tables of equivalence in Mesopotamian Law Codes differ from the Hittite in that they were often written out explicitly as conversion

tables whereas the Hittite is not. Moreover whereas the Mesopotamian Law Codes imply that some people used silver weights (if not all), the Hittite does not even allow the inference that anyone used them in practice internally.

This is not meant as a complete explanation. The Law Code clearly reveals the existence of a free artisan class which, though paid on occasion in farm produce, would be most unlikely to meet the penalties of the law in the agricultural equivalents I have suggested.[116] Payment in silver, however, is a problem if it had to be imported[117] and the way in which an individual outside the royal court might get hold of it not at all clear. Again the Law Code price-table provides an answer if interpreted as essentially giving equivalences, for the only metal listed there is copper ("The price of 4 minas of copper is 1 shekel of silver" II.181) and copper was most certainly extracted locally.[118]

As copper is here measured by weight, the class of those familiar with this precise type of weighing must be extended. The Code also gives bronze by weight[119] and as an alloy it is clearly closely related to the same groups of people as handled the copper. Three such groups can be isolated: (1) Assyrian traders at Kaniš in the early period;[120] (2) Hittite metalworkers including presumably those who made ateš and tapulli of II.157; and lastly (3) those who rented these same ateš and tapulli. Although these objects are obscure,[121] one might I think assume that their renters would accept the information about their weight from the makers. This reduces the above groups to only one Hittite class – that of specialist metalworkers.

A similar optional equivalence would appear to be indicated in the Law Code for cloth. Amounts of this are apparently quite adequately expressed in "bolts" in II.126, whereas a weight equivalence (7 minas = 1 bolt) accompanies the price (x shekels) in the table of II.182. The emphasis on garments in the same price table, and the listing of wool and tunics in tribute, attests to the importance of the "industry". The sheep-shekel equivalence as well as the optional nature of the cloth measurement inclines me to interpret the inclusion of this option as more for the benefit of foreign traders than the indigenous Hittite farmers.[122]

A chance reference to weighed bronze occurs in a legal text in which it is mentioned that 1 talent of bronze was paid for a horse.[123] The status of the people involved, officials of the royal court and in particular the store-keeper for the Queen,[124] keeps us within the relatively small circle of those familiar with weighing already established. The context of the law-court, however, may be in itself sufficient to explain the remaining commodity that could be measured by weight according to the Hittite Law Code - namely wood. The penalty for the theft of wood from a pond is related to the weight of wood taken: 3 or 6 shekels for 1 or 2T wood, and if 3T are taken "(it is a case for) the court of the king" (II.102). Although the round figures are suspicious and might indicate that the term "talent" here does not necessarily imply actual precise weighing,[125] it is unlikely that the weighing if it was done was performed by the thief himself. It was clearly incumbent on the court to assess the quantity stolen in order to impose the correct penalty or transfer the case to the King. Far from showing that the ordinary Hittite weighed wood, the passage indicates no more than the King's anxiety to safeguard it. The King's interest here, and his general position with regard to the law courts which were administered through his representatives,[126] provide a further reason for discounting the view that there is any direct evidence for familiarity with weighing of the type so far considered being at all general through all levels of Hittite Society. If my arguments above for an equivalency-interpretation of the siver-weight-penalties of the Law Code are not thought sufficiently convincing, it could still be pointed out that the lawcourts would be where these penalties would be measured out and that no more people need have been involved in the process than the King's administrators.

It should be emphasised that the results achieved so far are largely negative. Although there is evidence of weighing being used as a means of expressing precise amounts of certain commodities, there is no direct evidence for familiarity with this procedure extending beyond the relatively small circle of the royal court (its legal administrators, its priests and its traders) and specialist metalworkers.

References to weighing in Hittite literature are not, however, confined to the direct commercial or practical contexts so far considered. I have already mentioned the prayer of Kantusilis in which the phrase "the merchant or mortal holding the balance for the sun god and upsetting the balance" was said not to refer to a commercial action, but was related to some kind of calculation of misfortune. I shall continue this survey of Hittites by examining in greater detail the elements of weighing that are brought out by this and certain other rituals in which actual balances, rather than set weights, play a part.

The passages collected[127] fall into 4 groups:-

(1) Kantusilis' prayer. KUB XXX10 with supplements KUB XXXI127---III5f.; XXXVI.75II18f.; XXXII RS9. Translation ANET^2 400-1 (Goetze).

Kantusilis was a High Court official, probably of the time of Suppiluliumaš.[128] The prayer is an appeal to the Sun-god for relief of his present sufferings. These he argues to have been unjustified as he himself has done no wrong and has paid all due attention to the cult of the Sun-god. Rev. 11.10ff.

> To the Sun-god I sing-see! I, Kantusilis, implore my god incessantly. Would that my god might harken [to me]! Whenever in times past I, Kantusilis, performed the cult of my god, whenever I --- [--]ed to my god, thou gavest (?) me abundance (?), thou gavest (?) me strength (?). But now when I, Kantusilis, performed the cult for thee with the merchant, a mortal, holding the balance for the sun-god and upsetting the balance - what [wrong] did I do to my god?"[129]

The problems of interpretation of this passage are bedevilled by a large break in the middle of the text. The general context can be paralleled in the Mesopotamian Šurpu incantations or Hebrew Book of Job as in both a sufferer wonders what he has done wrong, and reviews all possible sins he might have committed.[130] Thus Kantusilis reviews his possible offences to the Sun-god (Obv.10ff: broken vows to the god, sacrilege, defilement of his person, withholding of due offerings, immoderate eating and drinking). Our passage comes later, after he has sought

answers to his sufferings in divination, or ascribed them simply to the Sun-god's anger. Though balance-falsification is listed as one of the possible crimes in Šurpu, it is not present in Job and, on grounds of context, I do not feel it can be argued for Kantusilis either. Moreover, it is difficult to understand how Kantusilis' reference to the "merchant" is a way of dissociating himself from a hypothetical criminal act. If only merchants might have acted in this way, Kantusilis was himself invulnerable; if it was a typical offence of merchants (for which there is no other Hittite evidence) Kantusilis' periphrasis is not much easier.[131] Finally there is no reason to believe that there is a necessary reference to any criminal act in this passage at all despite Otten's translation.[132]

If the presupposition that the merchant is doing something wrong with the balance is removed, a possible solution to the problem of interpretation lies in the connection between the Sun-god (to whom Kantusilis' prayer is addressed) and Justice. In both Mesopotamia and Hebrew literature it is possible to disentangle two elements of this divine justice: (1) the justice or injustice involved whether in the human action or (more rarely) the god's decision, and (2) the judging, or assessing, of the human situation prior to the making of this decision.[133] The peculiar relevance of the all-seeing sun-god to the justness of such operations as weighing is clearly brought out in Mesopotamian literature[134] and has been argued to explain certain elements of the Hittite Toten-ritual that I shall be considering below.[135] It is, however, in connection with the second category, simply judgement, that the Hittite Sun-god would appear best placed. Thus Muwatallis' (1306-1282) prayer to the Sun-god describes his taking his position as universal judge:-

> "Sun god of Heaven, my lord, Shepherd of mankind! Thou risest, O Sun-god of Heaven, from the sea. Thou takest thy place in heaven, Sun-god of Heaven, my lord. Over man, dog, swine (and) the beasts of the field dost thou, Sun-god, pronounce judgement daily." [136]

The Shepherd-motif recurs in Kantusilis, and although the condition

of the text at this point (Rev. init.) is very poor, it is significantly closer to the passage under consideration (at Rev. 12f.) than the list of possible offences (on Obv.). The immediate context of our passage I conclude to be the judgement, or assessment, of Kantusilis' predicament by the Sun-god.

On two occasions Job, whose predicament as innocent sufferer is identical to Kantusilis', brought the balance into the assessment of his position. In 6.2-3 his grief, in 31.6 his whole life, is to be weighed to corroborate Job's estimates, and the latter is especially relevant to god's understanding of them -

> "Let me be weighed in an even balance, that God might know mine integrity." [137]

There is an important difference between Job's "even" balance and Kantusilis' uneven/upset balance. The force of "even" in Job is that the weighing is to be accurate (the beam precisely level); in other words the weight is being measured as the weight of Job's grief is measured prior to comparison with the "sand of the sea" in 6.2-3. Kantusilis' "uneven/upset" is important, though not his fault it is nevertheless shown to the Sun-god. Why should it have been mentioned unless Kantusilis wanted the Sun-god to see it (just as Job wanted Yahweh's attention drawn to the weighing of his predicament)? In my view the function of the balance in both Job and Kantusilis is the same (the assessment of their sufferings), however the way in which it is being used is very different. More precisely, Kantusilis' prayer draws attention to three aspects of weighing none of which appear in Job - (a) an inclined/uneven beam being a situation from which something follows - (b) scales used to represent the state of man's fortunes, as unevenness combined with Kantusilis' plea of innocence can only amount to super-abundance of misfortune as compared to merit - (c) scales used as means of comparing weight (or indicating comparative heaviness) without calculating weight of either side compared.

This interpretation of Kantusilis' prayer is admittedly very hypothetical. The difficulty still remains of why a "merchant" is involved and this difficulty is increased when it is realised how radically different is this view of weighing from that I have argued to be directly associated with the Hittite merchants and

Court. It is not clear from the text whether an actual ritual accompanied Kantusilis' words or whether the reference to the merchant and his weighing is, like Job's scales, hypothetical. As scales actually appear in other rituals to the Sun-god and as their actual consultation by priests and divination is described by Kantusilis (Obv. towards end), one might expect a balance-ritual to be accompanying Kantusilis' words here.[138] The interpretation of such ritual is really impossible - sympathetic magic, the hope to influence the god by presenting a favourable change in angle of scales, seems less likely than symbolic representation of the status quo.[139] However in both events, if an actual ritual involved manipulation of the balance, it might be natural to employ in it an expert in such matters even if the use to which the balance was put bore no relation to his usual operation of it.[140] Nor would this interpretation be ruled out if the reference to a merchant with balance were in fact entirely figurative, as Kantusilis would, as a court official, be most likely to think of merchants as those holding balances.[141]

(2) Toten ritual. KUB texts of Šalliš Ḫuaštaiš collated, transliterated and translated by Otten (1958); parts translated by Gurney[3] (1961) 164-5 who dates the texts to the end of the Empire period, towards 1200 BC, p. 166.

Šalliš Ḫuaštaiš is the title given to the funerary ritual of a King or Queen from the first line of the ritual "Wenn in (der Stadt) Ḫattuša ein grosses 'Vergehen' (Šal.li.iš ua-aš-ta-a-iš) geschicht in dem König oder Königin Gott wird".[142] Although some ritual survives for others than the King and Queen it is very fragmentary and in particular shows no reference to scales, unlike the royal ritual.[143] Whether conclusions drawn from the additional detail preserved in the extant royal ritual might apply to a wider group, and in particular to the whole practice of cremation, attested from top to bottom of Hittite society beginning with the early years of Hittite history, will be considered below. First I shall consider the passages in the ritual that mention the use of a balance. It must be admitted that they are extremely obscure, and I have no complete interpretation to offer.[144] The possibility

nevertheless does emerge of something closer to Kantusilis than the commercial attitude to weighing and, in view of the possible connection of other elements of Hittite funerary cult with, say, Homeric ritual, justifies an attempt being made at classification in the very least.

There appear to be two types of occasion in which the balance appears. Both of them associate the Sun-god, to whom in particular the whole ritual is addressed.

A. KUB XXX 15---Vs. 26-36. Otten p. 69.

⟦On the second day, after cremation and after the pyre has been put out with beer and wine, the bones are gathered and dipped in oil and then wrapped in cloth... at the place where cremation took place an image of the dead man is made of fruits etc. and the priest (the "old woman") holds a ritual conversation with her assistants ...⟧

- The old woman [ta]kes a balance; in one <pan> [she puts] silver, gold and all <manner of> precious stones, in the other [she put]s *saluinan*.[145]
The "old woman" says to her fellow companions, naming the name of the deceased: "X is brought; who now brings him here?" Her companions answer "The men of Ḫatti, the Uruḫḫa (?) Men will bring him here." But she replies "They shall not bring him here." Her companions reply "Take the silver <and> gold." She says "[I shall] not [take] it [for myself]". And this is said thrice. On the third occasion she says to a follower "[I shall] take the I-woman".[146] Then the balance is broken and before the Sun-god it [---] there is "[sing]ing", and weeping [begins].[-

The problems of interpretation for us are obvious, the weighing and in particular the significance of saluinan, the refusals, and the breaking of the balance.[147] To judge from later ritual the "Old Woman" priest acts in her own right and not as mouthpiece for the Sun-god.[148] She is apparently resisting a bribe, or payment, for the saluinan that is related to the possibility of the deceased's return. If it is possible to relate the person's presence (while absent as not yet brought) with the image just made of him,[149] the saluinan may symbolise a means of sticking "him" together again.

The breaking of the balance could indicate that the deal was firmly refused.[150] The pieces may then be shown to the Sun-god (as the scales themselves are on other occasions) to witness what has occurred. On this interpretation the scene symbolises the fact that the man cannot be brought back to life by any amount of gold, silver etc. The function of the balance is to assist the transaction that is refused, but though it is represented as a commercial transaction - bargaining - there is no indication of precision in items placed on scales. Here is a noteable contrast with the weight specifications for the silver vase of oil in which the bones are dipped earlier on the same tablet.[151] I should conclude from this that, though it is placed in a commercial context, the balance is being used simply to compare (not to measure); it is not even specified that the weights should be equal - in fact with equal scale-pans the gold, silver and precious stones would be likely to outweigh an equal volume of saluinan . The ritual then reflects a simpler use of the balance in commerce than any we have yet encountered in the Near East. I can only think of one other passage to compare with it - Job 28.12-19 "Wisdom... cannot be gotten for gold, neither shall silver be weighed for the price thereof... the exchange of it shall not be for jewels of fine gold... for the price of wisdom is above rubies". The idea is the same: something cannot be bought for gold, silver or precious stones; but whereas Job speaks of exchange for stones and a set amount of silver is weighed for its price, in no sense is wisdom directly compared in a single balance with its price.

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B. (1) KUB XXX 19 --- Vs.I.32-5. Otten pp. 33-5 with commentary on p. 131-2.
(2) KUB XXX 24a --- Vs.I.6-11. Otten p. 58f.
(3) KUB XXX 24a --- Vs.I.23-6. Otten p. 58f.
(4) KUB XXX 24. Vs.II.1-4. Otten p. 60f.
? (5) 120/p. Vs.II.9-11. Otten p. 114f.

All these passages come from subsequent parts of the funerary cult in which an offering is made to the soul of the deceased and (in (4) and possibly (5)) to the Sun-god also. After this a balance is held up to the Sun-god and a formula recited to ask

the god to safeguard the deceased's right to the offerings made. Perhaps the fullest text is (2) and gaps can be made up from (1) and (3):-

- On a balance za.ap.za.ga.a.ia [are laid] and the old woman holds up the balance before the Sun-god and says "O Sun-god, see we slaughtered for you these animals! (Now, O Sun-god, deem this land legitimately dedicated to him! in (4)) now let no man snatch them (it etc.) away from him, let no man challenge his right to them."

The variants need not concern us here. Various objects, animals, land,[152] and possibly bread[153] are assigned to the dead in this way; yet in no case is it clear that they or even parts of them are placed in the balance. Only the obscure za.ap.za.ga.a.ia are actually weighed. Fredrich suggests "Glas, Glasschüssel",[154] but the immediate interpretation as "glass weights"[155] will not do, as nothing is mentioned as weighed against them and no directions are given as to what specific weights should be used. They are likely therefore to be either symbolic (of the transparency of the soul?) or functional (to catch the Sun's eye?), and there is no way of deciding the matter.

Nor is it easy to understand what the balance is doing in this context.[156] Importance is placed in the legitimacy of the offerings made and the deceased's right to them which was conceived as extending into the future. The ritual is proof against more sophisticated dangers than simple tomb-robbing, however reasonable an appeal to the all-seeing Sun-god might be in that context.[157] Clearly in no actual sense could the rights in question be challenged, and the level of the ritual is transfered from this world to the deceased's soul and the after-life, where the sacrificed cattle pasture on his symbolic field.[158] Could it be that the deceased was vulnerable to recriminations in the afterlife, as Egyptians sometimes feared?[159] The ritual of holding up the balance and reciting the prayer relates the present to this future; but the particular relevance of the balance is to the present, to the recently-completed offerings; and the future security of these is the concern of the prayer. The significance of the balance itself therefore depends on how it might reflect what has been

offered. The legitimacy of the offering is an important element but it is a justification against possible future challenges and even the absolute judgement on the offerings made is divorced from the human procedure and requested of the god.[160] It must be that the balance reflects directly the making of the offerings, and, if not legitimacy, then the deceased's gaining of the recent offerings is a plausible interpretation.

This can be supported by inferences from the description of the weighing done. Zapzagaia of non-specific weight are placed on the scales; there is nothing to indicate that balance is required; no other commodity is involved. Unless the balance itself has a symbolical significance quite apart from the angle of beam and objects weighed (in which case impossible to explain why zapzagaia appear at all!), the only circumstance that would manifest itself to the Sun-god would be the possible inclination of the beam. There is no reason to suppose moreover that zapzagaia were put in both scales, and if they were only put in one, an inclined beam would result and explain, if inclination was the point, why no weight is specified for the zapzagaia. It is not a difficult step to suppose that this inclined beam might represent the acquisition by the deceased of certain advantages (the offerings represented symbolically by the zapzagaia). Again not the justness but the acquisition is important.

Thus the interpretation of these passages might approach that advanced above for Kantusilis: the inclination of a balance beam representing the state of a man's fortunes, in šalliš ua̯štaiš the acquisition by his soul of certain offerings that would benefit, if maintained, his future life. Admittedly the arguments that can deployed in such an obscure area of ritual are hardly watertight; but to a certain extent a logically coherent picture can be built up and supported by inferences from the ritual itself. Whatever the interpretation, however, certain facts are beyond dispute - that specific weight or exact equivalence play no part in the weighing symbolism of this ritual, and that this is associated with acquisition of, rather than transactions involving, material advantages. It is clear that this picture in no way corresponds to that derived from the direct evidence of Hittite commercial activity.

It is however noteworthy that this conclusion is derived from the royal funerary cult, whereas it is in this same Court's activity, and only in it, that has been found evidence for the opposing attitude to weighing in the Hittite culture. Several arguments have been put forward against the extension of the measuremental weighing of external commerce into the general and basically agricultural commerce of the Hittites, and the question must now be asked of whether there are any better grounds for supposing that the type of weighing indicated in this funerary cult reflects the general experience of the original Hittite culture. Is the Šalliš Ḫaštaiš ritual the prime example of a general funerary cult or is it merely a top dressing?[161]

The most obvious feature of the royal funerary cult is that it surrounds the cremation of the King's body. This and other details of ritual have been compared to similar details in Homeric funerary rites,[162] and, as the practice of cremation can be attested from the earliest period of Hittite history, a common tradition is proposed to explain the corresponsion.[163] It is clear from the recognition of this common tradition that it included ritual details as well as the (most readily discernible) basic element of cremation. These ritual details might be supposed to vary according to the pocket of the deceased's relatives: but without affecting the fundamental concepts the rituals, where feasible, would bring out in actuality or symbol. Thus from the fact that cremation can be seen to have been practised in all levels of Hittite Society from the earliest times onwards,[164] I would deduce that the general Hittite attitude to the custom, and to the questions of life and death, necessarily associated with burial customs, was at least consistent enough over this same area to preserve the similarities that can be seen between Šalliš Ḫaštaiš and Homer.[165]

The extent to which an element in the ritual might be said to be generalisable and reflect either common practice of everyday life or fundamental attitudes to overall questions as life and death, this is the extent to which it is likely both to reflect a general view and to have survived the 500 or so years to the time of the Šalliš Ḫaštaiš tablets. The symbolism of the

balance that I have suggested as compatible (to put it at its lowest) with the evidence of this ritual, fulfills all these requirements. Combining the evidence of the Kantusilis prayer with the funerary ritual, the balance, or rather the angle of the balance, symbolises the fortunes of an individual in life (or his soul after death): and in confirmation of this is the ritual weighing 2 (B), that illustrates the simple application of this sort of balance in practice. This practical use of the balance is associated, via the evidence of cremation, with all levels of Hittite society from the earliest period onwards.

It would be convenient here to be able to point to parallels in Greek culture and the fact that no alternative explanation for this similarity can be shown to exist other than that it is derived from the common Indo-European origins of Hittite and Greek cultures. This would be to anticipate conclusions that follow however, and for the present I shall do no more than compare with the Hittite evidence so far adduced three pieces of the argument: (1) the broken scales of the Lefkandi cremation c.850 BC;[166] (2) the extent of the practice of leaving balances in Mycenaean graves;[167] and (3) the classical Greek view of the balance as symbolising by its angle good or bad fortune.[168]

An important qualification should, however, be introduced as to the extent of possible Mesopotamian and other Near Eastern influence on the religion of Hittite court and state. Recognisable most easily in the direction of the state cult syncretism[169] and the many myths and legends taken from the East, might not this source also have influenced the Hittites' attitude to life and death? Kantusilis' prayer contains observations on the supreme importance of life and the finality of death that are closely comparable to Mesopotamian (and Hebrew) attitudes:-

> "Life is bound up with death, and death is bound up with life. Man cannot live for ever; the days of his life are numbered. Were man to live for ever, it would not concern him greatly even if he had to endure grievous sickness".[170]

Kantusilis was greatly concerned with his present sufferings, and the extent to which the Sun-god might control these, and the

events of life in general, is the raison d'être of Kantusilis' appeal. However there is evidence that the Hittites considerably differed from the Mesopotamians in their basic religious beliefs (and similarities indeed end with superficialities of literary myth and state cult). The practice of cremation itself marks the Hittites from thedr Near Eastern neighbours,[171] and related to it may be the somewhat more optimistic Hittite appreciation of the life of the soul. Even Kantusilis shows this (Rev. 14f.) "Through misery my soul longs (?) for another place". Most of the offerings in Šalliš Ua̯štaiš are for the well-being of the separate soul.[172] To these arguments can be added the difference in the position of the Sun-god already noted,[173] language, and of course the many items of Hittite ritual, temple plan, and Kingship that are so very distinct from the practices further east.[174]

A second objection to the extension of the details of the (royal) funerary cult that I have argued here is that the Hittite King may have had a peculiar status. The recurrent title Tabarna of the kings of the old kingdom has been seen as a variant on Labarnas, an early king, and interpreted as evidence that each reigning king was regarded by the Hittites as the incarnation of their ancestor.[175] From the opening lines of the šalliš ua̯štaiš ritual, where the death of king or queen is described as their "becoming gods", a semi-divine status might be inferred.[176] Neither inference is, however, in my opinion justified. In the first place, the šalliš ua̯štaiš ritual makes no reference, apart from its opening lines, to either the deification of the dead king or his identity with his predecessors. These are moreover mentioned and given separate offerings.[177] That "is become a god" was a euphemism, can be argued from its application to individuals other than the reigning monarch (even if they be of the royal family they do not count) and its translation in parallel Akkadian texts as "gone to his destiny".[178] Secondly, it is particularly difficult to understand the upheavals of the early Hittite Kingdom period on the view that the Hittite king held a specially exalted (or semi-divine) status: these upheavals at the least show considerable faction amongst the nobles of the Hittite court, but have also been used to support the view that the early Hittite kingship

was elective.[179] Finally, it is difficult to see why the title Tabarna was dropped, if it was associated at all with the divine element of Kingship, and the more commonplace title "My Sun" adopted from the practice of the certainly divine kings of the Near East.[180]

Leaving aside the broader question of origin and the relation with Greece of the elements of the funerary cult concerned with weighing, three main results would appear to be established in this section. First, there is clear evidence in [B] of a type of commercial weighing different, in its use of the balance, from that already established for the commercial activity of the court. Second, the balance appears in the funerary cult as a symbol associated with the fortunes of the soul in the afterlife [A]. Thirdly, both these points are part of a general and widespread Hittite attitude to commerce and religion that goes back to the early years of Hittite history and antedates the subsequent Eastern influence, detectable in much later ritual, religion and royal court commercial practice.

Before reaching our final conclusions on the Hittites there are two further rituals involving scales that must briefly be considered. Although too obscure to add much to the position already reached it is significant that they do not necessitate its alteration, but can be plausibly interpreted on its basis.

(3) Ritual of the "weighing out" of years to prolong the life of King and Queen | 406/C Vs.19-22; translitterated and translated into German by Otten (1958) 132 whence my translation.

— "Lo! I clasp a balance and I weigh out (?) [Hitt. uš.ne.eš.ki-mi] long years to/for Labarnas; Lo! I clasp a balance and weigh out (?) long years to/for Tawanannas." <Thus> is the ceremony of the balance out of doors completed.

Labarnas and Tawanannas are the titles of the Hittite king and queen. The ritual is clearly a prayer for the long life of these two, the form of a ceremony with a balance directed towards the Sun-god.[181] Further details are not given, but the balance is clearly hand-held and, as the word used for "weigh-out" means "sell" or "stake",[182] it would appear that gold or silver or some kind of

payment is most likely being put in one side of the balance. Economy would suggest that nothing sits in the other. The whole adds up to "long years" and, after what has been said up to this point, might be interpreted as doing this by indicating good fortune by the angle of the beam. The term "sell" indicates a ritual action akin to a commercial transaction and, as the "long years" are presumably not going to be limited by specification, this is quite clearly a totally different use of the balance from that deduced earlier for external commerce. It strikes me as more than a coincidence that the person carrying out a possibly similar ritual for Kantusilis should be called a "merchant".[183] Thus this ritual shows at least (a) balance related symbolically to life and (b) a commercial use of the balance that does not involve equivalence or measuring.

(4) Exorcism (?) Ritual | Text 1378/c and 1540/c.III.5-11; translitterated and translated by Otten (1958) pp. 131-2 in German, whence my translation. Otten n. 1 p. 99 gives the Ḫurrian prayer in translitteration.

– When they carry it out, the king goes forward a little. The priest takes a balance and goes to the King. He gives the King a lead <weight?> and the king puts the lead <weight?> into the balance. The priest then holds the balance against the Sun-god, and speaks in Ḫurrian the following...

It would be optimistic to suppose that a decipherment of Ḫurrian would greatly affect the interpretation of this ritual, but without the ritual prayer it is impossible to deduce even the general context.[184] Again a balance is raised to the puzzled gaze of the Sun-god. One scale contains a "lead <weight?>",[185] and the situation is perhaps comparable to the possible "glass <weights>" (?) [zapzagaia] placed in the scales during the Šalliš Waštaiš prayers to the Sun-god.[186] Neither of these however are necessarily weights; the Hittite word is simply the substance "lead" or "glass", and as nothing is weighed against them they do not play a part in the ritual of weights and are certainly not specific weights, as no such specifications are given.[187] The significance of lead however is no clearer than that of glass in the other example.

One major variation from the funerary ritual is the actual involvement here of the King. Although the implications of this are again obscure,[188] with the further variant "lead" for "glass", it serves to show this ritual as independent of those considered, and yet as still incorporating the same type of activity: holding up unbalanced scales to the Sun-god, as in the examples already discussed, with the very doubtful exception of (3).[184]

The association of a Ḫurrian formula with this ritual is perhaps disturbing, as in other respects the ritual seems to fall easily into a class I have argued to be especially Hittite in origin.[189] Ḫurrian gods find a place, it must also be admitted, in at least some versions of the Šalliš Ua̯štaiš, and amongst them the god Allani, who also seems to be mentioned in the Ḫurrian formula at present under consideration.[190] The extent of Ḫurrian influence on the Hittites, especially in the sphere of religion, is generally thought to have been considerable, but its precise impact outside the readily recognisable formulae (because of their being actually written in Ḫurrian) is difficult to assess.[191] I am however inclined to discount a Ḫurrian origin for the rituals involving the balance. In the first place all the other rituals except this one (4) have no Ḫurrian formulae, and the inclusion of Ḫurrian gods need reflect no more than their (historical) inclusion in the Hittite pantheon. Secondly, from the other rituals a close connection with the Sun-god can be established for a type of ritual involving a balance. This Sun-god, and the cremation rituals with which he is associated, seem best derived from a period when the Indo-European Hittites occupied the western shores of the Black Sea.[192] As the relation between Sun-god and balance ritual in (4) appears basically of the same type as in these other rituals, it would seem reasonable to conclude that it was Hittite even though the context, and formula, of (4) might refer to a particularly Ḫurrian occasion.[193]

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It is now time to state briefly the conclusions so far reached on the Hittite attitudes to the balance, and to relate the two very different pictures this survey has revealed.

General conclusions on Hittite attitudes to weighing.

The direct evidence of the use of the balance in practice shows a uniform attitude to weighing as a means of measuring out set amounts.[194] Its use, however, appears restricted in two senses as far as the available evidence goes - both in the range of commodities weighed and in the class of persons involved. As regards the first, once the relevance of the Law Code price tables and certain ritual terminology is ruled out,[195] precious stones and metals are virtually the only things weighed.[196] Both exceptions to this conclusion, the wood of the Law Code and cloth mentioned as weighed there and in tribute lists, can be related to the operation of the royal court or its extension either to Law court or foreign treaty and therefore conform to the second restriction. This is that the evidence associates with this precise use of the balance officials of the royal court, priests, representatives of the king in local law courts, and "merchants" who appear to have been essentially concerned with trade between the Hittite Empire and outside it and to have been closely associated with the court itself. With the exception of specialist metalworkers,[197] no Hittite outside this circle is associated in any way directly with the use of the balance. Moreover this is the limit to our direct knowledge of the commercial activity of the Hittites internally as well as externally.[198]

It is difficult to believe that no internal trade occurred within the Hittite Empire despite the silence of the Law Code on this point.[199] To a certain extent the lack of evidence is due to the presumed custom of keeping the records of internal administration on wooden tablets that have perished, unlike the baked clay required for cuneiform.[200] However the lack of any mention in the Law Code of the usual Near Eastern directions over the use and misuse of the balance, together with the above restrictions in the available evidence of the precise measuremental use of the balance (to which alone such directions apply)[201], indicates that if the ordinary Hittite used the balance he used it in a very different (and non-precise) way. Of course, like the early

Egyptian on Glanville's thesis,[202] he need not have used the balance at all and traded simply by barter; alternatively the evidence may be entirely deceptive. There are, however, grounds for believing it is not.

A careful examination of certain Hittie rituals reveals a very different picture of the use of the balance. In these the balance appears in an apparently symbolic context, but whatever the balance itself actually is meant to symbolise, it quite clearly has nothing to do with precision, or measured amounts. The probable interpretation is that it represents in some way the variable fortunes of human existence. Interest is focused perhaps on the angle of the beam, the fact that it is at an angle even, rather than on the equivalence of the level beam required for measuring. Moreover there is some indication of commercial overtones to the use of the balance in these contexts.[203] Of particular relevance to the overall question of the Hittite attitude to the balance, this indirect evidence supports several important observations. First, it reveals the existence of an attitude to the balance totally different from that which I shall show to be commonly held by all Near Eastern cultures[204] and to a restricted extent by the Hittites themselves (as already argued above). Secondly, this peculiar attitude can be inferred to have been common to all levels of Hittite society and to all periods of Hittite history.[205] Third, it appears to be related to the Indo-European origins of the Hittites as a cultural feature brought by them from the western shores of the Black Sea.[206] Fourth, the lack of direct evidence for this attitude to the balance can be shown to be largely the result of the attitude itself wherein no weights are involved or measurements taken even though the balance itself plays a part in commerce.

As the idea of using the balance to estimate weight and measure it is well established for the Near Eastern civilisations before the arrival of the Hittites in Asia Minor, it would appear reasonable to suppose that it was adopted by certain Hittites alongside their own appreciation of the function of the instrument. Ample opportunities of experiencing the "new technique" were

available. Assyrian traders had established a colony in the centre of the Hittite area for the purpose of procuring copper even before the Hittites had properly emerged as a unified nation;[207] trade with the east grew rather than diminished with the establishment of a Hittite court that sought to emulate the major civilisations of the Near East.[208] It can therefore be no accident that the use of the balance to express weight appears in the evidence to be restricted to that class of Hittite society that alone had close contact (through trade, diplomacy, or technology) with these Near Eastern cultures.

In most of the areas of borrowing from the East, it is however possible to detect particular Hittite variations or the retention to a certain extent (alongside or underneath) of the original Hittite version. A good example is the adoption by the Hittites of cuneiform from the Sumerians, its modification in order to write an Indo-European language of their own, and its reservation on the whole for documents relating to external affairs.[209] The use of the balance would appear to be similar. In specialised contexts where weight mattered, such as metalworking, the Hittites quickly learned and retained the developed weighing techniques of the Near East. For general commerce however their own unsophisticated use of the balance, entirely adequate for their own purposes, was unsuitable for trade with the Near Eastern areas accustomed to a much more precise (more controlled) system. As a result the Hittites adopted for the purposes of this trade, and relations with the Near East as a whole, the measurement of amounts of materials by their weight. To a certain extent they imposed their own stamp on these weights,[210] and they also incorporated them superficially into their own administrative framework, itself closely based on Mesopotamian. However the internal use of these weights was neither enforced in the law courts[211] or in trade within the Hittite empire, where the balance continued in its former role as a means of comparing or illustrating differences. The ritual symbolism and law code equivalences attest to this as little else might be expected to, given the type of evidence that has survived.[212]

1. (3) Mesopotamia

A general survey of the Mesopotamian attitude to weighing is not necessarily as unreasonable or impossible as it may appear. Despite the extent of documented civilisation in the area (from before 2000 to well within the Greek period), the innumerable dynastic changes that occurred were all very much on the same pattern in that they affected the identity, but not so much the type, of administrative control. The relationship between temple or palace and surrounding town (or country) persisted unchanged and as a result the Mesopotamian economy in general, based on this relationship, and on other unchanging geographical factors, shows a strong tendency to retain, or revert to its original form.[213] Within this overall pattern some changes, or developments, did however occur. Of particular relevance to this survey is the gradual transition from a barley-, or grain-based economy to one in which silver was the ostensible medium of exchange. In so far as such silver was measured by weight, the practical extent of its use as a medium of exchange could be a valuable indication of the extent of familiarity with weighing itself in Mesopotamia. Although there can be no denying the transition to silver as attested by official documents of the controlling bureaucracy and many private transactions as well, it does not appear to have been complete.[214] The difficulty has already been encountered in the above discussion of the Hittite attitude to weighing. The procedures adopted by temple or palace bureaucracy need have little bearing on those outside this relatively small but highly organised community, especially procedures related to accurate accounting that most likely would be beyond the interest of the mass of Mesopotamians. On the other hand possible areas of overlap clearly exist in the relations between the bureaucracy and the outside (hiring of labourers, rents from land owned, penal codes), and I should like to think also in certain basic

cultural features (the primitive elements in religious symbolism etc. where not the result of foreign influence or imitation). Although inferences about this overlap, and about the attitudes of the largely inarticulate common people, must be carefully controlled, the Mesopotamian evidence does I believe reveal very much more than the Hittite about a general attitude to weighing over the whole social structure.[215]

In the first place there is direct evidence of Mesopotamian commercial activity on nearly all levels. This is an obvious context for weighing and clearly one in which, at the lower levels, the whole community is most likely to have had some experience of it. The most detailed documentation is of various trading companies operating inside and outside the Mesopotamian area. The Assyrian trade colony at Kaniš in Anatolia, established around 2000 BC, has already been mentioned as an important point of contact between the newly arrived Hittites and the Near Eastern cultures.[216] Tablets of Nuzi show the organisation of a trading concern from within Mesopotamia some four hundred years later.[217] Equally detailed, though much later are the fifth-century accounts of Murashu of Nippur and his family.[218] From such sources, however, a considerable variation in the terminology used to describe people involved in commercial activity emerges. This is true especially of the tamkarum (Sumerian DAM.GAR), which can refer to the private trader, the dealer abroad, the financial backer of a commercial interprise abroad who himself remains at home conducting business through his agents, or it may be a public servant, a special class of landed-gentry with certain commercial duties.[219] While related in part to the particular status of the individual merchant concerned, this variation clearly reflects the different status of the merchant inside and outside the palace-temple structure, and to a certain extent also his changing status in Mesopotamian society as a whole.[220] While I shall not attempt a full analysis of the tamkarum here, it must be noted that the possible range of function as indicated by the word qualifies considerably any inferences (about what type of trader is involved) from references to tamkarum in non-specific or non-dateable contexts.[221]

There clearly was a fair amount of small-time internal

trading, even if no market places existed on the Greek model.[222] This can be inferred from excavated shops and assumed for the distribution of the manufactured products of artisans.[223] It is directly attested for such trades as song-selling[224] or wine-selling.[225] The general practice of this level of commerce, is most relevant to this survey and evidence exists in the Law Codes, in some individual documents, and in even official documents involving ordinary people from which a clear picture of the everyday attitude to weighing with the balance can be constructed. The contrast with the blank found regarding Hittite documents concerning such activity is the result of two factors: (1) in Mesopotamia clay tablets were used from earliest times for all records internal as well as external,[226] but also (2) the commercial activity itself in Mesopotamia involved elements, noticeably the use of the balance, that could be controlled by higher authority, and needed such control.[227]

This is to anticipate however my conclusions on the type of use to which the balance was put by the Mesopotamians. This balance can itself be assumed to have been of the normal two pan-scale type. Though none have actually survived, the Akkadian word for the balance, zibānītu, contained a dual* zibana and might thereby reflect the two-sided nature of the beam balance.[228] Also representation of the balance on reliefs shows it of this form. It was either hand-held or freestanding; the pans themselves were made of copper.[229] All the evidence I have considered shows this balance used with weights as an instrument to measure weight. Whereas the abundance of Mesopotamian documentation is notorious and I cannot claim to have examined even all the available published evidence,[230] I have nevertheless tried to include as wide a range of contexts as possible. It is therefore possible not only to conclude that all levels of Mesopotamian society (represented by this wide range of material) were familiar with the use of the balance to measure, but also to infer with some degree of confidence that it was only used in this way.[231]

The most obvious place to begin a survey of Mesopotamian weighing is with the mass of material that implies the actual weighing of specific quantities of substances. Most commonly

expressed in this way are transactions involving payment in silver (or more rarely gold and lead): for example -

1. Law suits cited ANET^2 217^b. C (1) and (3) show a divorce settlement effected by the payment of 10 shekels of silver, and a loan of 120 shekels with interest worked out at "5 shekels per 60 shekels". The tablets are dated, and belong, to the twentieth century BC. (Sumerian).
2. Hire of a foreman at 6 shekels of silver per year, paid in instalments. (ANET^2 219 F (1). dated by King of Larsa c. 1700 BC) (Sumerian).
3. Marriage contract. ANET^2 219 F (2). The dowry of 19 shekels is forfeited by the party wishing divorce who "shall also weigh out $\frac{1}{2}$ mina of silver". Babylon seventeenth century BC (Sumerian).
4. Divorce settlement in Kaniš, Asia Minor[216] by the payment of "one mina of silver" (ANET^2 217 D (1)) twentieth century BC (Old Assyrian).
5. Transfer of 40 minas of silver from one person in Kaniš to another directed by the supreme court of Aššur. (ANET^2 218 D (2)) twentieth century BC (Old Assyrian).
6. Sale of a house: the goldsmith[232] of Aššur pays 5 Talents 30 minas of lead for a house in the city (ANET^2 221 I (2)) c. 1243 (Middle Assyrian)
7. Purchase of a female slave: "As her full price he weighed out 5/6 mina 1 shekel of silver and he also delivered 2/3 shekel of silver as additional payment" (ANET^2 218 E (5)) end seventeenth century BC Babylon (Old Babylonian).
8. Release on bail of $13\frac{1}{3}$ shekels of gold (ANET^2 219 G (2)) mid thirteenth century, Cassite dynasty, Babylon (Middle Babylonian).

These examples are taken from the earliest periods when silver was not universally used for expressing, and paying prices, but something more general, like barley.[233] Although the quantities of silver, lead and gold mentioned above might be the possession of only the Upper Classes of Mesopotamian society, the use of the balance was not restricted to them -

9. Temple accounts of Nippur BE.14 (dated to Cassite dynasty,

fourteenth century) One part, recording sheep and goats rented to an individual farmer, demands that he should weigh his wool and hides: "(For) [169] shekels of wool: (i.e. for) one sheep, one shekel; 44½ minas of wool; 20 minas of goat wool... The total of all his hides he shall weigh". (MB).

The range of commodities weighed is considerably increased by the requirements of ritual, medicine or mathematical example:-

10. Death of Gilgamesh ANET^{2} 51^{b} B.8-13, 28. Sumerian version, dating Nippur first-½ second millenium , describes the weighing-out of offerings to the gods. Bread only is preserved in the mutilated text.

11. Ritual when covering the temple kettle drum: ANET^{2} 334-8. Akkadian ritual parts of which were copied from older tablets in the seventh century BC.[234] Lays down, in A (iv), specific weights of aromatic plants, wool, alum ("from land of the Hittites"), varnish (?) in the list of equipment needed.

12. AMT.41.1r iv.19 "You chop these 24 herbs and aromatics and weigh them in a balance (in the quantities mentioned. i.e. one shekel, one and a half shekel, two shekels, one-half shekel, one-eighth of a shekel and one-sixteenth of a shekel, and one-sixth of a shekel)".[235]

13. Mathematical problem. Cited Roux Ancient Iraq (1964) 301-2. "I found a stone but did not weigh it; then I added one-seventh and I added one-eleventh. I weighed: one mana 8 shekels and 22½ "lines"."

14. Mathematical problem. Cited Contenau Everyday Life (1954) 224, 303. Thureau-Dangin Textes Mathem. No. 147. "A stone of unknown weight. I have subtracted 1/7 of its weight and ⅓ shekel and 15 grains. I restored 1/11 of the amount subtracted plus 5/6 shekel, thus restoring the stone to its original weight. What was the weight?" [236]

Apart from illustrating the weighing of stone, these mathematical texts introduce a new element - weighing to discover the weight of an unknown. This was shown by the weighing of hides in 9. above and can be illustrated in an entirely different context also:-

15. ABL. 292 r6 and 9. "Whoever captures or kills the king's enemy, just as my grandfather did with Sūzubn, whom he put

on a balance, and whose weight he paid in silver to [PN], now I will put him on a balance, weigh (him) and give him (whoever captures or kills him) his weight in gold".[237]

It is important to note here that two weighing operations are involved, the weighing of the body and the weighing-out of the silver or gold, and not a single one, in which the body is weighed directly against the precious metals.[238] Of the two operations, the first illustrates the use of weighing to discover the weight of an unknown, while the second is a further example of the more widely documented practice of weighing out specific amounts of silver or gold.

Apart from these specific references to the actual use of the balance in practice, an obvious source for evidence of much wider use is the Mesopotamian Law Codes. Several are preserved dating from the twentieth century to the fifteenth century BC[239] but two in particular, the Eshnunna and Babylon (Hammurabi) Codes, provide additional (as internal) reasons for extending the picture being constructed of the use of the balance in Mesopotamia. The problems of inferring actual practice from Law Codes have already been met in connection with the Hittite Code above.[240] With no alternative offered to the weighing of silver for prices and penalties,[241] it was there argued that the scarcity of silver and the complexity of the operation of weighing made it likely that payment was in fact made in other commodities (measured perhaps other than by weight). The presence of a price table giving equivalents between silver weight and other articles contributed to this conclusion as did the absence of any penalties concerning fraudulent weighing. Silver (and gold) were hardly less precious to the Mesopotamians[242] and the procedure of weighing itself no less complicated,[243] but the Mesopotamian Law Codes do not present such a complete or far-reaching silver-based pricing system as the Hittite. In particular, barley, or grain, is well in evidence as an alternative to silver for prices and on occasion for penalties also.[244] It is much easier therefore to accept at face-value payment in silver where it is specified, although the extent of the use of the balance implied by this actual silver weighing might be restricted to the officials of law courts and the relatively few occasions when pricing is in silver.[245]

By considering in detail the individual law codes themselves this field can be considerably widened. Probably the earliest is that of Eshnunna.[246] This opens with the clearest tabulation of equivalences that has survived: 1 shekel of silver is given its equivalent in barley, three types of oil, lard, wool, salt and copper (refined and unrefined) (§1), and then the value of barley is given for 1 qa of each of a similar list of commodities (§2). That these equivalences are genuine alternatives is shown by subsequent sections of the code where certain (but not all) payments are expressed in both silver and barley. For example §7:-

"The wages of a harvester are 2 seah of barley; if they are (paid in) silver, his wages are 12 grain."[247]

It is not however possible to isolate any section of the society for which the code was designed as more likely to use either of the two available methods of payment.[248] Crimes, stealing or assault, such as might be committed at all levels of society, are always given silver penalties, and whereas such agricultural activities as harvesting (just cited) might be paid for in either silver or barley it is difficult not to infer that the harvester could well be familiar with silver transactions.[249] Certain problematic variations in the silver : barley ratio, through the occasions where equivalences are given in the code, would appear to confirm the suspicion that the alternative of silver or barley-payment is not as straight-forward as it appears.[250] Whatever the explanation might be for this, a distinction that does at least suit the specification here is between prices and hire, where alternatives are given, and penalties for criminal offences, where silver (or payment in kind but not as an alternative) is laid down. That alternatives should be offered in one and not the other, and that the availability of silver does not precisely seem to match its equivalence-value in barley,[251] both imply that silver penalties should be paid in the manner (silver weights) specified.[252]

The Code of Hammurabi[253] contains no table of equivalences and gives no alternatives to the method of payment (silver or grain) specified in its prices and penalties. Though there is some evidence to the contrary, these payments are clearly intended to be made precisely as specified and four main arguements support this conclusion. Firstly, the cases where alternative payment

is envisaged concern the activities of merchants and not the administration of the law.[254] Even though the correct alternatives are to be worked out on the basis of "ordinances of the King" there is no reason to suppose they applied to the Law Code itself from which any mention of equivalences is conspicuously absent.[255] Secondly, this alternative payment is in any case only allowed in exceptional circumstances where a debtor cannot pay in the manner specified[256] and there would have been no need for mention of this situation at all if the method of payment was entirely at the choice of the payer.[257] Thirdly, the variation in relative values of silver and grain in the "ordinances of the kings"[258] (————————) and the possibly different interest rates that are laid down in the Code of Hammurabi itself[259] make it extremely unlikely that individuals might be allowed to choose whichever method of payment was at the time least expensive. Finally, the fact that the code itself specifies with such care silver or corn payments but on no occasion both for the range of subjects covered is clear evidence of the fact that payments were to be made as specified, for a consistent and easily operated codification could have been much more simply achieved by all payments in silver with a table to convert into other commodities where this was more suitable.[260]

Now that it is established that silver payments in the Code of Hammurabi can be taken at their face value it is possible to consider how widespread such manipulation of weighed amounts of silver is indicated by the Code. It is apparent at the outset, however, that no social distinction, as between town and country, will entirely explain the distinction between prices expressed in silver and in grain. While in the majority of cases grain is laid down for agricultural payments, there are exceptions, such as the payment of the vetinary surgeon §224 f. or the labourers of §273,[261] where silver is prescribed, and, even though the people concerned may be professional or occasional workers from town, those making the payment are certainly in the agricultural context. The same difficulty recurs more acutely in connection with the penalties laid down in the code and only a minority of the crimes of agricultural nature are penalised in grain,[262] with the

vast majority (especially those of general nature invoving all sections of the community) accorded silver penalties.[263] As already noted for the law code of Eshnunna above , the weighing of penalties may be the court's business, but it nevertheless remains true that all sections of society were supposed to be in possession of silver and it would be remarkable if they were not acquainted with the way of measuring it (viz. weighing).[264]

Of the two remaining Law Codes I wish to consider here the Lipit Ishtar Code, and the Middle Assyrian Laws. The main interest in the former is its early date.[265] Surviving fragments deal mostly with damage to agricultural property, the condition of privately-owned slaves, inheritance and estate ownership. No prices are given, and the few penalties expressed not in kind, are all in silver.[266] No indication of grain alternative to the paying of those penalties in silver is given in the Code and no conclusions can as a result be drawn about the actual use of the balance from the Code. Very much the same is true of the Middle Assyrian Laws.[267] The chief peculiarities of these laws are the emphasis given to a complete range of corporal punishments[268] and the fact that certain penalties are expressed in weighed amounts of lead with silver reserved for extremes.[269] While the occasions on which this penalty is prescribed are very few in number, that it is a practical alternative to silver and therefore that actual payment in it is expected, would seem a reasonable inference. The sums involved, however, are remarkably unwieldy - and mainly in the talent range[270] - and this might account for the frequency with which corporal punishment as a more practicable means of penalising people is prescribed. No prices are specified, with the doubtful exception of the redemption of a female slave for 4 T lead (in tablets C and G. 1), and no inferences of a general use of weighing can be drawn directly from the Code, apart from the court-room measurement of lead already mentioned.

There are, however, in Middle Assyrian Laws indications that the society for which the Code was written used weighing for normal commercial transactions, and I shall move now onto a consideration of this indirect evidence in the Law Codes already examined. Middle Assyrian Laws (Tablets C and G) contains three

references to silver in connection with the purchase of oxen etc., goats and people.[271] This silver must be in weighed units even if the text is too fragmentary and the allusion too general to specify how many. Another indication of weighing, in the context of general activities of tamkarum and of the wine-seller, is given by LE.15 "The tamkarum and wine-seller shall not receive silver, barley, wool (or) sesame oil from a slave or a slave girl (as an investment?)".[272] Of these both silver and wool would be weighed. The clearest evidence of sale involving the weighing-out of silver is the crime of the "wine-seller" in the Code of Hammurabi §108. However this passage is interpreted,[273] it remains clear that she could offer her drinks for sale in either silver or grain.

To summarise the results of this survey of the Mesopotamian Law Codes so far. It has been established that payments specified in silver or grain were to be made as specified. Penalties most often were expressed in silver, but while the measurement of such fines might be the function of the court officials only and while general experience of this situation (paying a fine) might be slight, it nevertheless remains a valid inference that people generally were expected to possess the silver and is not an unwarranted assumption that they know how to measure what they possessed (i.e. weigh it). This is moreover confirmed by the indirect evidence just considered and directly by the explicit charges and prices in the Law Codes both of which show that silver (along with grain) was in general use in the community itself by the first half of the second millenium BC.

A significant indication of the degree to which the Mesopotamians were familiar with the procedure of weighing can be derived from their concern for the correctness of this weighing and their awareness of abuse. On the one hand there is the existence of weights inscribed with notices of their accuracy. These survive from all periods of Mesopotamian civilisation, and in cases reveal a remarkable degree of accuracy.[274] They were clearly carefully looked after, as is shown by the British Museum weight with an inscription that certifies it to be a copy of a weight made by Nebuchadnezzar (605-562) according to a weight of

Shulgi (a king of Ur III whose dates are put at c.2095-2048). The shekel on which Nebuchadnezzar's weight is based is said to vary only 0·15 gm. from that found in Ur III weights inscribed with Shulgi's name.[275] This is impressive evidence of the consistent high-standards of royal accounting in Mesopotamia, as well as concern for accuracy, but does not provide any indication of the application of this precision outside the royal court or the extent to which ordinary commerce made use in any way of weighing.[276]

For this we must turn back to the literary evidence where can be found a considerable number of passages revealing concern about fraudulent use of the balance. Not only do these indicate the general familiarity with weighing through most levels of Mesopotamian society, but they indicate how extensive was the <u>type</u> of weighing with which the above weights are associated (namely the measuremental). I have already mentioned the wine seller of the Code of Hammurabi §108 and will now consider this passage in detail along with others from a remarkably wide range of sources.[277] As the principle of inclusion in the list that follows is mention of misuse of the balance it will be necessary to define what offence(s) are involved. This affects the interpretation of the Code of Hammurabi §108 which I shall therefore leave till last.

Giving false weight or misusing the balance is included in the catechism of possible offences that might have angered the gods in the <u>Šurpu ritual</u>.[278]

[II.37 He gave with small (measure) and received with big (measure).[279]]

1. 42 He us[ed] an untrue balance (but) [did not us]e [the true balance].

2. VIII.65 The 'oath' of giving with a small shekel-weight but taking with a big shekel-weight.[280]

66 (ibid. for mina-weight).

67 Together with the 'oath' of using an untrue balance (or) taking untrue money and swearing (it was rightful).

3. To which could be added the abbreviated 'oath' of III.119 "the 'oath' of barley or silver" which appears between "heaven and earth" and "cattle and wild animals" and is

clearly meant to refer to two of a kind.

4. Another magical text[281] is closely parallel; it contains spells to release a man from curses arising out of such offences as:-

- giving (payment) by small measure, receiving (payment) by great measure.
- giving with one small shekel, receiving with one great shekel.
- keeping false scales.[282]

5. The hymn to the Sun-god Šamaš, to the Babylonians explicitly god of Justice,[283] contains a general picture of the god furthering the commercial fortunes of those who weigh honestly.[284]

ll. 107-111 The merchant who [practises] trickery as he holds the balances
Who uses two sets of weights thus lowering the...
He is disappointed in the matter of profit and loses [his capital]
The honest merchant who holds the balances [and gives] good weight -
Everything is presented to him in good measure [...].[285]

112- The merchant who practises trickery as he holds the corn measure
Who weighs out loans (of corn) by the minimum standard, but requires a large quantity in repayment
The curse of the people will overtake him before his time...

118- The honest merchant who weighs out loans (of corn) by the maximum standard thus multiplying kindness
It is pleasing to Šamaš, and he will prolong his life.[286]

Finally there are two passages in the Code of Hammurabi. The first concerning loans made by the tamkarum and their fraudulent collection, the second concerning the wine-seller.[287]

6. §P. If a merchant has given corn or silver on loan and when he gave (it) on loan gave the silver by light weight or the grain by light measure...

7. §108. If an ale-wife does not accept grain for the price of liquor (but) accepts silver by the heavy weight; or (if) she makes the value of the beer (given) less than the value of the grain (received)[288]; they shall convict that ale-wife and cast her into the water.[289]

Before facing the difficulties in this last passage it must be noted that the lack of connective particles in the Babylonian text makes two other versions possible. One of these is to understand three separate offences (all covered by the same penalty) namely: refusing to accept grain, accepting silver by the heavy weight, and not giving full measure for grain. Driver and Miles (BL I.203) discount this subdivision of the first part on grounds of rhythm and because there is no evidence that a seller might not stipulate how he be paid. The Code of Hammurabi §51. L, M are special provisions for altering contracts (and a sale might be considered such a contract) should the debtor be unable to pay in the manner specified by the merchant in the original contract.

Another interpretation is reached by taking the whole section as one offence, the second part being an explanatory gloss on the first. Different supplements are necessary, and Meek's version (ANET[2]) is best reproduced here in full:-

> If a woman wine-seller, instead of receiving grain for the price of a drink has received money by the large weight and so has made the value of the drink less than the value of the grain, they shall prove it against that wine-seller and throw her into the water.

If this interpretation were adopted, or even possible, the implications would be far-reaching. In particular this version indicates that an offence in weighing should be explained with reference to an inequality in capacity measuring and thereby implies considerable unfamiliarity with not only the silver-weight value system but also with weighing in general. This interpretation can however be disregarded for a number of reasons.[290]

Firstly this version, quite apart from its obscurity,[291] appears illogical. As a result of the wine-seller's demanding

too much silver the equivalent value of the drink thus purchased would be either more than the grain (as the silver was more than the equivalent of the grain price) or at least unchanged (as the grain price is unchanged). Secondly, §108 should be considered in the context of the rest of this group concerning weight offences. These generally include misuse of measures where they mention misuse of weights, and this is also true of §P, itself from the Code of Hammurabi also. As the wine-seller operated both in silver and in grain one might reasonably expect to find both methods of sale covered in a section, as §108, regulating fraudulent sales.[292] Thirdly, it is difficult to see why the wine-seller should go to such lengths to achieve what could simply be done by using false grain measures, an offence amply illustrated by the other passages in this group. Fourthly, the "large weight" on this interpretation is no less a false weight in the context, and, as we know false weights are not exactly favoured by the gods, it is difficult to see how this might be overlooked in §108 and only the obscure purpose to which it was put penalised. Finally, the very implication that this interpretation threatens is so completely against the not inconsiderable evidence pointing to its very reverse, viz. that weight and familiarity with weighing played a fairly important part in normal Mesopotamian life.

Returning to the interpretation first offered, therefore, the possible offences of the wine-seller are two-fold - according to whether the sale be made for silver or for grain. Whether in the latter case she uses too small a beer-measure or too large a grain-measure[293] is not clear, but need not concern us here except in so far as both indicate the existence of a standard measure. This is similarly implied by the sale-by-silver offence, for the heavy weight, as already pointed out, is false by being heavy in the context[294] and must therefore be heavier than a certain, presumably defined, standard weight that should have been used. About the enforcement of standard weights however we find no evidence, and their relevance to general commerce, and the wine-seller of §108 in particular, remains problematic. Another difficulty raised by this passage is why mention of direct sales should be restricted to this one mention of the wine-seller. Although not all Mesopotamian Law is completely preserved, this

one reference is nevertheless somewhat isolated in a mass of regulations concerning other aspects of trading, in particular loans and contracts. Both these questions may be helped by a general consideration of the whole group of passages collected here.

It would appear that two types of weighing offences are covered by these passages, one concerning weights of which (7), §108 Code of Hammurabi, is a special case, the other concerning balances.

(1) Offences with weights

(a) The normal form of this offence is where heavier weights are used for receiving than for paying out. Thus (2) (4) and (6) where the context is given of loans. (5) must refer to the same activity, the "two sets of weights" being used to the merchant's advantage just as is shown in the more explicit passages. Two problems arise: are all the contexts of this offence necessarily loans? are any standard weights implied? Although no direct evidence exists to my knowledge, this offence could well apply to any sale of a weighed commodity against silver (weighed as usual) or any other similarly weighed commodity. This weighing was not done by direct comparison and bags of weights were carried by merchants for the two weighing processes involved.[295] The activities of the tamkarum in the hymn to Šamaš are certainly closer to the Old Babylonian commercial travellers[296] than to their namesakes, the state finance officials of the Code of Hammarubi (i.e. (6)). If this view is correct, the use of the balance would be spread throughout everyday commercial activity in Mesopotamian culture from early times onwards. The Hebrews are but an example of such tamkarum as described in Šamaš.

As regards the second question posed above, there is no indication that any official standard lies behing the offence being considered. The variation between the two sets of weights used, described as "light" and "heavy", sufficient in itself for the successful fraud, is entirely independent of any set base or official standard. "Light" and "heavy" are purely relative to each other and as natural a mode of expression as the leicht

and schwer of modern descriptions of Mesopotamian standards.[297] Clearer perhaps is the contrast in (5) between the giving of "good weight" and the use of two sets of weights. In fact there is no evidence of official attempts to enforce standard weights (with the possible exception of the Code of Hammurabi §108 on which see below)[298], although the passages being considered here show both official and moral concern for consistent use of weights. That there existed in fact a great variety of weight standards, even down to those of individual traders, is well known from both archaeological and literary sources.[299] On the other hand it should be pointed out that, though no constant standard was prescribed, a uniform system of weights was in operation. (2) refers to shekel- and mina-weights as quite distinct offences; (3) mentions the shekel, and so does the hymn to Šamaš just before the passage cited as (5).[300] Similarly the interest for the loans such as the merchants make in (6) is expressed in shekel weights (also grains) and corn measures.[301] This point is important as it is not correct to infer from the non-standardisation of weights and measures that precision and measurement of weight did not apply to transactions involving non-standard weights. It clearly did - but everyone measured in a way they could rely upon; and this, as long as weights were not fraudulently substituted during a transaction, was quite satisfactory.

(b) Code of Hammurabi §108, (7), is a special case. Although the sense of "heavy weight" is relative as in these other examples, it is relative to a standard that has not been set up on an earlier occasion by the wine-seller herself, but is officially laid down. As the wine-seller is involved in dual pricing, it would be reasonable to suppose relevant those "ordinances of the King" that laid down the equivalence rates for payment in silver or grain.[302] These must have required (expressly or not?) the use of defined standards of weight and capacity for conversion of this nature. Why the wine-seller is under special control is not at all clear,[303] but is in no sense an argument for all commercial activity to have been under such control. As the variation in individual weights just mentioned would indicate, this was simply not the case.

(2) Offences with the balance

Although in (1) mention is only made of "using an untrue balance", (2) (4) and (5) all show that misuse of the balance is something other than the substitution of weights (offence 1 (a) above) or the use of false weights (1 (b)). Simple repetition is unlikely. The style of Šurpu (i.e. (1) (2)) is laconic in the extreme, and the misuse of the balance in (4) is grouped with offences both involving measures and weights. In (2) Šurpu VIII.67 "together with the 'oath' of using an untrue balance..." the same distinction is made. It also occurs in Hebrew literature[304] and raises the question of how in fact a balance might be misused. The Šamaš passage, (5), possibly indicates faulty methods of suspension and Šurpu VIII.67, (2), might refer to misreading the levelness of the beam.[305] This certainly would be one easy way of misusing the balance.[306] The writer of [Arist.] Mechanics suggested another, namely a beam weighted at one end.[307] All these offences operate simultaneously with the operation of weighing, unlike the weight substitutions in 1 (a) above which require two occasions.

This widens considerably the types of commercial transactions for which weighing can be inferred, and the general argument a fortiori from misuse to use of the balance can now be concluded. To recapitulate:- the Code of Hammurabi §108, (7), was seen to be a specialised kind of commercial sale under state supervision. Possibly because of this state control it is the sole direct reference to the misuse of weighing procedure in sale (as opposed to §P Code of Hammurabi, loans). Weight substitution offences, though they indicated a fairly general commercial context, show general concern only for loans and sales involving two weighing operations (this latter by inference only). Finally, concern for the misuse of the balance, brings in all transactions involving it either to measure the commodity sold or the method of payment (silver being the most usual).[308]

On the one hand, therefore, we have arrived at what must be evidence of fairly considerable familiarity with the use of the balance in commercial transactions, sufficient that is for it

to occur in the wide range of contexts from which these passages are taken (general religion as Šamaš; particular magical texts with relevance directly to those involved, Šurpu; and the legal code context of §P and §108). Moreover all types of commercial use of the balance are covered in the range of possible misuses for which concern is expressed. From this alone it is not possible to infer that the commercial activity was either general or extensive. The evidence of the Law Codes considered earlier is, however, that silver weighing was familiar to all levels of Mesopotamian society, and a fortiori the weighing of other materials. Moreover, this misuse of weights and measures is one of the main crimes attributed to merchants (especially in Šamaš, where support of honest dealing is the main attribute of the god). It would therefore seem reasonable that the concern for correct weighing applies to almost as wide an area as commercial activity itself, and certainly wider than simple application of state authority (the Law Code). Even though no uniform weight standards would appear to have been imposed, there existed in Mesopotamia a general and clear understanding, not simply of weighing, but also of possible abuses of the procedure involved. This leads on to a significant addition to the conclusions so far reached as the use of weights: the offences arising from the use of weights, plus the obvious concern for precision shown in fear for the misuse of the balance itself, all point to the weighing being of one type only, namely to measure specific amounts.

That weighing of this type was familiar to most levels of Mesopotamian society is therefore shown not only by the official law codes, but now more extensively by the moral condemnation of its abuse.[309] Though the specific context of such abuse may be commerce, the activities of the tamkarum are considerably more far-reaching than normal trading, and an even more general use of scales would be implied by the mention of their abuse in the Šurpu ritual.[310] The balance itself appears consistently as a precise and technical instrument designed to measure absolute weight, and that the Mesopotamians understood this concept is indicated also by the price-weight systems in fairly extensive

use as well as by the mathematical problems concerning weight itself.[311] It must be emphasised however that this is a particularly restricted use of the balance; yet despite its sophistication there is no evidence of any interest at all in simpler aspects of the balance (such as its use for direct comparison of weight and an inclined beam). All Mesopotamian equivalence calculations are accomplished by intermediary concepts such as measured weight, value, and "ordinances of the king" specifying specific exchange rates.

This restricted use of the balance applies not only to the practical occasions of its use, the administrative, legal and commercial already considered, but also to literary metaphor and theological writing. Although very few references to the balance in fact occur outside the purely practical context, enough survives to indicate that even here the shop or court-room, and the type of weighing done in them, is in the writer's mind if not explicitly mentioned.

The list with which I conclude this survey of the Mesopotamian attitude to weighing and the balance, begins with a clear metaphorical literary reference. I am not sure that anything further in the list actually adds anything to what has already been said and one passage ,(3), should probably be considered a direct allusion to commercial use of the balance. Certain passages are obscure and I leave them as such. The final brief discussion of the Mesopotamian view of the after-life is of importance even if there is nothing in this theological speculation that can with any certainty refer to the balance of a post-mortem judgment (contrast both Egypt and Hebrews) or the balance of fortunes (on my interpretation true of Hittites, but certainly of Greeks). As these subjects play a considerable part in the other surveys it seemed reasonable to devote a little space to the Mesopotamians here.

1. The lamentation of the fall of Ur. Ur III fell c.2000 and the Sumerian text is dated to the first half of the second millenium BC: Kramer translation ANET^2 455A .

1.244. "The Subarians and the Elamites, the destroyers, made of it thirty shekels."

Kramer suggests that this means they treated it (Ur) with the utmost contempt (ANET^2 460 n.73) but whatever the interpretation (and 30 shekels is quite a large sum, no farthing certainly) the phrase is metaphorical, not literal, and yet still refers to evaluative (not comparative) weighing. "30 shekels" is a weight not a lump of silver.

2. Šamaš. Bibliog. given above in Šurpu ritual.[284]

1.22. "You suspend from the heavens the circle of the lands". Lambert notes that "the picture here is that of Šamaš holding up the earth like a pan of a balance. Nowhere else, however, in the hymn is Šamaš said to have a balance himself despite his interest in the way merchants might use it, and the image of suspending a single object, which might imply a steelyard or other single-scale balance, is not particularly suited to suspension of two-scale balances (and only these were used by the Mesopotamians: see above, the references to 1 and 3 scales in inventories prove nothing). In any case simple suspension is neutral for the conclusions I have drawn on Mesopotamian attitude to the balance as opposed to comparative attitudes (as Greek).

3. Famine conditions in the city before the flood. From Atraḫasis, relevant tablets only preserved in Assyrian versions from Assurbanipal's library but may go back, as do other parts of the epic, to Old Babylonian times. Fullest edition Lambert and Millard Atraḫasis (1969), but also introduction and translation by Speiser ANET^2 104-6.

The progressively worsening conditions in the city during the six years of siege are described in graphic detail, but the 5th year is particularly relevant (Lambart and Millard Rev.v. 12-26 = Rev.vi.1-15; Speiser ANET^2 105 f. D(i)≡(ii). I follow Lambert and Millard's translation omitting the supplements and writing balance for scales as CAD sv. zibānītu 1 (a)

translate the passage).

- When the fifth year arrived daughter watched the mother's going in
  But the mother would not open the door to the daughter.
  The daughter watched the balance of the mother
  The mother watched the balance of the daughter
- When the sixth year arrived they served up the daughter for dinner
  They served up the son for food ----

Speiser interprets the crucial phrase "watched the balance of etc." as implying that nobody trusted anyone (ANET^2 105 n.13). In what this mistrust lay is not at all clear - if cottage industry the element of competition is not easily explained in the context; but it could be that the phrase is metaphorical.

I should however prefer to accept the interpretation offered by Lambert and Millard and brought out in their translation "The daughter watched the scales (at the sale) of the mother" etc. The context is increasing food problem: 4th year cramped conditions to 6th year cannibalism and the opening lines of the 5th year indicate an attempt to reduce the number of mouths to feed in a single family by cutting down its size (refusing entrance to the daughter). Lambert and Millard compare the account of the siege of Nippur (late seventh-century and so close to the date at which these tablets were written) where documentary evidence shows that many families were forced to sell their children for money to buy food. Oppenheim[312] translates a tablet referring to one such sale (2 NT.293). The father speaks -

- "Take my small (female) child Sulleâ-taššmê and keep (her) alive.
  She shall be your small child! Give me six shekels (of silver) so that I may give [---] and that I may eat"
  Thereupon Ninurta-Uballit [accepted his offer] and weighed and gave him in one [?payment] six shekels of silver...

Thus the balances in the Atrahasis passage are such as used here by Ninurta-Uballit at the sale of the daughter. Mother and daughter appearing in apparent competition might indicate that the father wished to see who fetched more money, but I am

more inclined to understand poetic synchronisation of the experience of several families (i.e. some families abandoned daughters, and some sold either daughters or mothers).

This second interpretation appears the more likely and as such the reference is to no more than a straightforward commercial transaction (and at a late date when silver weight purchases were the rule: clearly however barley alternative ruled out by famine conditions!).

4. Prayer to Nabu for someone in distress. STT.I.65.1.17 Cuneiform text only and CAD sv. zibānītu 1 (a) partial translation only. See Roux Ancient Iraq (1964) 297 on the Sultantepe archives in general.

5. Judgement of the dead and the afterlife[313]

The Mesopotamians had a fairly pessimistic view of the after-life. Their belief that man was created for the service of the gods, a service which would be terminated by the death of man when he was no longer of use, was only slightly alleviated by the hope that life might continue.[314] This was conceived of as a shadowy, miserable sort of existence in the "land of no return", Kurnugia.[315] Possibly some sort of distinction might result from the maintenance and splendour of an individual's tomb offerings.[316] Certainly the service a man put in for a god in his lifetime was, it was hoped, likely to stand him in good stead,[317] but there is some doubt as to whether this would be effective after death. Nothing of a man's achievements would appear to count then: as reflects the master, he will not do something helpful for his country, a deed "placed in the bowl of Marduk", because as the servant points out it will not help afterwards -

> " Climb the mounds of ancient ruins and walk about: look at the skulls of late and early (men); who (among them) is an evildoer, who a public benefactor." [318]

Morality is so far as it can be detected at all similarly only applies to fortunes of this life.[319] There is no evidence of a judgement in the afterlife of an individual's former actions. Inscriptions of certain sixth-century or seventh-century BC Susa tombs are both late and peripheral, and the translation of the words mushekil and gabûth as wäger and wägschale made by Ebeling is vigorously disputed by Aynard.[320] Apart from this doubtful source there is no reference to the balance in actual or metaphorical sense in any other judgement scene. These are fairly well attested, and to return to the question of the afterlife it must be admitted that judgements were given there and judges of the underworld were thought to exist. Their functions would appear to be threefold: (1) to assign the newly arrived dead their places in the underworld;[321] (2) to act as judges in the underworld administration, just as judges in this world administer justice between men living;[322] and (3) to judge when an individual must enter the underworld, i.e. to decide when he should die.[323] None, however, are associated with, or use, a balance.

1. (4) Canaanites and Phoenicians

The peoples of Syria and Palestine do not fall easily within the scope of this survey. A linguistic grouping of Semitic-speaking cultures is both too wide (as including Akkadian it would extend to Assyria and Babylon) and of doubtful implications beyond the superficial linguistic affinities.[324] Nor can one simply set the confusing political history of tha area down to successive waves of migrations introducing new elements upon the scene. There were wandering tribes and their impact on Syro-Palestinian history varied inversely with the degree of order exercised over the area by the major powers who came one after the other into political control of it.[325] These powers have already been discussed, and the unstable local elements are either too obscure or transient to merit more than a mere mention here. Thus of the Aramaeans little can be said to have resulted from their activities in the area from the fourteenth century onwards beyond the fact that their language emerged as that used throughout the Neo-Babylonian Empire.[326] The waves of "sea-peoples", end of thirteenth century and early twelfth century, left their mark on Ugarit (never to be inhabited again after its destruction), and one group, the Philistines, actually settled in S. Syro-Palestinian coast somewhat enigmatically siting their cities away from the sea.[327] The so-called Neo-Hittites, a cultural group using hieroglyphic Hittite that established itself in N. Syria from Cilicia across to Antioch from the tenth to eighth centuries, is little understood as yet but seems to have had little impact.[328] Of the guerilla hill-tribes, the Habiru or 'Apiru of the Amarna period,[329] the Elamites, Moabites and other restless groups of the Hebrew Kingdom little need be said. There is some doubt as to whether the Hebrews originally split off from the group I shall be calling Canaanite or whether they came, as Abraham, as relatively late arrivals into the Syro-Palestinian area prior to their sojourn

in Egypt (approximately 1600-1250).[330] It is however clear that by their return in the thirteenth century the intense nationalism that informed both their political and religious thinking, as too the circumstances of their need to conquer and hold a homeland, are sufficient grounds for treating their culture as individual. As their literature affords a compact and comprehansive source of evidence I shall be able to consider them separately below.[331]

Despite these confusing moments there was an important and remarkably stable culture in the Syro-Palestinian area possibly from as early as the third millenium BC.[332] This, generally called Canaanite, is associated especially with the bronze-age cities as Ugarit, Megiddo or Byblos, and continued to develop in the iron-age coastal cities, more commonly labelled "Phoenician" from the name the Greeks gave them, of which Aradus, Byblos, Sidon and Tyre are the most important. The Near East referred to these people as Canaanites both in the bronze-age Amarna letters and in much later iron-age Hebrew histories; and there is some reason to suppose this is how they themselves were called.[333] Essentially a city-state culture, the Canaanites appear to have flourished under the foreign control of the major Empires of the Near East. This has been attributed to the commercial importance of the cities concerned.[334] In effect their role seems to have been as the ἀγορά of the advanced civilisations whose boundaries met in the Syria-Palestine area and in all of whose interests lay the continued prosperity and security of the Canaanite "ports of trade".[335]

The most complete picture of the bronze-age Canaanite trading city is provided by Ugarit of the fourteenth to thirteenth centuries (both documents and archaeology) and this can be supplemented by the closely similar contemporary evidence from Byblos and Megiddo.[336] The Ugarit documents can be divided into external and internal administration, and into literary or religious texts.[337] The former reveal not only the variety of foreign powers on diplomatic terms with the King of Ugarit, but also the extent to which commerce formed an important part in relations on this level. Thus for example a treaty was made between Ugarit and Carchemish regulating penalty for the murder of foreign merchants in each of the two countries.[338] A similar treaty presumably also existed with the

Hittites.[339] More direct control of trade can be seen in the restrictions negotiated on the period of the year during which Hittite merchants of Ura could trade in Ugarit,[340] in the rules laid down concerning the Siyannu wine-traders[341] and more generally in the fact that complaints about customs taxes would be handled at this high diplomatic level.[342] On another occasion the prefect of Ugarit confiscated four thousand shekels from a caravan owner.[343] Although a number of these cases may be also put down to the administration of justice rather than simply to commercial interest, it is nevertheless clear that commercial arrangements formed the basis of the foreign relations of Ugarit.[344] Exceptions are particular individuals recommended from one court to another, or general political arrangements.[345] A similar role can be seen fulfilled by Gezer to the South, held responsible for procuring best-quality slave-girls in return for Egyptian products and manufactued articles,[346] but in the Amarna period the political uncertainties were already endangering the stability of trading relations.

Interest in foreign trading has been noted for Hittite, Mesopotamian and Egyptian royal courts, but there is evidence that the Ugaritic interest went much further than the direct profits of the King's court, and that, whereas the Hittite merchants might appear to be special representatives of the Hittite King, those of Ugarit had a more independent existence. This can be inferred from the concern shown by Ugaritic Kings over competition of merchants of Ura and Siyannu.[347] It is also indicated by the amount of documents between the King and Ugaritic merchants themselves. Nougayrol draws the following picture of society in Ugarit: "à son sommet le roi... surveille de près la vie économique, règle l'effectif des corporations, sanctionne par sa présence, ou dirige par ses initiatives, la répartition changeante du capital (immobilier)... favorise le commerce des "hommes d'affaire"... encourage les enterprises maritimes et la colonisation intérieure."[348] As examples of the control of internal trading could be cited the table of weights and measures,[349] or the "fixed price in the town" as variant for Sumerian "cost".[350] But more significant is the internal structure of Ugarit itself, the records of individual traders and of specific transactions. These in themselves reveal

two important points, namely considerable commercial activity apart from, though often related to, the conveyancing of goods by caravan owners and other foreign trade specialists,[351] and, secondly, the extent to which silver in particular was used as a universal medium of exchange.

The practical use of silver for payments has been queried in many of the cultures already discussed, and its extent even in Mesopotamian society argued to be rather limited. There is, however, no indication of alternative means of payment in Ugarit being at all usual or as general as the explicitly attested use of silver.[352] From the documents of PRU III alone, the range of contexts in which silver amounts (weight) are paid is considerable - from penalties, to gifts, debts, indemnities, ὑποθηκη liberation, accounts, "bankers' orders", joint payments as well as straightforward purchases.[353] Amounts range from five shekels up to ten talents (a threatened fine), and although round figures are more common, a clear practical example is afforded by the fifty-seven shekels paid paid for a vine in PRU III 15.37. The implications for the prosperity of Ugarit itself are clear.[354]

So also is the implication that experience with measurement of weight by means of the balance was commonplace to Ugaritic society. To the weighing out of silver implied in the prices and penalties referred to above can be added the description of amounts of wool, flax, and copper in shekels where weighing can reasonably be assumed,[355] or the explicit measurement of the weight of amounts of gold, and bronze where šugultašu "weighing..." (adjectival) is explicitly mentioned and where non-round figures indicate that this is not just a rough estimate.[356] There are many other occasional references to weighing in the documents quite apart from where a specific weight is given - thus Abiramu's injunction to Silabanu to give the weight of the precious stones he has sent in silver to the merchants.[357]

Three further pieces of evidence support this picture though the first is not particularly easy to interpret. This is the table of weights and measures, already mentioned above,[358] which simply lists, in ascending order of size, measures of weight, capacity, and area. The weight series is as follows:-

$\frac{1}{2}$ grain/$1\frac{1}{2}$ 2 $2\frac{1}{2}$ 3 whole numbers to 22 $22\frac{1}{2}$ 23 whole numbers to 30 then 35 40 45 50 55

$\frac{1}{3}$ shekel $\frac{1}{2}$ $\frac{2}{3}$ $\frac{5}{6}$ 1 $1\frac{1}{6}$ $1\frac{1}{4}$ $1\frac{1}{3}$ $1\frac{1}{2}$ $1\frac{2}{3}$ $1\frac{5}{6}$ 2 whole numbers to 19

$\frac{1}{3}$ mina $\frac{1}{2}$ $\frac{2}{3}$ $\frac{5}{6}$ 1 $1\frac{1}{3}$ $1\frac{1}{2}$ $1\frac{2}{3}$ $1\frac{5}{6}$ 2 whole numbers to 20 then 30 40 50

1 talent $1\frac{1}{6}$ $1\frac{2}{6}$ $1\frac{3}{6}$ $1\frac{4}{6}$ $1\frac{5}{6}$ 2 whole numbers to 20 then 30 40 50 60

With a talent of 3600 shekels the weight system indicated in this table is not that generally supposed to be the Ugaritic, which is claimed to have been based on a 3000-shekel talent or 50-shekel mina.[359] A practical relevance is made unlikely by the extremes of the table, ranging from near 0·025 gm. to 1·944 kgm. (on 9 gm. shekel base),[360] and which are individually (and most certainly together) beyond the capabilities of any balance available to the ancient world.[361] The sequence of the figures, in particular the increasing intervals, are inconsistent, but also without apparent relevance to known Ugaritic commercial practice, as such figures as 57 shekels appear in documents and quite large shekel weights are given with real reluctance to convert them into minai where relevant. The figure $22\frac{1}{2}$ grains is perplexing[362] and might indicate that the table played some part in the problematic business of corrollating Near Eastern weighing systems and weight standards. As a conversion table is obviously out of the question in view of the absence of any second column of (Ugaritic?) weights, a simpler explanation, that the table merely illustrates for scribes the Akkadian weight system, may be more likely.[363] On any view, however, the weight table show a clear interest in the measurement of weight and in the precision with which this, however optimistically, might be expressed. It also shows in Ugarit this interest in a weight system that is not that officially, or possibly generally, in local use.

Secondly, the Ugaritic version of the treaty between Niqmadu and the Hittite King Suppiluliumaš specifies "heavy shekels" where the Hittite version reads shekel weights simply.[364] This implies an official recognition of the difference between two quite legitimate standards, and the "heavy shekels" of this treaty are not to be compared to the Mesopotamian "heavy" and "light" shekel references which I argued above to be simply comparative and not necessarily related to any recognised standard.[365] The implication for Ugarit on the other hand is that at least at the

official court level there existed a sufficiently standardised Ugaritic weight system and the practical ability, as different weights would appear to be used, to weigh in other systems.[366] In so far as commercial relations between Ugarit and outside have been argued to extend below this official level of royal court, so, it might be suggested, also extended this awareness of distinctions between differing weight systems. The operation over such differing systems does I believe indicate quite an advance in technique over the simple operation of weighing with one's own set of weights. There is, however, no direct evidence for supposing such sophistication on other than the official level of this treaty.

Another indication of the extent to which Ugarit was familiar with weighing, and in the measuremental sense again as all the evidence so far considered, lies in the number of both scales and weights that have been recovered in archaeological excavation of the city. This evidence is difficult to interpret and I am more inclined to emphasise simply the extent, the variety of weights and the fact that weights are commonly and widely found, than to follow Schaeffer's actual identification of the use of Egyptian, Mesopotamian and Ugaritic weight standards.[367] Very few weights are actually inscribed, and the bronze recumbent bull-weight (that is apparently marked with Egyptian numbers ∩∩ = 20) corresponds to no known unit, Egyptian or otherwise.[368] The six weights found along with a pair of scales might, though unmarked, be more promising.[369] However, although their published weights do not all fit easily into a single weight system, it would be difficult to suppose that, being unmarked, they could have been used in practice to distinguish different weight systems. These weights must have been meant to represent, or used as, a single system; and the one that does not seem to conform can either be seen as an intrusion into the set on its burial or as a mistake.[370]

Although full details are lacking, the variety of Ugaritic weights would appear to correspond quite simply to the variety of places where they were found - and therefore to the individuals who used them.[371] They are explicitly associated by the excavator with artisans, in particular metalworkers and jewellers, and therefore their actual use need not be related to commerce (internal or external), but simply for the technical purposes of the

individual user.[372] This hypothesis is sufficient to explain both the fact that they are unmarked and that they vary to the extent of being identifiable as representing several different Near East weight systems, as the cosmopolitan nature of the Ugaritic population, and especially that of the artisan element, is well recognised.[373]

Ugarit in the late bronze-age was, it would appear, a city where all levels of society had some direct experience of weighing. While individuals might possess their own weights and systems, the city recognised an official standard and was able to correllate it to other Near East standards. Although not all weighing was directly related to commercial activities or, because of the variety of individual systems, not necessarily compatible, every instance of weighing described in documents or implied by the presence of weights is of the same "measuremental type" - either to ascertain the weight of an object or to weigh out specific weights of a material. Ugarit therefore reflects the prevalent experience of the Near East just as could be expected from the mixed Near East elements of its population. The bulk of its trade was also with these same Near East cultures. The documents only occasionally mention other than overland trade and where references occur to ships and the sea[374] there is no justification for supposing other than transportation to Cyprus, further down the Syro-Palestinian coast or to Egypt. Contact with the Western Mediterranean was assured by and carried out by Minoan-Mycenaeans who, down to the break up of the administrative centres of the Greek bronze-age, controlled the sea to the West of Cyprus, and whose direct presence at Ugarit is clearly attested by archaeology.[375]

A substantial amount of Ugaritic (and early Canaanite) literature has survived,[376] its variety suggesting association not only with Mesopotamian myth but with certain Hebrew stories of the period of the patriarchs also, and even possibly with Minoan/Mycenaean legend.[377] This is a clear reflection of the cosmopolitan structure of the city itself; but the commercial life, that appears to have been such a central activity there, is not reproduced in the literature. Gnomic sayings attest the experience of merchants and their reliability as travelling companions,[378] but the bulk of

the texts are mythical or religious, and of interest for the general cultural background of the Canaanites rather than their everyday activities. As such they are particularly important to fill the later gap caused by the virtual absence of Phoenician literature as will be seen below.[379] The cult of the dead shows a belief in the afterlife to the extent of the deceased's feeling hunger and thirst, but there is no evidence of any detailed theological beliefs or any indication in particular of judgment of humans either pre- or post-mortem.[380]

Direct reference to weighing and to weights does occur, but only of gold and silver and in the most general terms. Thus Hayyin, the craftsman god, and Khasis make "a gorgeous dais weighing twice ten thousand (shekels)" out of molten gold and silver;[381] and later the repeated lines

> " the mountain shall bring thee much silver,
> the hills a treasure of gold "

are even more general.[382] Of the fair amount of metaphor in the literature it is worth contrasting the Canaanite phrase "to become like an empty cauldron"[383] with what would appear to have been the Mesopotamian equivalent for poverty: "to be reduced to 30 shekels".[384] The Canaanite is perhaps more literary, it is also more practical. The same could be said of a remarkable simile in the legend of Keret where the King weeps for the misfortunes of his house:

> " his tears do drop
> like shekels to the ground ".[385]

The term is remarkable where no coinage can yet be envisaged, and is eloquent testimony of the familiarity with weighing and dealing with weighed lumps of silver (the colour of tears).[386] Later in the same story he is negotiating for Hurriya's hand, and offers gold and silver in weights proportionate to that of the girl herself. Though the relative amounts are obscure in the text, it is clear that the matter was to be conducted by separate weighings of the girl and the metals.[387] It is fair to conclude that the literature bears out the above survey of Canaanite attitude to weighing as a means of evaluating precise weight: even though the extent to which commercial activity itself is reflected is perhaps disappointingly slight.[388]

Ugarit was destroyed around 1200 and never recovered.[389] The raiding sea-peoples had no desire to preserve the stability of the Near Eastern market, that depended on the free and secure prosperity of the Canaanite "ports of trade"[390] and the inland tribes were able to profit from the temporarily withdrawn control of the area by the larger Empires to carve out relatively strong positions for themselves.[391] As a result new factors emerge relevant to the continued commercial activity of the Canaanite cities that survived these troubled times, noticeably the coastal cities to the south of Ugarit which from this period onwards are usually called Phoenician from the name the Greeks gave them.[392] Pressure from inland forced these cities to adopt defensible positions on the coast, population problems (partly a natural increase, partly a result no doubt of restricted territory) would be eased by further expansion in this coastal area and ultimately overseas.[393] This in itself was a new area for Canaanites, who do not appear themselves to have ventured west while the Minoan-Mycenaean thalasocracy controlled the sea and was able to provide the Canaanite cities with what material they needed from this area by way of trade. With the collapse of this control, the Canaanites had now themselves to go and fetch these materials.[394]

The effect on Canaanite culture and administration of these new factors was probably considerable. From being largely static trading communities, that profited from their geographical position on the axis of East/West, North/South trade-routes in the Near East bronze age, they were now on the edge of their former world and were forced into a very much more active commercial role. On the one hand they became explorers, probing deep into western waters and even beyond the limits of Mycenaean-Minoan contacts. No longer treating with sophisticated Near East cultures, they faced here the problem of trading with peoples of very primitive levels of civilisation. On the other hand their home cities had to be organised to resist inland pressure, and the trade on which the cities depended protected by political administration. There is some evidence that the place of the Kings in the bronze-age society was now taken in some cities by a sort of mercantile aristocracy.[395] The cities themselves however remained as politically independent as before, and as competitive

as in the El Amarna period. Despite the obvious importance of commerce for those cities it is not, however, clear that trade rivalry formed a significant aspect of this competition.[396]

Phoenician commerce, for all its importance is nevertheless very poorly documented. The reasons which led to the adoption of Phoenician script in the Greek world, that it could easily be written on plane surfaces (and so on perishable materials as papyrus or wood), account also ironically for the virtually complete loss of both literature (which was possibly extensive)[397] and, more important for our purposes, of contemporary business documents. Enough survives in archaeological remains of cult practices and votary tablets to show that the Canaanite culture had persisted from the bronze age;[398] and the Ugarit cuneiform tablets can be used to illustrate the religious and mythological attitudes of the later period.[399] For trading practice however apart from about two pieces of direct Phoenician evidence inferences can only be made from the archaeological remains (which show extent but not type of trading),[400] or from the remarks of contemporaries in other cultures (esp. Greek and Hebrew). The relevance of Ugaritic practice must be considered with caution for the reasons already given of changed trade conditions in the early iron age.

There can however be little doubt that a large bulk of Phoenician trading continued on virtually unchanged lines. Ezekiel's description of Tyrian trade around the start of the sixth century BC clearly attests to the amount of overland trading with Near Eastern peoples;[401] and this can be supported by other Biblical references to commercial relations between the Hebrews of David and Solomon's day with Phoenicians, in particular Hiram of Tyre.[402] Although these do not specify weighed amounts of materials, or indeed silver payment, it would be reasonable to assume both continued (where applicable) on the lines of bronze-age trade contacts with the same areas as shown by the Ugarit evidence discussed above.[403] The extent of the use of silver in Babylon in particular increased, rather than decreased, in the iron age.[404] The Phoenician cities themselves also clearly retained the ability to weigh in silver; their tribute to Persia

was assessed in silver talents along with that of Palestine and Cyprus.[405] Moreover it would appear that their own weight systems (and probably standards also) continued in use, as they reappear in mainland coinage of the fifth century[406] and in the much later (and more isolated) sacrificial tariffs, of the third century BC, found at Marseilles and Carthage, which explicitly refer to shekel-weights of silver and weighed amounts of meat.[407]

If trade with the Near East and internal commerce continued virtually unchanged into the iron age, can the same be said of the new trade overseas with non Near-Eastern peoples, now for the first time brought within the Phoenician field? This aspect of their commerce is emphasised by Ezekiel[408] and I have already suggested the importance of the need for the Phoenicians to fill the gap created by the collapse of the Minoan-Mycenaean administration of Mediterranean trade in particular.[409] Whereas trade considered to this point, however, remained within an area that I have shown to be (generally) familiar with a particularly precise use of the balance (in connection with weights either official or individual), outside this area of Near Eastern trade (and Minoan-Mycenaean world can legitimately be considered to have been a part of it)[410] such practice would have been initially inapplicable.[411] Either the Phoenicians would have to educate the people with whom they traded in their own use of the balance, or they would modify this; on the other hand they might adopt alternative uses offered by their trading partners, or finally they might abandon any attempts at weighing and revert instead to simple barter. One aspect of this dilemma has already been encountered above in considering the thesis that Phoenician trade carried Phoenician weight standards to the Greek colonial cities of the West in pre-coinage times.[412] Apart from the special difficulties of this theory, it very much begs the question being here considered whether weighing played any part in Phoenician trade outside the Near Eastern area. Moreover not only must weighing have played a part in their trading, but it must, on this thesis, have been measuremental weighing, a type I have been concerned to show above that the Greeks did not use for trading; and it must have involved Phoenician weights. It is only on this model that the area in which a Phoenician type

weight system might be identified would be any indication of trade-routes. But the identification of the weight system is doubtful and the model itself anyway false.

We have as it happens two descriptions of Phoenician trading, outside the Near East area, with primitive African tribes; and of these both show that they made no attempt to teach the natives the use of the balance and weights that would have been the normal way in the Near East of handling the materials being traded - gold, and hides.[413] Both Herodotus' description of Carthaginians trading with Libyans beyond the pillars of Hercules[414] and the later account (in the mid fourth-century periplus Pseudo-Scylax) of Phoenician trade with Cerne Island on the West African coast[415] show simple forms of barter in operation. It is, however, a mistake to consider this primitive commercial practice as typical of all Phoenician trading,[416] for, as I have shown above, they retained a much more sophisticated practice in the Near East and within their own culture. The African civilisations of the above examples of the use of barter were well below the level of the Near Eastern from which the Phoenicians came and no doubt remained well below the eventual level of Greek commercial practice of the fourth century. There is some indication that at this later stage the Phoenicians were using sophisticated weighing techniques at least in thier trading with Greeks in that the writer of the Mechanics of the Aristotelian Corpus refers to the way in which the ἁλουργοπῶλαι, who may be Phoenicians, deceitfully weighted the beam of the balance.[417] It would appear possible to explain the variations in Phoenician commercial practice from their own, retained, Near-East type (measuremental) to the barter used with Africans, as dependent upon the experience of the peoples with whom they traded rather than as characteristic of the Phoenicians themselves.

Evidence of a certain flexibility can be seen in Canaanite commercial practice from the bronze-age period of Ugarit's activity where many weight systems have been shown to have been in operation. Similar flexibility appears later in Carthage's adoption of Greek weight systems to issue its late fifth-century coinage in silver.[418] Apart from barter, however, there is no clear indication that such flexibility was more than the

adaptation of elements of their weighing experience; in particular there is no evidence that the Phoenicians so fundamentally modified this as to operate the balance on as radically different a principle as is represented by what I have shown to have been the fundamental Greek attitude. Here of course the evidence presents a somewhat impossible barrier. Homeric and Herodotean references to Phoenicians' stealing women from various parts of Greece may represent typical Phoenician practice, but show the abuse of trading relations and in no sense the way trade was conducted.[419] On one of these occasions Herodotus distinguishes the trading from the women-snatching that followed it at Argos, but the phrase ἐξεμπολημενων ... παντωνconveys no indication of how this trading was conducted.[420]

In conclusion, the Phoenicians, and the wider group the Canaanites, appear to have a consistent attitude to weighing as a means of precise measurement, to weights as conforming to units of a specific system. From the bronze age to late third century BC there is no evidence of any deviation from this attitude. Though weighing played an important part in earlier trading within the Near East area where a similar attitude prevailed, it was apparently dropped entirely in favour of barter where this sophisticated operation of systems of weights did not apply. But this variation in trading practice does not amount to a variation in their attitude to weighing itself. Neither the Ugaritic evidence nor the Phoenician contains any reference to weighing or the balance outside the practical contexts discussed: it would appear for them to have been an entirely prosaic tool.[421]

1. (5) Hebrews

No survey of Near Eastern cultures would be complete that did not take into account the wide-ranging evidence of the Old Testament. Although there are serious problems in using this source as a historical document because of the chronology of its composition,[422] it is particularly important for this subject in that it combines in a literary document the several other fields of evidence - law code, theology, everyday life and official inter-state relations - from which independently the attitude of other Near Eastern peoples to weighing has been built. It is also a convenient source, as no other documentation survives of the attitude to weighing of the Hebrews in Palestine for the period of this survey which I set at from the mid thirteenth century to beyond the Greek conquest of the area under Alexander.[423] These limits are themselves virtually set by the Old Testament itself which contains very little historical fact of the patriarchal period, sets forth in some detail the history of the Jews from Exodus to Babylon, and which was for the most part written in its present form by the late fourth or third century BC.

Traces of the patriarchal period however can be found in the Old Testament; and in Genesis 13[1-4] Abram is shown as an itinerant merchant trading gold, silver and livestock from the north to the south of the Palestine area. When he purchased land he weighed out silver "current with the merchants" a phrase which probably relates to weight rather than quality though this is not entirely certain.[424] Certainly he will have used weights, as land could not be conceivably weighed, and these may have corresponded with one of the official systems of the period although the evidence of Ugarit would indicate there was no need for this.[425] At a period when Hebrew culture (where it did lay down any roots) was virtually indistinguishable from surrounding Canaanite[426] there is little reason to suppose commercial practice

varied and no point in this brief survey in attempting to pursue such open questions as the origins of the patriarchs themselves.[427]

It is only after the Exodus from Egypt and return to Palestine in the late thirteenth century of those tribes as had been in Egypt that Hebrew culture can be said to begin to differ from Canaanite, and even at this stage the material differences are slight.[428] The problems of carving out their own territory in a particularly turbulent area and the accompanying (effect rather than cause?) nationalistic religious outlook, created a strongly individualistic people with a centralised temple administration. The Hebrews are essentially a product of the iron age, contemporaries of the Phoenicians and Philistines who had at the outset a material advantage in that they were better established and more advanced culturally.[429] The vicissitudes of Hebrew fortunes in the succeeding centuries were considerable. From an Egyptian environment, in which they had lived for over 300 years, they escaped to enjoy a time of independence during which close ties were made on both diplomatic and commercial levels with the Phoenicians;[430] in the ninth century the country split and by the seventh century only the southern part remained to be subjected to the heavy tribute of Assyria. This was followed by Babylonian control in the sixth century and the removal of a greater part of the population to Babylon itself.[431] Their eventual return was only effected by the exchange of Babylonian for Persian rule and this continued, with direct effect on the Hebrews,[432] down to the time of Alexander.

Although the details are not important, the variety and extent of this contact with other Near Eastern peoples is of certain relevance to the commercial practice of the Hebrews and even more so to the vexed question of Old Testament metrology. As has been argued in general elsewhere, metrological analyses beg the more basic questions, of use and attitude to weighing, that I am attempting to consider in these surveys. This is no less true of the Hebrew, but in this case the evidence is more difficult to interpret and the modern literature most considerable.[433] A brief description of the matter is called for. The basic problem is probably that the Old Testament writers themselves were as assiduous as modern scholars in seeking to present a standard unity to the terms of measurement, particularly weight,

they had reason to mention. Certainly there is no reason to suppose a common, commercial weight as Scott.[434] Hultsch's approach[433] at least allows for Babylonian, Assyrian and Persian weights lying behind the Biblical ones, even though his identification of these is open to wild disputation. The Elephantine Jews clearly used Persian weights, and their specific reference to them may be no more than that they lie outside the Biblical literary tradition.[435] That Hezekiah's gold tribute in 2 Kings 18^{14} corresponds to the thirty-talent figure also recorded in Sennacherib's account need occasion no further comment than that the tradition of Kings was so reliable.[436] Preserved archaeological weights correspond exactly to no known, or inferred, standards.[437] In view of the chequered history of temple law reform in Israel there seems little reason a priori to suppose that the "sacred shekel" or "shekel of the sanctuary" has escaped the syncretistic tendency of the literary tradition any more than the simple shekel or talent.[438] Finally, the Hebrew of the Old Testament itself preserves no less a variety of weights than might be inferred from the historical administrators of Israel. Apart from multiples and fractions of shekels (and the problem of thirds of 20-gerah shekels is not commented upon by either Scott or Hultsch[439]) there is the unidentified q^{e}sîtâh[440] of Job 42^{11} Genesis 33^{19} Joshua 24^{32}; the minai of Ezekiel 45^{12} (60 shekels) and Ezra 2^{69} Nehemiah 7^{71-2} (probably 100 sigloi[441]), the darics or drachmae[442] of 1 Chronicles 29^{7} Ezra 8^{27} 2^{69} Nehemiah 7^{71-2} and the talents (Assyrian and other) constantly referred to in the temple accounts or tribute descriptions.[443]

Of weight systems, which might be thought less variable than individual weights,[444] there are only two Old Testament pieces of evidence. Exodus 38^{25-26} totals a bekah or half-shekel each from 603550 men as 100 talents and 1775 shekels, and this implies a talent of 3000 shekels. Ezekiel 45^{12} rules that the shekel be 20 gerahs[445] and the mina made up of 60 shekels.[446] A single weight system can without inconsistency be deduced from the simple addition of these two pieces of evidence and there is nothing to disprove the possibility of a 50-mina talent. Even the "Ugaritic" weight system is open to just this possibility as

noted above.[447] As temple context applies to both Exodus and Ezekiel traditions there is no question of alternative standards, or even of that hypothetical commercial standard already dismissed and for which there is no independent evidence.[448]

I shall not pursue this somewhat fruitless line of approach any further, but in common with the other surveys of this section propose to adopt an entirely different direction and consider the Hebrew attitude to weighing in general. To what extent were weights used, and weight systems thought important? Did all Hebrew experience of the balance place it in the same context of measuremental weighing that has been shown consistent for all Near Eastern cultures so far considered (with the doubtfully Near Eastern exception of the Hittites)? As pointed out above some conclusion to these questions must precede debate about possible standard weight systems in operation, but it is also important to note that the general attitude to weighing that I shall discuss need not rule out variations in the weight standards (if they existed) themselves. In what follows I shall use almost exclusively the Old Testament and pay particular attention to the literary and theological metaphor that this source so eloquently presents. First, however, the apparatus and the practical side of weighing must briefly be discussed.[449]

The Hebrew balance was the normal two-pan type. Mō'zĕn (S.3976) is the word used in most references to the balance[450] and is found only in dual form (compare the Akkadian zibānītu).[451] It is not clear whether this balance was necessarily hand-held or standed; although that in use at Elephantine would appear to have been the latter type, this may well have been simply the Egyptian scales being available to the colonists.[452] If it is fair to use the evidence of Megiddo, the scale pans were of bronze suspended by chains from a wooden beam.[453] I am doubtful about the identification of the later bone disks with tabs as scales despite the excavators' suggestions, as very similar articles have been found at Byblos but without holes in the supposed suspension tabs.[454] That weights existed and were made of stone is confirmed both by the Hebrew word 'eben (S.68), stone or weight (just as Akkadian), and archaeological

evidence. These weights could be owned by individuals (presumably merchants) who carried them in bags, and the practice was suffiently commonplace for the simple reference to the bag in this context as Proverbs 16[11] "all the weights of the bag are his work".[455] That weights occur here and in other such passages in the plural implies that these formed parts of a weight system,[456] although there is no reason to infer that this was constant from one bag to another. From the frequent references to "the shekel of the sanctuary" might also be deduced the existence of some physical weight kept there under the eye of the Levites;[457] but in this case only the "shekel" weight would appear to have been preserved, as there is no mention of "sacred" gerahs or minai etc. Finally under the monarchy there was a "weight (actual) of the King", against which Absalom's hair was weighed in 2 Samuel 14[26] and with which no doubt many of the weights of gold and silver booty were measured. Again this was only a unitary weight.[458] Weights and the 2-pan balance (dual) probably rule out the appearance of a steelyard in the later Old Testament books composed within the period when these instruments had been introduced by Rome.[459]

In almost all aspects of their everyday life, the balance would appear to have played a familiar part. The idea of weighing and the relevance of weights accompanies every instance that can be cited, and throughout the Old Testament reference to any aspect (practical, that is, for the moment) of weighing consistently attests the weighing of specific amounts. This is true even of such unspecific passages as Ezekiel 5[1ff.]:

> "And thou, son of man, ...take thee a barber's razor, and cause it to pass upon thine head and upon thine beard: then take thee balances to weigh and divide the hair."

This division is by 3 as the subsequent symbolical destruction of the 3 third parts (by fire, sword and wind) shows, and such division could only be done by first measuring the total weight and then weighing out separately what has been calculated as thirds of this total weight.[460]

Accounting. Certainly the most frequent occurrence of weights and weighing is in the temple administration and possibly

this application was fundamental from which others derived:-[461]

Exodus 38^{24-29} (tabernacle metals); Numbers 7^{13} and passim; 2 Kings 12^{10} (money weighed[462]); 1 Chronicles 28^{14} and passim; Ezra 8^{25-34}; Solomon's omission to weigh the temple brass was not forgotten 1 Kings 7^{47} 2 Kings 25^{16} 2 Chronicles 4^{18} Jeremiah 52^{20}; so also David 1 Chronicles 22^{3} and 14; 2 Chronicles 3^{9} (gold nails); Numbers 31^{52} (war booty from which offering made).

other straightforward examples of accounting are:-

Judges 8^{26} (gold); 1 Kings 10^{14} = 2 Chronicles 9^{13} (Solomon's gold revenue); Genesis 43^{21} (merchants' money at the top of their sacks found to be full weight).

Derived from this is the frequent practice of describing objects of metal by weight as if inventoried; and no doubt many of these objects were weighed for inventory purposes as temple offerings:-

Genesis 24^{22} (gold jewellery); Joshua 7^{21} (lumps of gold and silver); 1 Samuel $17^{5, 7}$ (Goliath's coat and spear); 2 Samuel 12^{30} = 1 Chronicles 20^{2} (the gold crown of Rabbah); 2 Samuel 21^{16} (spear).[463]

Comparable also is the simple measurement of the weight of hair[464] in 2 Samuel 14^{26} (Absalom) and implied in Ezekiel 5^{1}; and the "dust of Jacob" in Numbers 23^{10}[465].

The weighing out of materials comprises the other side of the same activity: instead of an unknown weight compared to known weights (accounting), known weights (specific) are made up out of required commodities. Weighing out of such specific quantities in general contexts is shown by:-

Exodus $30^{23-4, 34}$ (ingredients for temple perfume); Leviticus 26^{26} (bread); Isaiah 46^{6} (gold and silver for goldsmith)[466]; Ezekiel $4^{10, 16}$ (meat by weight as water by measure); Leviticus $27^{3ff.}$ (vows of 50, 30, 20, 10, 5, 3, 15, 10 shekels of silver).

Included in the above list are several specifications of temple law. This consisted of a series of directives (prohibitions and commandments) with little distinction between ritual, moral and civil offences. All were equally threatened with the wrath of Yahweh. In this general lack of specified penalties the Hebrew Law Code differs greatly from the other Near Eastern

codes discussed above. Nevertheless certain penalties are prescribed on the more usual model and like the model they are expressed in kind[467] or, rarely, in silver. Thus:-

Exodus 21^{32} fine of 30 silver shekels where an ox injures a person.[468] Elsewhere no precise figure is given (cf. 21^{35} or 21^{22} where the matter is left to the judges).

Numbers 3^{47} = 18^{16} redemption money 5 silver shekels per person.

Deuteronomy 22^{29} sexual offence liable to 50 silver shekel fine and in 22^{19} a fine of 100 shekels is laid down for casting aspersions wrongfully on the virginity of one's wife.

Tribute and taxes are an obvious instance of this type of weighing of specific measured weights:-

Exodus 38^{25-6} ($\frac{1}{2}$-shekel temple tax); Nehemiah 10^{32} ($\frac{1}{3}$-shekel temple tax); 2 Kings 15^{20} (50 shekels from each person for Assyrian tribute of 2 Kings 18^{14}, although this total figure was of course laid down by Sennacherib).[469]

More important, however, as reaching the widest section of the population, is the part played by weighing in commerce. Although barter is attested in the Old Testament, and in the absence of token media of exchange it would be surprising if this were not so,[470] the weighing of measured amounts (especially of silver) would appear to have been the normal experience of the majority of Hebrews, once allowance is made for the temple bias of the Old Testament source and the peculiar trading ventures of such Kings as Solomon (1 Kings 10^{26-9}).

Job $28^{12ff.}$ is a good indication of how readily a fourth-century Hebrew might turn to weighing in the context of purchasing: although in vain "man knoweth not the price thereof (viz. wisdom) ...it cannot be gotten for gold, neither shall silver be weighed for the price thereof". Gold is in fact very rarely used for purchases, and apart from Isaiah 46^{6}, which is dubious,[471] I know only of the 600 gold shekels paid by David for one of his altar plots 1 Chronicles 21^{25}. Otherwise the metal is only weighed for accounting purposes or the payment of tribute, 2 Kings 18^{14}.

Of silver prices and payments examples are more readily found:-

Purchase of land: Genesis 23^{16} (Abraham weighs out in balances 400 shekels).

2 Samuel 24^{24} (David pays 50 shekels for threshing floor and oxen on another altar site).

Jeremiah 32^{9-10} (Jeremiah buys a field for 17 shekels: "and weighed him the money in the balances").

Hire: Judges 17^{10} (hire of a Levite at 10 shekels per annum all found).

Isaiah 46^{6} "and weigh silver in the balance and hire a goldsmith".[471]

Zechariah 11^{12} "So they weighed for my price 30 pieces of silver".[472]

Purchase: Genesis 37^{28} (Joseph sold for 20 pieces of silver).

1 Kings 10^{29} = 2 Chronicles 1^{17} (chariots for 600 shekels, horses for 150 shekels; royal monopoly?).

2 Kings 6^{25} (donkey's head 80 shekels: "lowst beans" NEB for 5 shekels: siege conditions Samaria).

2 Kings $7^{1, 16, 28}$ (measure of flour and 2 measures barley each 1 shekel after this siege).

Hosea 3^{2} (15 shekels silver in part-payment, the rest in barley, for a woman).

On at least one occasion a price in silver is specified in the law code:

Leviticus 27^{16} "an homer of barley seed shall be valued at 50 shekels of silver."

Comparable to the stampede at the city gates of Samaria (2 Kings 7^{17-20}) is finally the general picture of the part played by weighing in commerce as conveyed by Amos 8^{5-6}, describing dishonest and greedy merchants:-

"When will the new moon be gone that we may sell corn? and the sabbath that we may set forth wheat; making the ephah small, and the shekel great and falsifying the balances of deceit? That we may buy the poor for silver, and the needy for a pair of shoes; yea, and sell the refuse of the wheat?"

Apart from misweighing (on which see further below), these merchants practised a double deceit in selling their wheat by short measure and weighing the silver offered in paymant for this by a weight above the standard expected.[473] Amos is generally thought composed in the near-contemporary eighth century BC,[474] and this passage therefore clear evidence of wide extent of

experience with weighing by most ordinary levels of Hebrew society. It, moreover, conforms to the picture presented by all the other evidence so far cited that this weighing was consistently and exclusively of the measuremental type. Like the closely similar Code of Hammurabi §108, however, the implications about weight standards are not absolutely clear.

From the dishonest practices of the merchants of Amos' day it is natural to move on now to consider the quite remarkable extent to which Hebrew literature reveals anxiety about such deceits. It is additional and significant, evidence of their general attitude to weighing and parallels closely the Mesopotamian evidence of similar concern about weights and measures. To the Amos passage can be added Hosea's description of Ephraim:-

"He is a merchant (lit. Canaanite) the balances of deceit are in his hand: he loveth to oppress (lit. defraud)."
Hosea 12^{7}.

But the majority of passages, as indirectly this last one, reflect the concern of Yahweh for just weighing:-

Leviticus 19^{35-6} "Ye shall do no unrighteousness in judgment, in meteyard, in weight or in measure. Just balances, just weights, a just hin shall ye have: I am the Lord your god."

Deuteronomy 25^{13-16} "Thou shalt not have in thy bag divers weights, a great and a small; Thou shalt not have in thine house divers measures, a great and a small. But thou shalt have a perfect and just weight, a perfect and just measure shalt thou have: that thy days may be lengthened in the land which the Lord thy god giveth thee. For all that do such things, and all that do unrighteously, are an abomination unto the Lord thy God."

Proverbs 11^{1} "A false balance is abomination to the Lord; but a just weight is his delight."

" 20^{10} "Divers weights and divers measures, both of them are alike abominations to the Lord."

Ezekiel 45[10-12] "Ye shall have just balances ...and the shekel shall be twenty gerahs: twenty shekels, five and twenty shekels, fifteen shekels shall be your maneh."[475]

Micah 6[11] "(the Lord's voice crieth...) Shall I count them pure with the wicked balances and with the bag of deceitful weights?"

In all these passages weight is represented by the Hebrew word stone (ʾeben S.68) and balance by the usual mô'zên and there can be no doubt that the actual practice of weighing is meant.[476] Problems arise, however, in Proverbs 16[11] – both in the general interpretation and in the precise meaning of what the Authorized Version translates as "a just weight and balance are the Lord's: all the weights of the bag are his work", the New English Bible as "scales (or pointer (sic)) and balances (prob.rdg.; Hebrew balances of justice) are the Lord's concern; all the weights in the bag are his business." The general context is the functions of terrestrial kings, and it has been suggested that the presence of Yahweh is here a scribal error on the basis of Proverbs 11[1] for nothing more exalted than such a terrestrial king as in vv. 10-15.[477] If this is so we have here the only evidence that there was any official concern for Hebrew weights and measures outside the temple; and as Yahweh's interest is stressed elsewhere to the exclusion of civil enforcement, there can be reasonable doubt over the emendation proposed for Proverbs 16[11]. That it should then be so awkward in the context of the functions of kings is no less a difficulty than the syntax itself, whereby the adjectival "of justice" is applied only to peleç and not to mô'zên. Editors have suggested ignoring the adjectival completely[478]; but the alternative, that peleç is on a different level, referring to mental rather than physical weighing,[479] does not really resolve the problem of this, rather than physical weighing, being described as just, where both are clearly meant. In view of these difficulties I should prefer to leave the passage on one side and certainly am not tempted to build any variation on the otherwise established picture on its slender base.

On a much more straightforward level is the normal man's fear of being defrauded as expressed by Job:-

Job 31[6] "Let me be weighed in an even balance, that God may know mine integrity!"

The word "even" here is precisely that used elsewhere for "just" balances, but its inclusion by the writer is not material to his main point: the wish to be considered and evaluated as opposed to being entirely ignored,[430] and as such is quite a significant indication of the suspicion with which weighing was attended.

The interest of Yahweh in these matters is precisely that assumed by the Mesopotamians for their god Šamaš, as too the elevation to the level of morality of correct weighing and non-fraudulent weights and measures.[431] This implies as much the absence of general weight standards as the absence of administrative control of them. Though the Levites are mentioned as being in charge of the temple weights and measures and although the greater part of Old Testament weighing is concerned with this temple activity, the passages under consideration referring to fraudulant weighing seem to emphasise non-temple activity and in particular the general practice of everyday buying and selling. Deuteronomy 25[13-16] explicitly mentions the weights of the individual's bag and the measures kept in his house. Amos portrays the operations of somewhat irreligious merchants, and such was Ephraim also. If the problematic Proverbs 16[11] can be avoided, the absence of official control in this considerable use of balances and weights amply explains why Yahweh should be so optimistically accredited with their careful supervision.

Less clear, however, is what this morality was supposed to protect. The above passages show two, or possibly three, sorts of offences connected with weighing: a more general offence with the balance, and those involving false or variant weights. The problems in elucidating these are precisely those already encountered in discussion of the Mesopotamian evidence and I shall not repeat my arguments here. As regards the balance itself, nothing other than simple immoral use is indicated by the Old Testament descriptions,[432] although this misuse would appear to be separable from fraudulent weights. One can only speculate on what could be involved - misreading of the level or weighted balance beam?[433] The use of weights however is by no means ruled out by the possibility of independent balance frauds.

More important perhaps are the offences with weights themselves, as they raise the question of absolute weight standards outside the temple administration. Again there is little help from the terms in which these offences are described in the Old Testament Hebrew. Deuteronomy 25^{13} "divers weights, a great and a small" would however appear to condemn precisely that same inconsistency in the use of the weights that I concluded above to have been the Mesopotamian legislator principal concern.[484] At the same time Deuteronomy goes on to insist on a "perfect and just weight", using the same word[485] lit. "completed" as in Proverbs 11^{1}. The variation from specific shekel and ephah of Amos 8^{5-6} can be added to these two passages as evidence, in a general commercial context, of the idea of a specific weight that is being inaccurately reproduced.[486]

There can be little justification in doubting this inference that absolute weight standards could be applied by Hebrews to general commerce.[487] That in the Old Testament so little is made of the distinction I have drawn between the two types of offences with weights (inconsistency and inaccuracy) need be no more than because, from the point of view of the moralist, inconsistency and inaccuracy are immaterial to the basic crime, the deceit involved in both.[488] There is however no reason to suppose that the absolute weight standard of these general contexts was other than that of the temple itself.[489] Certainly no additional system is laid down and the stipulation of Ezekiel 45^{10-12} does not relate simply to the temple, whereas mention of the "shekel of the sanctuary" elsewhere can be seen as simple references to the one (and only)[490] place where an accurate example of the weight could be found: i.e. what for practical purposes was the weight standard. The importance of the use of this standard in general commerce depends entirely on the enforcement of it. Left to Yahweh and the youthful Ephraim[491] it is not difficult to explain how extant weights appear to fit no single system. Moreover, given the awareness of the lack of supervision and unreliability of weights that the Hebrews seem to have had,[492] it is possible to infer that for practical purposes consistency in use, rather than accurate adherence to standards, was what most Hebrews

expected of weights. This situation can be seen reflected in the somewhat contradictory expression of Deuteronomy 25^{13-16}: what mattered most was that "divers weights and divers measures" were not used to merchants' advantage.

This considerable suspicion of the use of balances and weights does not in the Old Testament appear to have been directed explicitly at any one group of individuals such as at the merchant class in Mesopotamia.[493] Although several merchants are associated with actual misuse, the criticism itself is noticeably not levelled at the great trading cities of Tyre and Sidon whose success rather then methods excited Yahweh's anger.[494] The Hebrew "merchant" was essentially itinerant[495] and therefore only a part of those whom the lawgiver of Deuteronomy 25^{13-16} ("thou shalt not have in thine house divers measures") urged to use honest weights and measures. Such appeals/laws are as general in application as the mistrust felt by individuals as Job or the explicit wariness of Yahweh. However, the circumstances in which deceit might occur in weighing are surely only those in which some gain is to be derived from the deception i.e. in commercial transactions rather than accounting or simple measuring. Thus, while not all Hebrews were professional merchants this evidence would indicate that most nevertheless were acquainted with the dangers, and so a fortiori at least with the practice of weighing in the context of buying and selling which appears to have been conducted normally by means of weighed amounts of silver.

A brief resumé of the range of materials weighed by the Hebrews of the Old Testament might be expected to throw further light on the extent of the practice of weighing, though it will be seen that the source is largely responsible for the unbalanced picture that results... The main group is of metals.

Silver most commonly and passim[496]
weighed in shekels (1100 Judges 17^{2}; 1000 2 Samuel 18^{12})
minai (2000 Ezra 2^{69}; Nehemiah 7^{71-2})
talents (2 Kings 18^{14}...);
a composite figure 100 talents 1775 shekels occurs only at Exodus 38^{25}.

Gold while less frequent is still common,
weighed in shekels (as many as 700 in Judges 8^{26})
minai (1 Kings 10^{17})
talents (2 Kings 18^{14}; and composite 29 talents 730 shekels at Exodus 38^{24})
darics (1 Chronicles 29^{7} 8^{27} in thousands)
drachmae (Ezra 2^{69}; Nehemiah 7^{71-2}, again in thousands).

Bronze (Authorized Version "brass") usually only weighed when in large amounts and the omission of its weighing by Solomon has been noted (1 Kings 7^{47} etc.);[497]
weighed in shekels (5000 1 Samuel 17^{5} 300 2 Samuel 21^{16})
talents (18,000 1 Chronicles 29^{7});
with composite figure 70 talents 2400 shekels at Exodus 38^{29}.

Iron again mainly large amounts, or not weighed at all as 1 Chronicles 22^{14};
expressed in shekels (600 1 Samuel 17^{7}),
talents (100,000 1 Chronicles 29^{7}).

Lead is only doubtfully weighed, although with tin it is cited as an alloy in Ezekiel 22^{18}, on the "talent of lead" in Zechariah 5^{7} see above[498].

Apart from these metals, actual weighing is rare:

Ingredients for temple oil: Exodus 30^{23-4} (myrrh 500 shekels; cinnamon 250 shekels; aromatic cane 250 shekels; cassia 500 shekels).

Hair: ritual Ezekiel $5^{1ff.}$ (no weight specified); Absalom 2 Samuel 14^{26} (200 shekels).[499]

Bread: Leviticus 26^{26} but this is warning of rationing necessary under famine conditions.

Meat: Ezekiel $4^{10, 16}$ temple prescription for all to eat 20 shekels per day.

With the exception of the weighing of silver in general commerce, it is only this last reference to meat weights that, despite its occurrence in temple law, necessarily involves the average Hebrew in actual weighing. The temple taxes, and state tribute would be managed by specially appointed agents as too the administration of the law courts and even Solomon's trading ventures.[500] For the

greater part of the occasions where weighing is implied in the Old Testament there is no indication that the general public was involved.

Nevertheless, drawing together the various arguments so far mounted, it is possible to get behind the temple orientation of the Old Testament and see a quite general awareness and use of weighing: especially in the field of commerce but also in the home (with meat weighed and accurate measures kept).[501] Despite the relatively few descriptions of commercial transactions it is noticeable that the buyer is on occasion actually described as weighing out silver.[502] Elisha's prophecy of flour and barley sold for shekels in the gate of Samaria was surely a vision of return to normality,[503] and Amos' merchants exhibit no indications of abnormality.[504] Similarly one must accept Job's readiness to <u>weigh out</u> silver when he was considering the possibility of buying wisdom.[505]

The infrequency of any indication of barter as an alternative to the widespread use of silver in commerce has already been commented upon and would support this same use. Nevertheless it poses the problem of availability of the precious metals themselves that had to be imported.[506] It is not possible to solve this difficulty by suggesting that alternative means of payment existed, as the Hebrew evidence consists primarily of the use of weighing rather than simply the stipulation of weights in law as for Mesopotamia and the Hittites where these alternatives might have existed.[507] Moreover, there is ample Old Testament evidence that gold and silver did abound in Israel from the early monarchy when Solomon "made silver to be in Jerusalem as stones".[508] Its common use is neatly indicated by Saul's servant[509] carrying ¼-shekel silver as loose change in 1 <u>Samuel</u> 9[8]. While it may well be the case that the incidence of barter was much higher than the Old Testament indicates, it is nevertheless clear that the emphasis in that source on account-weighing is a distortion of a very widespread use of weighing in general commerce, and can best be explained as a reflection of the interests and status of the religious writers of that temple history themselves.

A precisely similar type of weighing is however involved in both accounting and this general Hebrew commercial practice, namely the weighing out of specific amounts or what I have termed measuremental weighing. In all cases theoretical weights are used to count these amounts, and in this connection it is interesting to note that the Hebrew verbs for weighing most commonly reflect the words for the specific amounts: shekel and mina. Thus the most usual verb for weighing shâqal (S. 8254) is the same root as shekel (S. 8255) and mishqâl (S. 4948), or "weight" in passages where this is numerically estimated.[510] Shâqal similarly relates to numerically-estimated weight, as in Numbers 7^{85} "all the silver vessels weighed two thousand and four hundred shekels, after the shekel of the sanctuary";[511] but it can occur absolutely, as Job 6^{2} "on that my grief were thoroughly weighed" where the translation "thoroughly weighed" could equally be rendered "measured in a balance".[512] Less common is the verb mânâh (S. 4487), related to mâneh or mina (S.4488), cf. Numbers 23^{10} "Who can count the dust of Jacob". This must refer to weighing as in the more specific passage 2 Kings 12^{10} "The King's scribe and the high priest came up, and they put up in bags, and told the money that was found in the house of the Lord". The last passage continues (v. 11) "They gave the money (lit. silver) being told into the hands of them that did the work", and the verb here is tâkan (S. 8505) which recurs in several passages, of more metaphorical nature, yet to be discussed: Proverbs 16^{2}; 1 Samuel 2^{3}, and is of the same root as t^{e}qal (Chald. S. 8625 = 8254 Heb) of Daniel 5^{27} "TEKEL: thou art weighed in the balances and art found wanting." In this case the word probably refers to the idea of levelling involved in all measuremental weighing, which accounts for the somewhat contradictory Authorized Version translation of Job 28^{25} "he weigheth the waters by measure".[513] Even without these linguistic pointers, however, the explicit mention of specific weights, the frequent references to actual weights (lit. "stones"), and the strong suspicions associated with the misuse of these weights in weighing, all imply that the balance is being used to correllate a known against an unknown, and even the unspecified deceitful use of the balance probably implies as much in that the levelness

of a balance beam plays such an important part in measuremental weighing.

These conclusions reached for the practice of weighing can be supported by the literary metaphor of the Old Testament and to a certain extent by Hebrew religious thinking.[514] The correllation between Hebrew literature and practice is particularly interesting on account of the richness and variety of the former which affords the closest parallel in the Near Eastern evidence to the largely literary Greek evidence for weighing on which the greater part of this survey as a whole has necessarily been based.[515] Moreover there is an aspect of Hebrew theology, namely the interventionist judgments of Yahweh, which can be usefully contrasted to the Greek equivalent (Zeus' scales) to illustrate the fundamental difference that can be inferred to have existed in the attitude to the balance held by these two cultures. In particular, it will be seen that though the balance and weighing do have a place in Hebrew literary metaphor, it is by no means as versatile or extensive an image as in the Greek.

The place of the balance in Hebrew theology is in the judgment of Yahweh upon individuals or nations. Its most explicit expression is in the late second-century BC vision of Daniel:[516]

"MENE - god hath numbered thy kingdom and finished it
TEKEL - thou art weighed in the balances and found wanting"
Daniel 5^{27}.

Probably two centuries earlier it occurred to Job that his deserts should be registered on a balance for Yahweh to see them:[517]

"Let me be weighed in an even balance
That God may know mine integrity." Job 31^{6}.

and the undateable Proverbs 16^{2} reflects a similar thought:

"All the ways of a man are clean in his own eyes,
But the Lord weigheth the spirits."[518]

In all these passages the weighing involved is a sort of measuring. The Hebrew verbs used, respectively t^{o}qal, shâqal and tâkan are all related to the unit weight shekel and as argued above the actual words indicate weighing to discover, and to measure, weight. The point of all these passages is the evaluation of what is weighed, and it is important to note that this does not involve comparison

between contending forces, be they good and bad or simply Hector and Achilles.[519] Although Daniel's expression implies that the nations to be destroyed weighed less than a required standard, it does not mean they were not weighed accurately but that their evaluated weight was found to be insufficient (when God came to decide upon it) to ensure their survival. This idea of a standard is however interesting simply because it is a standard of weight rather than truth (as Egypt) or, in Greek practice, competition; but it is also relatively late and cannot be understood in Job's case or, despite the rendering of the New English Bible,[520] be assumed for Proverbs 16^2. These two passages in fact indicate a further point of contrast with the Greek view of divine judgment that is to a certain extent obscured by Daniel. Though the Hebrew Yahweh might use the balance in order to evaluate, he had still then to decide and act. In the Greek picture the scales and weighing depict judgment and execution at one and the same time - Zeus is a singularly impotent bystander.[521]

The practical difficulty of evaluating good and bad in a single weighing of an individual would have perplexed a Greek and raises a question of whether the Hebrew Yahweh was actually supposed to reach his decisions in this way at all. In none of the passages already cited is any indication given that Yahweh necessarily or even normally resorted to weighing himself. Compared to the innumerable occasions in the Old Testament where he does reach decisions and destroys individuals or nations, his use of the balance is remarkably restricted for a start. It is only one of several ways explored by Job for his case to be considered.[522] Moreover a consideration of the motives and decisions of Yahweh, which display a remarkable range of moralities let alone reasons,[523] would suggest that the idea of a carefully measured assessment by as precise and impersonal a means as a balance was a late development. It is more likely that the balance was the product of the prophets' imaginations than established theology at the best of times, and its use in Job's case comes closer to criticism of the methods Yahweh was employing than application of a general rule. Moreover, other metaphors existed that might correspond to the predicament of Daniel's doom - noteably

the book of the living from which people might be blotted[524] - and the importance of the balance, exaggerated for the purposes of this survey and by the subsequent development of Christian eschatological symbolism,[525] is best minimised.

In the field of literary metaphor, however, the ground is a little firmer. It will be clearer if passages are arranged according to the metaphor involved, and as the above three passages all represent weighing to measure or evaluate, this forms a convenient starting point.

On a divine level, measuring individual morality Job 31^6 Proverbs 16^2, or nations Daniel 5^{27}. There is also the possible measuring of actions in 1 Samuel 2^3:

"and by him actions are weighed".[526]

On a less exalted level is the measuring of Job's grief and calamity: Job 6^{2-3} "Oh that my grief were thoroughly weighed, and my calamity laid in the balances together! For now it would be heavier than the sand of the sea."[527]

(I shall leave Psalm 62^9 to later although it properly would come here.) Again the verb used in Job 6^2 is shâqal as in 31^6, implying measurement in shekels. The picture is of the grief and calamity measured together on a balance, only subsequently is their weight compared to that of the sand. No direct comparison is envisaged any more than in Proverbs 27^3

"A stone is heavy and the sand is weighty but a fool's wrath is heavier than them both"[528]

where the metaphorical sense of heavy, as burdensome or troublesome, is in relation to experiences outside the context of weighing, and no measuring or indeed weighing is involved.

Although I have expressed some doubts over the New English Bible rendering of 1 Samuel 2^3 "fixes a standard",[526] the metaphor according to this interpretation requires a slight extension of this first category to include measuring out weighed amounts. This is probably also the correct interpretation of the description of Yahweh as a god with total knowledge of the universe in Isaiah 40^{12}

"Who hath measured the waters in the hollow of his hand, and meted out heaven with the span, and comprehended the dust of the earth in a measure, and weighed (again shâqal however)

the mountains in scales and the hills in a balance?"

However the occurrence here of the measuremental verb shâqal might suggest the alternative understanding of this passage as derived from the practice of accounting. To this category of metaphors can be assigned two further passages -

"Behold the nations are as a drop of a bucket, and are counted as the small dust of the balance" Isaiah 40^{15} (529)

and the, possibly derivatory,

"Because the whole world before thee is as a grain in a balance". Wisdom of Solomon 11^{22} (530)

All these metaphors reflect the measuremental use of the balance in one way or another and there is to my knowledge only one passage in the Old Testament that might be suppposed to make use of the image of weighing without this metrological intent. This is Psalm 62^{9} where I shall cite the New English Bible rendering [531]

"In very truth men are a puff of wind, all men are faithless; put them in the balance and they can only rise, all of them lighter than wind."

Here is clearly an uneven scale being used to depict lightness without any measurement being involved. It will, however, be immediately apparent that in fact even this image is drawn from the practice of measuremental weighing, as it is a denial of the possibility of weight measurement. "Rise" here, Revised Version "go up", is opposed to the position of level balance from which weight might be calculated by reading the contents of the other pan; it is not opposed to the Greek alternative of "going down". [532] As above no comparison (direct) is involved.

In conclusion it is fair to say that there is no real departure from what I have termed measuremental weighing in the metaphor of Old Testament literature. The Greek metaphors of fortune, derived from the physical activity of comparative weighing, and reflecting the sinking of one pan against the rising of the other, have no Old Testament parallels. Hebrews described their national fortunes as progressing, or regressing, linearly with the promised fulfilment of the Covenant as the ultimate goal. Backslidings, set-backs, the sins of fathers, or lack of divine favour affected

their position along this single-minded road: but the chosen race had no competitor whose fortunes mirrored their own. More significant perhaps is the lack of metaphor taken from the image of the weighing machine: only Psalm 62^{9} reflects the rise and fall of pans and even there measuremental weighing is in fact the standard with which comparison is being made. Equally, comparisons of weight have been shown to be solidly based in the context of measuremental weighing, and the metaphor of variable weight where the two are compared (as Daniel 5^{27} Job 6^{2-3}) set in the abstract comparison of weight rather than the uneveness of two pans of a single balance.[533]

That the Greeks used the balance metaphor in this way has been argued to reflect their usual experience of the practical operation of the instrument when weighing, and the Hebrew abstinence from similar metaphors can equally be explained on the grounds that all their weighing was designed to balance the beam as level as possible. They would then not have thought it at all significant that one pan's rising was necessarily connected to the other's sinking before such equilibrium was attained. Where the Greeks saw an intimate relation between light and heavy and up and down the Hebrews saw none, or at least not a relationship that they thought reflected in their weighing.[534] Entirely consistent with this is the fact that the only type of weighing indicated both by practice or metaphor by the Old Testament is the measuremental: such aspects of this as are picked out by metaphor are the preciseness of weighing,[535] the lower limit of the sensitivity of a balance[536] and the importance of avoiding the use of fraudulent scales and weights.[537] Not one of these aspects however can be convincingly illustrated from the evidence of Greek literature.

Additional Note on Fifth-Century Elephantine.

As already indicated above[538] the Jewish mercenary colony of Elephantine is not easily included in any one of the main cultures discussed separately in this survey. As Jews they appear to reflect only the pre-exilic religious outlook, moreover they had long lived alongside and on equal terms with the native Egyptians by the fifth century, whence date the greater part of the papyrus evidence.[539] The documents, however, are themselves written in the Aramaic of later Mesopotamian administration and to a large extent directly reflect the Persian administration of Egypt.[540] Rather than attempt the improbable task of sorting out cultural elements in this amalgam, it would appear best to set down here briefly the quite compact picture presented by this source. While noting the variety of elements in it, at face value it is at least an accurate and direct indication of Persian rule in fifth-century Egypt.[541]

Cowley on internal grounds has worked out the weight system in operation. 1 mina = 6 kerashin (karash an apparently Persian word found on a trilingual weight in the British Museum); 1 karash = 10 shekels; ¼ shekel being denoted as R (or ?D) and equalling alternatively 10 hallurin.[542] Although talents and minai occur, the sums involved are usually expressed in shekels and kerashin, with preference shown for the latter where possible.[543] Expressed in this way are penalties in agreements, including marriage contracts, contracts for loans, and contributions to temple funds. Silver is on all occasions meant, and its purity is usually specified either as an alloy of 5%[544] or as "pure silver" though the former is more usual.[545] The karash does not occur in the Old Testament, and in fact that Persian weight systems are in operation is quite explicitly indicated on a number of occasions: the most usual formula being as "20 kerashin royal weight at the rate of 2R to the ten" (a. 465 BC conveyance: Cowley no.6 14-15). In 26 21 "Persian weight" is specified, and here probably to distinguish the Egyptian weight that is now lost from the text of 26 17. The only other indication of variant weight standard

is "the weight of Ptah" in 11^{2}, which Cowley explains as reflecting the temporary revolt of Egypt from Persia around the time, 460-450, to which this document belongs.

Apart from the weighing of silver for penalties, it is also given in valuations (at least in Cowley's translation): most noticeably the inventory of Mibtahiah's dowry in no. 15. There furniture, wool, shawls, bronze mirrors, trays, cups and bowls are all listed with value in kerashin and shekels of standard 2R to 10 royal weight. Compare also the more fragmentary and less valuable dowry in no. 36 . This idea of expressing value in silver occurs in the semi-literary expression for high value "worth as much as a thousand talents" (used of burnt sacrifices in 30^{28} 31^{27} and possibly to be restored also in 50^{9}). There would appear, however, to have been no necessary use of silver for purchases (thus the claimant of 44^{8-10} "he did not give me either money (lit. silver) or value in exchange for the half of it (viz. she-ass in dispute)"), and on one occasion at least a barley fine is specified (probably mid fifth-century, no. 45^{8}). In 13^{6} a house is given in return for goods to the value of 5K.

Scales are only directly referred to on one occasion where Mibtahiah is required to return to the scales in order to weigh out and pay back precisely what she had received as her dowry (15^{23-4}).[546] Apart from silver, weights are given or weighing of implied, of arsenic and sulphur, for sails and awning of ships (by Persian weight), and wood (by Egyptian weight) - all in no. 26, official specifications for a boat. The last is the largest figure mentioned: 1 talent 10 minai.[547] Gold possibly is mentioned in the fragmentary 39 but no weight indicated.

The general impression given by these documents however is that weighing was essentially restricted to measurement of silver and that even this was, for practical purposes, avoided, with price or penalty paid in more practical goods and these assessed or valued only in terms of silver. To a large extent this confirms the suspicions expressed generally in the above surveys as to the direct implications of silver weights occurring in law-code or other documentary evidence: and in addition it is to be noted that the Elephantine papyri are as a group later in date than most of the other evidence discussed here.

1. (6) Bronze-Age Greece

In this section will be considered together the various cultures that flourished during the Bronze Age in the area that later was classical Greece. The grouping of Minoan and Cypriot with Helladic and later Mycenaean is admittedly superficial, but is quite simply justified by the lack of any evidence to distinguish them as regards the evidence at present available of balances, weights, and weighing. Where the possibility of any such distinction arises, it will however be indicated. I shall begin with the clearest.

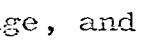
The most frequent context for Later Helladic (Mycenaean) balances is in tombs.[548] In many cases, and most noteably the third shaft grave at Mycenae, the balances are obviously too flimsy for actual use. They were equally clearly considered an important element of tomb content, and in the case noted were made of gold. A reflection of eschatological beliefs seems certain, but the question of what these beliefs were remains open. The Mycenae scales bore representations of butterflies; these may be simply decorative, or alternatively, as many scholars have been eager to point out, they may symbolise "souls". The Greek word ψυχή was applied to the insect by Aristotle, and Evans thought of dead-looking chrysalises and the implication of reincarnation: the same idea may however have occurred to Aristotle, and the Mycenaean belief in reincarnation is clearly not proven by the fact that the only other parallel has been found on the so-called "ring of Nestor" that most scholars believe to be a forgery.[549] Nevertheless the presence of balances in Mycenaean tombs remains a fact, and further remains a point of contrast with other bronze-age cultures of the Greek area. Schlieman rightly doubted the possibility of comparison with Egypt;[550] nor does Hittite ritual seem to provide a very much closer parallel.[551] The problem is probably insoluble in the lack of any literary evidence or exact parallels.

I should like to note however that the balances in question are for use after-death[552] and are found in essentially princely tombs.[553] The fact that no sets of weights are found with them does not entirely rule out the interpretation I should tentatively offer that they were to enable such princes (or close officials) to measure their riches in the afterlife (and check against theft from their tombs) just as they seem to have done while alive.

This suggestion is supported by the clear evidence of weight measurement in the accounts of many bronze-age palaces, contrasted with the lack of identifiable (certainly of marked) weight series. This last must in general be an accident as sophisticated weight systems existed (see further below). The accounts involving weights are essentially inventories; various commodities are weighed: especially metals, but also wood, eruthra etc. The context is inventory keeping for palace administration.

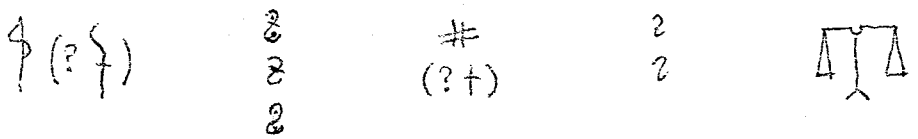
Little can be reconstructed of weighing outside this context. The existence of independent internal commerce should probably be discounted in the light of the strength of palace control; but it is not inconceivable. Aspects of metal working may have involved weighing rather as in later Greece[554] but direct evidence is ambiguous. The Enkomi Foundry hoard, that included the bronze pans of a balance, contained both smith's tools and raw materials and also tools for sale and scrap metal objects. It is thus as likely that the balance was for sale also, or scrap, as that it was of use to the smith as a balance.[555] The crystal disks of the Mavro Spelio tomb that contained the remains of a once usable balance were identified as "part of the apparatus of a craftsman";[556] but this inference seems rather speculative.

There is no evidence of any official concern for, or regulation of, weights, nor can any inferences of such control be drawn from the objects that have been thought to be weights. None of these, as already noted, are marked in a recognisable manner, and no individual weights can with any certainty be identified,[557] nor in consequence can the absolute values of bronze-age weights be inferred. Many scholars, impressed with the consistency and shape (which resembling an ox-hide was argued to reflect the ox-unit of value) of metal ingots, have assumed them to represent (standard)

weights.[558] Certainly metal was handled in this form throughout bronze age Greece: for trade,[559] for storage, and the symbol , identified as an ingot, also appears on inventories.[560] However the weights of such ingots varied from over 35 kg. to under 25 kg. and though ingenious explanations for this in terms of the local variation in metal value have been advanced,[561] it is equally possible that the sizes and shapes <u>simply</u> represent the internal consistency of different places of manufacture and the practical considerations of handling and storage.[562] It remains possible that officials then accepted such local units as units of weight for convenience; but it appears that metals even in ingot form may well have been weighed.[563] The identification of other bronze age "weights" is very much more improbable, though the accumulation of various conjectures has rendered the analysis of bronze-age weight systems extremely sophisticated.[564]

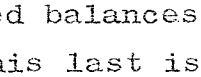
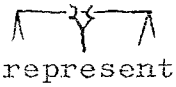
Though the absolute values of bronze-age weights must I believe remain a matter for speculation, the elements of the weight systems have been established by cautious and often brilliant analysis of the few relevant tablets.[565] Greatest progress has been made through establishing the numerical systems used in Linear A and B. From this study the respective weight systems may be seen to differ. Linear A counted with whole numbers, and below them, fractions; in Linear B the identification of fractions is uncertain, but for the most part systems of measurement incorporate a series of (related) units each of which is represented by a different symbol (<u>rather than</u> a fraction of the earlier). Ventris and Chadwick[566] suggest the following interrelationship of these units for weights:-

1				
6	1			
72	12?	1		
288	48	4	1	
8640	1440	120	30	1



I shall restrict myself to three observations on this table. (a) The extreme range, whereby the lowest unit is 1/8640 th. of the largest, must indicate sophisticated and precise weighing. (b) The system of subdividing the upper unit most immediately relects the situation of early Greek (commercial) weight systems where the stater (as 1/30 th. talent) and not the mina (1/60 th.) appears. However the temptation of further inferences (such as a relationship between this Linear B system and later Greek) should be resisted: the 1/30 th. here in Linear B does not subdivide into thirds. (c) The upper unit is depicted by a sign representing a balance. This alone invites comparison with the later Greek weight unit τάλαντον, also used of the balance; and further confirmation may lie in the phonetic values of certain apparently related (though simplified) signs. Thus compare, in Linear B, ⊦ da or better 𐀓 ta (as on its side this becomes 𐀔); and Cypriot ⊦ ta.[567] The comparison does not indicate necessarily correspondence therefore, and certainly does not impair the independent use by later Greeks of τάλαντον and related words in the manner argued above in VI. 5 (1).

Representations of balances in the semi-pictorial scripts of bronze-age Greece are also a major source for the reconstruction of what the balances in use were like. Many actual balances have survived, but the majority are represented solely by matching pairs of pans.[568] These pans, in practicable balances invariably of bronze, range in diameter from 4·5 cm. (LH II Vaphio) to the largest pair 22·5 and 23 cm. (Enkomi Cyprus Foundry Hoard: twelfth century BC); in all clear cases four holes are regularly spaced round the rims of these pans for suspension, which was probably of perishable cord except where traces of bronze wire (Enkomi Foundry hoard) or gold strips (Mycenae and a special case) have survived. The gold scales from Mycenae had a wooden beam surrounded by hollow gold sheeting; the suspension strips came out of the ends of this tube; there is no evidence of a central point being marked or incorporating a pointer. The practical use of the balance is in serious doubt and so inferences cannot be made of general suspension or pivot systems from it.[569] Indeed the gold strips could hardly have been attached in any other way.

Unfortunately further evidence of these elements is hard to find.[570] Nor do representations of balances help on these details; though it is the case that none show clearly any pointer, the central position is frequently indicated by a vertical line which can either be pointer or handle or both, and when shown protruding below the beam would appear more likely to be a pointer ().[571] At least one or two representations would support the idea of suspension cords coming out of the ends of a hollow beam, though others rule this out. Two features are however clear: <u>first</u> the existence of standed balances as well as hand-held[572] in the Linear B areas, while Linear A seems only to show hand-held balances; <u>secondly</u> a particularly distinctive pivot arrangement for these standed balances that resembles horns ( or ). This last is to be <u>contrasted</u> with the Egyptian representations (including the hieroglyphic),[573] and appears peculiar to Linear B. Whether it is symbolical or reflects a particular mechanical arrangement I am not prepared to speculate.

In conclusion the evidence for weighing in bronze-age Greece is insufficient to illustrate with any certainty the type of weighing involved. Many more balances survive than from later classical Greece, but this survival indicates no more than a symbolical (eschatological) belief, also concerning the balance, that cannot be elucidated because of the lack of literary references and any clear means of establishing links with later traditions. The contexts in which weighing can be identified appear much more restricted than even in classical Greece: palace inventory and only very doubtfully also certain aspects of metal working. Weight systems can be detected, though no weights survive to elucidate them convincingly. Such evidence that there is, points to measuremental weighing; but the possibility of other aspects remains open, and so the possibility of a closer relevance to the origins of the later Greek weighing.

2. The origins and historical development of Greek weighing

2.(1) The contrast between Greek and other Near-Eastern cultures

The largely negative evidence for weighing in bronze-age Greece will first be put on one side and the general survey of other near-eastern cultures considered (IX.1.(1)-(5) from Egypt to the Hebrews). This has produced nothing comparable to the Greek picture. Some elements may correspond (as the association of the balance with death in Egyptian and Palestinian theology, or the murkiness of the afterlife in She'ol and Kur-nu-gi-a), but the corresponsion is nowhere complete and, most importantly, the balance plays the precise, and altogether non-Greek rôle of measuring weight. It has however been shown that the theological and literary appreciation of the balance, and of the weighing operation itself, is intimately related to the experiance of everyday weighing in the cultures concerned. This is confirmation of what I have shown was also the case in Greece.

Conclusions along these lines have only been possible for cultures with some degree of literature. This is most serious in the case of Phoenicia where an answer to the question of the possible source of the Greek attitude to the balance could plausibly lie. The same consideration applies to the several cultures of bronze-age Greece.

Another caveat is that the majority of instances of weighing considered in these analyses involved objects of relatively high value, or concerned important moments of people's lives. Thus Egyptian scenes for the most part depict the accounting of gold and silver for Pharaoh's treasury, or the weighing of a man's heart at the crucial moment of judgment; the Eloquent Peasant on the other hand lived in a land where capacity measures of grain were the units of value.[574] Solomon and David were not concerned to weigh their brass, though even spoons of gold and silver were carefully accounted.[575] By far the more usual penalties in the Hittite and Mesopotamian law codes are set in silver shekels, but in one place an alternative to a silver-based price list is provided in sheep units,[576] and in another minor adjustments to a silver-weight price are made in capacity measures of barley.[577] The possibility that at these dates and in these cultures weighing was a complicated and expensive procedure, reserved for the handling of high-value objects, has been stressed by certain scholars.[578]

This possibility should however be kept in perspective. In the first place, the nature of the evidence is artificially restricted to high-value or important matters: if monumental, it relates noteworthy events concerning royal, or at least important individuals; if enshrined in religion, it is bound to reflect issues significant in people's lives. The literary metaphor not hampered by the dictates of subject matter in this way, is therefore more valuable evidence - and more significant in that it is drawn from everyday experience. This literary evidence, where it exists, confirms the general conclusions. Secondly, there is a distinction between a weight system established (and possibly administered from the centre) in silver, and the use of the system for objects other than silver.[579] This wider use is not ruled out by the base being in silver. The near-eastern cultures as discussed above illustrate two practices (considering Phoenicia a blank in this respect it is omitted): the Nub weights of Egypt appear to have been used exclusively for the weighing of gold,[580] whereas the Hittite mina might be used for a variety of commodities.[581] The former practice, which is perhaps more frequently found in measures of capacity,[582] is the only one that might restrict the relevance of this study of weighing technique. In none of these cultures however was all weighing restricted to one commodity, and in all there can be shown to have existed at least one weight system that was used for more than a single commodity.[583] Thirdly, the frequency with which balances were used, and the extent of their penetration into everyday life, appears to have varied between the different cultures. This could account for the variation in the readiness of the literature of these cultures to use metaphors of the balance or the operation of weighing. The literary evidence however is too uneven and haphazard to allow a proper comparative check to be made on this possibility.

In so far as we are here concerned especially with the type of weighing and the point of weighing in these near-eastern cultures, the argument is not properly vulnerable to this doubtful possibility of restricted use by only a small section of the community or for only certain commodities. Weighing appears primarily to have been thought of as a means of measuring weight. The contexts and aspects of weighing in most cases confirm this across all fields examined: law, commerce, religion, and the experience of everyday life (as reflected in literary simile and metaphor). All the exceptions noted are either extremely doubtful, or of a date subsequent to the Greek.[584]

The contrast with the Greek attitude to weighing is therefore striking and fairly complete. The basic Greek concept of weighing has been shown to be a way of comparing with a view to distinguishing. This is supported

by consideration of balance design (and its operation); of extant weights (and their variation); of recorded weights (when their contexts are taken into account); and of the more general view of weighing shown by literary metaphor and by religious beliefs. Though the use of the balance may have been widespread in Greece, it was essentially to measure out units. These units need not have been regarded as units of weight, but the operation rather involved the multiplication of amounts. The absolute values of the units were not necessarily important, but probably reflected practical considerations that varied with the particular context and the commodity handled. The absolute values were not precisely reproduced, and the operation is best interpreted as the measuring out of more than, or of at least, the set unit in each case. Only in specialised contexts was weight measurement (of an unknown object in terms of known, and controlled, absolute units) attempted. In the most common of these contexts (the inventory of silver and gold) such measurement derived from, and so properly constituted, the description of value. The weight units involved were those of silver (and gold) coins; and, though theoretically these coins were of set weights, in practice the distinction between their value and absolute weights was blurred or often ignored.

Two points can be repeated to illustrate the different experiences of weighing. First, there are no Greek complaints about false weights, and only one reference to a deceitful balance (that may in fact be operated by non-Greeks);[585] the Near East on the other hand was obsessed by the problem, and to it they urgently directed the attention of their gods: Marduk, Šamaš, and Yahweh - "A false balance is abomination to the Lord; but a just weight is his delight". Secondly, the Eloquent Peasant's view of justice[586]

> Carry out punishment against him who should be punished, and none shall equal thy scrupulousness. Does the hand-scales err ? Does the stand-balance incline to the side ? Is even Thoth indulgent ? Then thou (also) mayest work mischief... Thy tongue is the plummet (of the balance), thy heart is the weight, and thy two lips are its arms.

is notably different from that found in Aeschylus[587]

> ῥοπὰ δ' ἐπισκοπεῖ Δίκας
> ταχεῖα τοὺς μὲν ἐν φάει
> τὸ δ' ἐν μεταιχμίῳ σκότου
> μένει χρονίζοντας ἄχη,
> τοὺς δ' ἄπρατος ἔχει νύξ.

2.(2) The origins of Greek weighing

An explanation for the peculiarity of Greek weighing could be sought in direct parallels in other cultures with which the Greeks are known to have had contact. The Greek attitude could be conceived as the result of reaction to varied external influences over a period of time. Alternatively, and I believe more likely, it is the result of an independent internal development.

Greek weighing has been shown to be in essence a procedure to distinguish items being compared by means of a tilted balance beam. The only parallel that I have found for such an attitude might lie in obscure, and equally unique, elements of Hittite ritual.[588] The link with classical Greece is tenuous. Common Indo-European origins are of conceivable relevance, but I have not been able to trace the idea in other western cultures, and Indian weight measurement had certainly advanced to a sophisticated level at an early date.[589] Contact between the Hittites and bronze-age Greece can perhaps be suggested as an alternative.[590] Here we are faced with the unfortunate blank of what general attitude to the balance obtained in the cultures of this area. That the Mycenaeans at least (though probably not the Minoans) incorporated the balance into their funerary cult is possibly reassuring. The feasibility of transmission from this period to later iron-age Greece may be indicated by certain words and the context of the earliest-known Greek balance.[591]

However, a fundamental argument against such transmission hypotheses, apart from the lack of solid evidence to support them, is the historical. Mycenaean weighing (as other bronze age weighing) was part of palace bureaucracy; both ritual and practice were associated with those in charge of the central administration. All this collapsed at the end of the bronze age; the weights, the balances, and the centralisation of wealth they weighed, did not survive. Transmission of an approach to weighing can only have been at the lower social levels; there is no reason to suppose such levels in fact operated balances in the bronze age, and therefore apart, from the remote and improbable possibility of a common ethnic attitude to weighing, there was nothing that could be transmitted.

If the origins of Greek weighing are therefore to be sought in the period subsequent to the collapse of the bronze age cultures, it is immediately possible to rule out contact with other cultures, as these

no longer knew of any alternative to measurmental weighing. The only uncertain culture is the Phoenician, with which the Greeks had indeed early contact. However it is more likely than not that the Phoenicians regarded weighing as their other near-eastern customers; their background (cf. Canaanites) was certainly of measuremental weighing. Furthermore their approach to foreign trading techniques appears to have been negative; they are unlikely to have exerted any pressure on the way commercial goods were priced or handled.[592]

It is necessary to consider the hypothesis of independent internal development to explain the origin of Greek weighing. This seems very reasonable. Greek weighing is essentially weighing without weights. For weights to be properly significant they must be standard, and in some way regulated. As Greek weighing developed, and was established as practicable, in a period when such regulation, in terms of official control, was for historical reasons lacking, it is not surprising that it took a form that did not require such weights. I have argued that Greek weights only became standardised, and began to be systematised, after the introduction of coinage which was the first area of weighing with which the Greek states were concerned. That these states did not more vigorously pursue the control of weights than they did, and that the basic Greek attitude to weighing survived well beyond the introduction of coinage and related weight systems, both points to the fact the this attitude was very firmly established before such developments. The "Dark Age" of Greece is significant (not simply convenient) for the development of many aspects of later Greek civilisation. The point being made about the concept of weighing suggests that commercial practices were also established for which it was suited. The lack of state control of weights in this period can therefore be cited as an example of the general disinterest of states in trading that was subsequently so characteristic of the Greeks.

The survival of the Greek view of weighing could be thought remarkable. Yet I have shown it to be eminently suited to a certain level of trading.[593] It was quick, convenient, decisive, and psychologically suitable to buying and selling. It was also a simple operation, calling for no high-precision in either equipment or use. Its main defects can be accounted for: bargaining for unit price reduces the importance of precision in the weights and procedure used to measure these out; accuracy appears to have been less important than precision in contexts where value was measured in weight; the need for accurate weight measurement arose only in certain specialised contexts and modification of the peculiarly Greek attitude to weighing can

be assumed for these contexts without affecting the fact that this attitude was more basic and more general. Comparative, overbalance weighing suited a society that was not interested in the practicalia of such specialist (and "low grade") professions as manufacturing or inter-state trading.[594]

Around the late fifth-, and early fourth century traces of a possible change in the Greek approach to weight measurement can be detected.[595] This change was associated with, and remained restricted to, an academic élite interested in a precise and scientific approach to natural phenomena. With the reassertion of theoretical dogma by the later fourth century this approach was abandoned.[596] It never had any practical or technological significance. The developments of the third and following centuries should be separated from this; they belong to a wider, and no longer Greek world. It is hard to decide whether the changes in Greek weighing technique now resulted from the initiative of private enterprise,[597] from the independent pressure of commerce,[598] or from the practices of other cultures now directed, often forceably, upon the Greeks.[599] Though the peculiar Greek attitude to weighing persisted into this period, it is possible that it had become a literary cliché rather than a reflection of actual practice; in many local areas of Greece however I have little doubt but that it still persisted.

GENERAL CONCLUSION

The most important point established is without doubt that Greek weighing was fundamentally non-measuremental, that most Greeks weighed to compare and distinguish. Their balances were unstable, and weighing was the observation of overtilting or inclined beams; it was not the operation of making them level.

Weights varied with commodities and contexts. Originally such variation was total, the weights being unrelated to each other and to higher or lower weights. Systematisation began in the sixth century with coin weights, and although this was subsequently applied to other weights, the standard systems that resulted were theoretical to the extent that the weights in them were used essentially as units for measuring out commodities. The accuracy of coins and weights was never generally controlled; nor were complaints apparently made about the considerable inaccuracy that obtained and that can be seen from surviving examples.

The Greeks did nothing to advance the techniques of weight measurement. Their balances were sensitive to quite small differences in weight, but their weights were unable to measure such differences. The Greeks were not apparently aware of, or concerned about, the inaccuracy (in absolute terms) of their weighing. Such contexts where accuracy was relevant, and where technological improvements to balance design were made, involved specialist professions only. Theoretical work on the principle of leverage in the third century and following can be related to the bismar described by [Arist.] Mech. 20 and used by meat merchants. The more practical steelyard, based on the same principle, is however a product of Roman technology.

The Greek sttitude to, and practice of, weighing supported a belief in the distinctness of light and heavy. This encouraged a serious misconstruction of the concept of weight that survived into the Middle Ages.

Whether this approach to weighing, with the evident lack of precise official control of weights and the absence of inter-state standardisation, had a profound effect on Greek commerce is difficult to judge. Pricing and the calculation of profit margins must have been that much more difficult or their manipulation by traders avoided. However traders who needed accurate and standard units of measurement could well in practice have provided their own. There is isolated evidence of the concept of tare weight. The lack of standardisation of weights is symptomatic of the general disinterest of Greek states in trade (except as a source of revenue). In so far as state involvement is a sine qua non for the standardisation of weights, the effect of this disinterest was probably more significant here than in many other areas. That traders eventually had to insist on their own general standard by the late second century (IG II^2 1013) may indicate the extent to which they felt themselves hampered by earlier variations, but the lateness of this double standard is also significant.

The most long-lasting effect of the Greek view of weighing has been felt by subsequent iconography and literature. Transmitted through Hellenistic Egypt to the early Christian Church, the tilted balance as a means of distinguishing is an important element in many representations of the Last Judgment. The illogicality of these representations (two naked souls weighed against each other, the Devil pulling down one pan, the carefully-drawn pointer on the balance beam..) reflect the incorporation of elements from measuremental weighing and underlines its difference. The "weighted argument" "tilts the scales in favour of" comparative weighing, a concept for which the Greeks alone are responsible.

These conclusions concerning Greek <u>weighing</u> are very much more significant than unprovable hypotheses about <u>weights</u>, weight standards, and weight systems. I do not however feel simply to have by-passed

the traditional metrological approach. Its justification can only lie in recognition of the possibility of such hypotheses (bimetalism, close control of weight measurement, inference of precise standard from the variations of surviving weights and coins, interrelation and transmission of systems and standards etc..) and I do not deny that such justification can be found for many cultures. It does not however exist for the Greek. The fundamental Greek view of weighing I have shown to be non-measuremental; all avenues of possible evidence have been considered: no weights are shown on representations of Greek balances, which also incorporate no means of detecting a level, balanced position but clearly operate by overtilting; weights and coins vary with no evidence of strict control not complaint about such variation; historically, standardised weights and their systematisation only follows the introduction of coinage; before and after this weights are used as units primarily in which amounts (rather than weights) of various commodities are variously measured out; consideration of indirect and direct evidence confirms the general extent of non-measuremental weighing, and weight measurement itself, which can nevertheless be found, is shown to be restricted to certain contexts and must be qualified further by the fact that the point of weighing in the only significant context is not to measure weight so much as to describe value. Very similar conclusions can I believe be reached for other aspects of Greek "measurement": what has been said here of Greek weights should be applied also to measures of capacity and length for example. This I should hope to be able to show in further studies. In the present I conclude that traditional metrology is irrelevant for weighing in ancient Greece.
