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THE ANCIENT EGYPTIAN BALANCE - PART II*

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SUMMARY

Continuation of the paper of Mikhail and Robens (Thermochimica Acta 82 (1984) 63-80; fig. nos. are continued from that paper); some extensions and corrections are made with regard to the history of ancient Egyptian balances and the exhibits of the Cairo museum. Data presented in this paper should be used to replace those of Part I.

THE ORIGIN OF SCALES

After the ice-age the climate changed dramatically. In Egypt the Nile decreased, turned to its actual bed and become enclosed by an almost impassable desert on both sides, concentrating the human population, forcing them to settle in the few kilometers wide valley which existed, and producing agriculture in that extremely fertile area. As a consequence, a specialisation of production of goods, trade and traffic in the modern sense began. It can be assumed that such business as well as new techniques like metallurgy required measuring instruments including scales. We may conclude that the balance was invented at the beginning of the neolythicum about 5,000 BC, and there is no reason for an earlier dating as suggested by several authors (ref. 1).

The earliest weights were found in the Nile valley (Figs. 1-3). They are attributed to the pre-dynastic Negade I (Naqada) era 3,700 - 3,200 BC (refs. 2,3). Also in Mesopotamia and in the valleys of Indus, Jangtse-kiang and Huangho reportedly very old weights were found (ref. 1). The oldest "balance beam" (Fig. 4) (the original is in the Petrie Museum, London) was found in upper Egypt (refs. 4,5). The material (red limestone) could indicate a predynastic date. By a parallel balance depicted in the tomb of Hesy-rè at Saqqara a dating at the third dynasty (about 2,600 BC) is suggested (ref. 6). However, there are doubts whether this

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object is indeed a balance beam (ref. 7). The Hithite balance shown in Fig. 5 usually designated as a coin balance could not have been destined for that purpose because the Hithite empire was destroyed in 1200 BC;whereas the use of coins began not earlier than about 700 BC. Most probably, the scales had been invented in the Mediterranean area. This could have been Egypt, but we should admit that this could also have been in another country with less favourable conditions for preservation of artefacts.

All early depictions show equal armed balances operated in equilibrium. A few Egyptian drawings, showing balances with only one pan are regarded as incomplete (ref. 8). Balances with only one pan and with variable lever arm, like scales with sliding weight or with sliding suspension of the fulcrum, steelyards and bismars, should be dated later than we previously suggested, some hundred years BC (ref. 4). Most likely the thousand years earlier attribution of such instruments to the Egyptians (ref. 9) resulted from the wrong interpretation of the plummet as a sliding weight on account of misunderstanding the Egyptian method of painting: in this non-perspective view the indicator system is depicted beside its real place at the center of the beam (ref. 7). Variable-lever arm balances were first described about 350 BC (ref. 10). To derive satisfactory sensitivity and reproducibility using such scales, knife-edges made of hard metal are necessary. Thus the steelyard was most probably invented by people familiar with iron work, as was the case in the Northern or Eastern Mediterranean region, rather than in Egypt. Steelyards found in the Nile delta are dated to the Roman period and may have been imported (ref. 11).

THE SCALES OF THE CAIRO MUSEUM

Important corrections are to be made with respect to the two balances of the Cairo Egyptian Museum. We learned that these had been reconstructed by Ducros (ref. 12) on the basis of fragments which he found besides other things in a case in the Cairo Egyptian Museum. From the "hand balance" (Figs. 9. 31) only a wooden beam and pans were found. He assumed that it was equipped neither with a pointer nor a plummet and served only as a rough instrument (ref. 13).

Only the beam, two pans and the upright form of an arm of the second instrument was found assumed to be a "stand balance". The beam is made of a rolled copper or bronze sheet. Ducros supplemented the beam with a wire pointed at one end and bent to a ring at the opposite side. The wire was passed through the central bore hole of the beam, the straight section serving as a pointer and the ring as a part of the suspension. Because of the large ring the axis of rotation was far above the connecting line of the bearings of the pan suspensions and the center of gravity of the beam. With regard to the short beam this reconstruction is, thus, largely insensitive.

For technical reasons Ducros' reconstruction of the stand balance is most probably incorrect (ref. 7). But also our schematic drawing of the beam (Fig. 33) is incorrect: the lateral boring is biased and comes out on the side of the beam as shown in Fig. 34. In Table 1 the dimensions of these parts according to Ducros' measurements are summarised; values indicated by an asterix were obtained by us using a scale model with string suspensions for both the hand and the stand balance.

TABLE 1

Dimension of scales exhibited in the Cairo Egyptian Museum reconstructed by Ducros, supplemented by scale model investigations with string suspension (*). The sensitivity was defined as the mass producing a beam deflection of 1 degree.

		"hand balance"	"stand balance"
catalog number		31489	
material of shaft		-	copper
height of standard shaft	(mm)	-	158
material of beam		mahogany	copper or bronze
length of beam	(mm)	277	138
diameter of beam	(mm)	6 - 8	2 - 4
mass of beam	(g)	13.50	4.85
distance of side-holes	(mm)	137	78
material of pans		metal	copper
diameter of pans	(mm)	61	58
height of pans	(mm)	3	3
mass of pan A	(g)	7.05	7.76
mass of pan B	(g)	7.03	8.00
maximum load	(g)	* 200	* 60
sensitivity at 0.5 g load	(g)	0.05	* 0.10
sensitivity at 30 g load	(g)	0.15	* 0.12
sensitivity at 60 g load	(g)	0.30	* 0.15

OPERATION OF THE ANCIENT EGYPTIAN STANDARD BALANCE.

One type of hand or stand scales of various sizes is very often depicted in scenes of daily life (ref. 14) (Fig. 35) and of large stand balance in the death tribunal (ref. 15). In order to understand better the design of this "Egyptian balance" we should

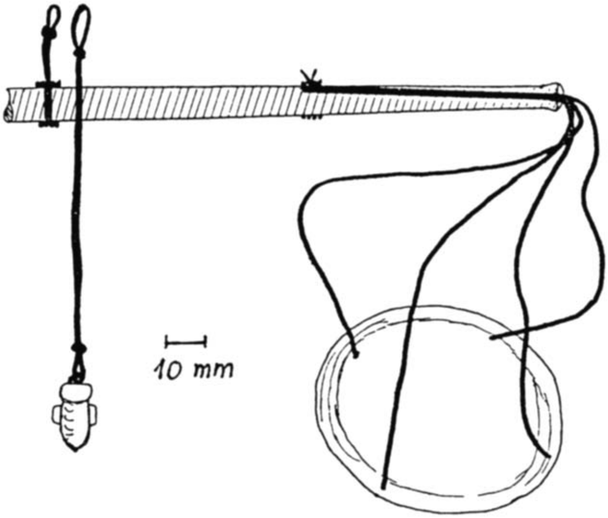
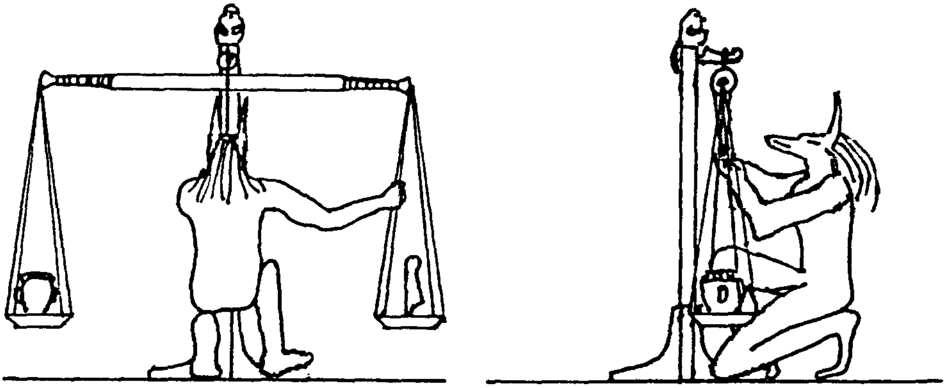


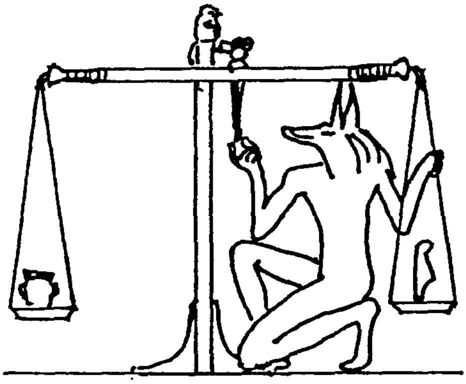
Fig. 34. Design of the hand balance as reconstructed by Ducros.

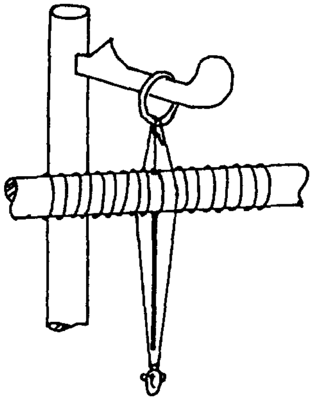
Fig. 35. Three weighing scenes. Tomb of Mencheperre-seneb, 18th. dynasty, Schech abd el Gurna (ref. 14).

keep in mind the method of Egyptian painting: they never used perspective, each subject is shown as a silhouette. However, each part is shown from its most detailed side. If necessary, parts were twisted 90 degrees within the figure. With regard to the operation of the scales we made some sketches showing Anubis running the death balance: one side with the heart of the deceased, and as the counterweight Maat's feather, the symbol of truth. Anubis is kneeling in front of the balance, showing us his back (Fig. 36 a) and arresting the pan suspension with one hand. With the other hand he touches the plummet, as it can be seen from the side view (Fig. 36 b). Now we can see that the Egyptian method of drawing (Fig. 36 c) is a combination between front and side view which delivers very instructive representations. It may be



a. front view b. side view
Fig. 36. Anubis operating the death balance.





c. Egyptian representation Fig. 37 Two string hypothesis

mentioned that also some sort of time compression is depicted: at first the pan suspension was caught to arrest the pans with load and weight, respectively. Then, the indicator system was stabilised by manipulating the plummet, and checked.

We should consider also beam suspension and indicator system as a problem of non-perspective drawing. The most detailed item is depicted in order to explain its function: the painting becomes in addition a technical function sketch. Unfortunately, such drawings can be read in different ways.

At the Dijon conference an arrangement was discussed, consisting of a needle pointer and a plummet suspended by two strings. The strings run on opposite sides of the beam and in this way creating a triangle, in the middle of which the pointer oscillates (Fig. 37). However, this idea cannot correspond to reality with respect to the existing colored triangles and the extended middle lines. Considerations relating to the beam suspension and the indicator system are discussed in separate papers (ref. 16,7).

At any rate, the observation of the indicator system was carried out most carefully. In contrast to remarks made in the previous paper, we are sure that the Egyptians knew very well what had to be done in order to obtain results as precisely as possible using balances they had.

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