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INDICATOR SYSTEM AND SUSPENSION OF THE OLD EGYPTIAN SCALES*

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SUMMARY

Detailed analysis of drawings of both the death balance and scales of daily life together with technical considerations suggest a triangular pointer perpendicular to the balance beam and a plummet suspended in front of the beam. The suspension was made using a rope or metal rings, the axis most probably piercing the beam horizontally.

INTRODUCTION

Many wall drawings and papyri found in Egyptian tombs indicate that, very early in their culture the Egyptians performed weighings in manufacture (in particular of precious metals) and trade (refs. 1,2). These drawings going back to 2,500 BC show symmetric scales equipped with two pans, the mass being compensated for by weights. This primary type of the balance was invented in prehistoric time. Whereas the wall paintings consistently show large scales, up to a man's height, the findings are parts of small scales (ref. 3). The oldest "balance beam" dated back to 3,000 BC is made of limestone, and was found in upper Egypt. Exhibiting a strange shape as it is only 85 mm in length but heavy, there are doubts that this object was used for the purpose of weighing. The existence of balances of any size is testified for by weights, the oldest reliably identified pieces likewise found in upper Egypt and attributed to the Amratic period (Negade I) 3,700 - 3,200 BC.

Speaking today of the old Egyptian scales we don't think of the commercial scales but of the cultic balance in the death tribunal. In the so-called Book of the Dead (refs. 4,5) - some hundreds being preserved in museums - a papyrus roll of up to 20 m in length including vignettes, the way in the nether world, which the

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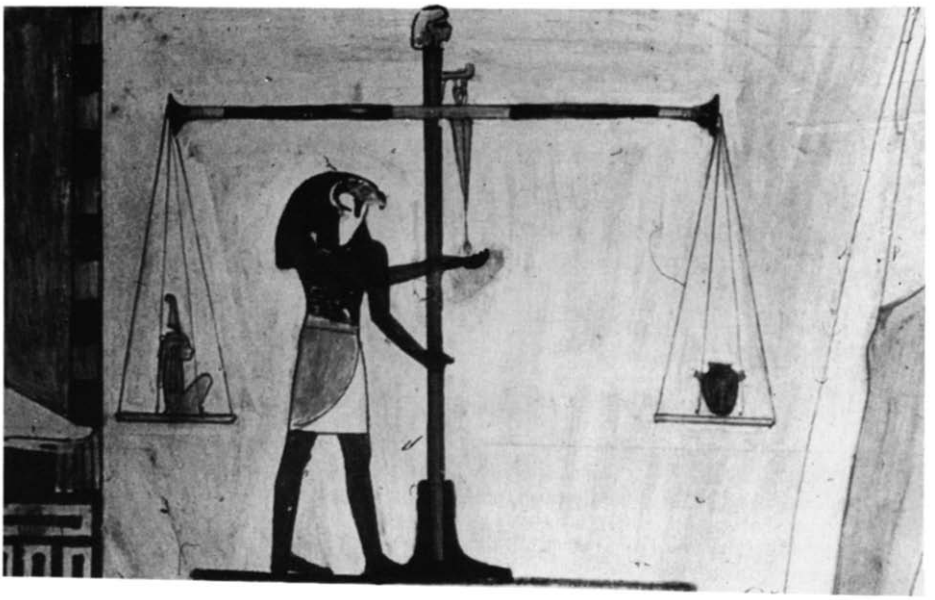

Fig. 1. Death balance with compact triangular pointer. Tomb Theben (18th dynasty). The pointer is light-coloured as some parts of the beam, whereas behind the pan suspensions the background can be seen clearly (ref. 6).

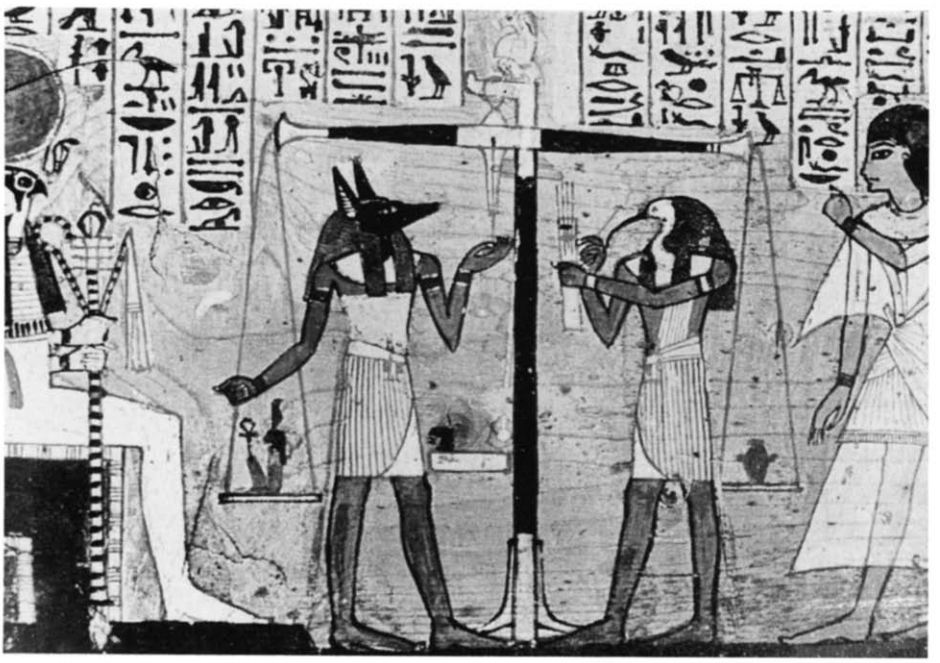

Fig. 2. Death tribunal on a shabti-case, Louvre, Paris (21th dynasty, ref. 15) (ref. 7)

deceased had to pass before being admitted to eternity, is described. At the end he must give a "negative confession" explaining that he didn't do bad things. If the 42 judges evaluated the result as positive he was recommended to Osiris. A central part of the death tribunal (Fig. 1,2) described in the chapters 30 B and 125 is the psychostasy, the weighing of the Ka (something like his personality) of the dead or his heart against Maat's feather - the goddess Maat bears a peacock's feather in her crown - as symbol of truth and justice. Only in the case of equilibrium is the result positive. The ibis-headed Thot, god of knowledge, writing and counting, records the result. If negative the dead are swallowed by the Gluttoness, a monster made up of lion and crocodile. He dies a second time and is extinguished for ever. If positive he is presented to Osiris and deified.

The scales used in the death tribunal are exactly the same as used in daily life (Fig. 3). Whereas some drawings represent even details very correctly, others are made carelessly and even wrong, suggesting the painter had never seen a balance. Often it is very difficult to distinguish incorrect drawings from those of deviating, more primitive or unsuitable construction (ref. 7). There are, however, enough characteristic common features (symmetrical design, stand, pans, pan suspension, shape of beam, plummet) which justify speaking of the "Egyptian balance" (ref. 8).

The old Egyptian stand balance obviously was suspended by means of metal rings or a flexible loop on a hook which was fastened on an upright. The hook is often in the form of Maat's feather. The master of weighing - in the death tribunal the dog-headed Anubis - stands or kneels sideways in front of the scales, reaching for the pan suspension or arresting the balance beam and holding his other hand below a plummet suspended from the hook or the beam (ref. 9).

As shown in nearly all drawings, equilibrium was the balancing requirement. Inclination balance could not be discovered in antiquity (ref. 10). Equilibrium can be observed only roughly estimating visually the beam's horizontal position. For more exact measurements a detector system is required. Rejecting unclear and obviously false designs a most favourable standard type of this item can be ascertained , an acute-angled triangle the small base of which connects to the beam (Figs. 4,5). The triangle is divided by the middle line through its base . This middle line is mostly extended below the tip of the pointer and equipped with a plummet at the end. In psychostasis this plummet is often in the

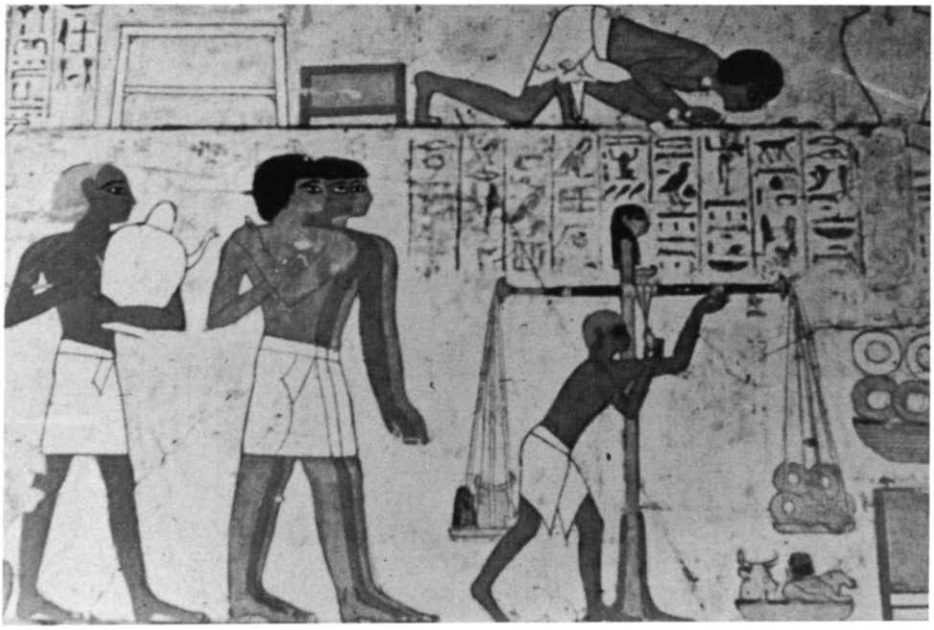

Fig. 3. Goldsmith's balance, tomb of Rechmere (18th dynasty) (ref. 1).

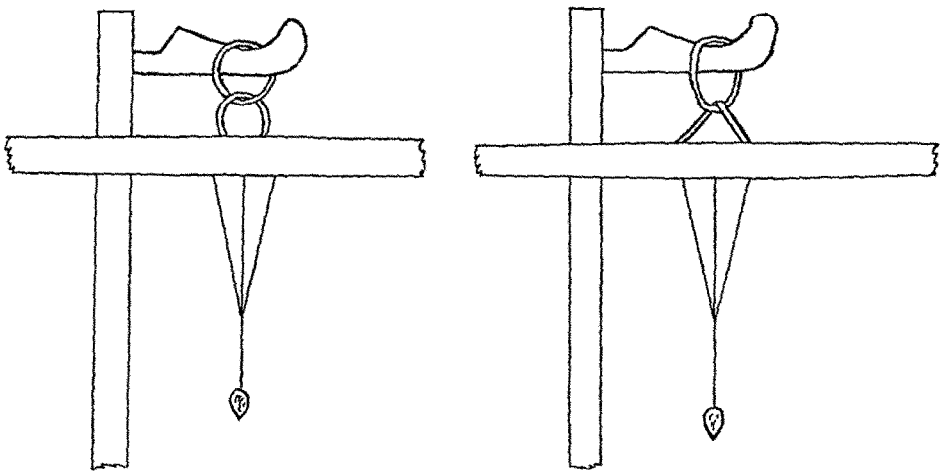

Fig. 4,5. Indicator system and two types of suspension schematically depicted in Egyptian style

form of a heart.

In the following some explanations of the suspension and indicator system published by other authors are critically evaluated and a new interpretation is presented (ref. 11).

THE INDICATOR SYSTEM ACCORDING TO WILKINSON

Wilkinson (ref. 12) is probably the first who attempted to give an explanation of the indicator system of the symmetric scales (Fig. 6): "The beam passed through a ring suspended from a horizontal rod immediately above and parallel to it, and when equally balanced, the ring, which was large enough to allow the beam to play freely, showed when the scales were equally poised, and had the additional effect of preventing the beam tilting when the goods were taken out of one, and the weights allowed to remain in the other. To the lower part of the ring a small plummet

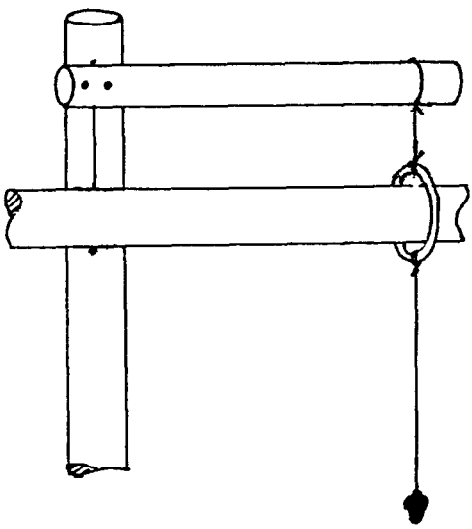

Fig. 6. Sketch of the indicator system after Wilkinson's hypothesis

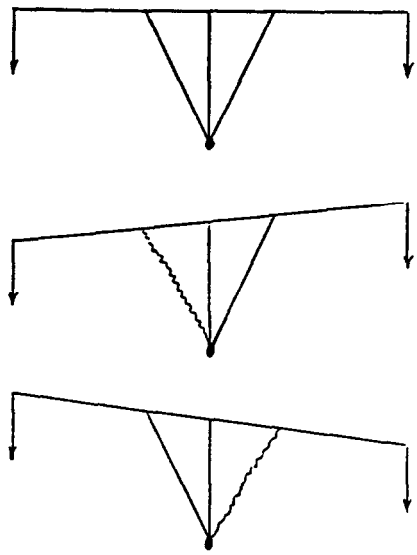

Fig. 8. Three string hypothesis according to Spiegler

was fixed, and this being touched by the hand, and found to hang freely, indicated, without the necessity of looking at the beam, that the weight was just."

Such an indicator system allows better observation of a beam deflection only in the case that this rod is as long as the

balance beam and a rod of such length is not anywhere represented.

THE INDICATOR SYSTEM ACCORDING TO PETRIE

Flinders Petrie (ref. 13) contradicted Wilkinson's explanation: "The beam was suspended by a loop or ring from a bracket projecting from the stand; this bracket is shown in side view though at right angles to the beam, just as the Egyptians drew a full eye in a side face. Then below the beam a long tongue was attached... To test the level of the beam, a plummet hung down the tongue, and it was this plummet which was observed to see if the tongue was vertical and the beam horizontal. The weigher is often shown steadying this plummet with his hand, as it would be set swinging by the motions of the beam."

This rather simple explanation was accepted by other authors; it should be stated, however, that it is not exhaustive in detail. Feldhaus (ref. 14) supposed that the coincidence of the tip of the pointer with the plummet line was observed. Seeber (ref. 15) pointed out, that in drawings suspension and indicator system are represented mostly unclearly and that both seldom can be identified as separate parts. Furthermore, the plummet is very often described in words but seldom the pointer. Also is a balance without plummet seldom depicted but often without pointer.

THE RECONSTRUCTION OF DUCROS AND A TWO STRING HYPOTHESIS

Ducros found in a case of the Cairo Museum of Antiquities among other things parts of two small scales. Using a beam, made of a rolled copper or bronze sheet and 138 mm in length, two pans and an upright form of an arm he reconstructed a stand balance (ref. 16,17). Ducros supplemented the beam with a wire pointed at one end and bent to a ring at the opposite side (Fig. 7). 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. Furthermore he added a plummet. Possibly, Ducros had the idea that the needle-like pointer should be observed between the two plummet strings of the slope split by the hook. 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 we suspect that this reconstruction of

the suspension is incorrect. The balance was subject of discussions at preceding microbalance conferences. The authors assumed, however, a complete original and drew erroneous conclusions (ref. 18).

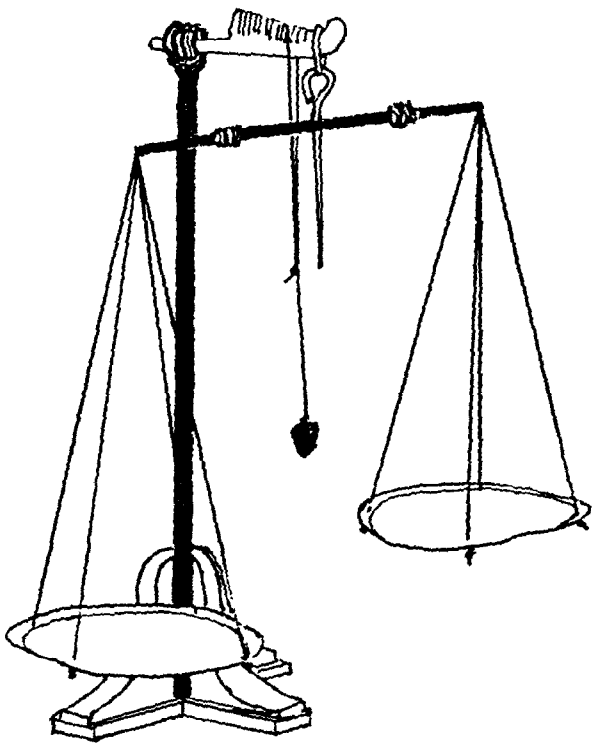

Fig. 7. Sketch of Ducros' reconstructed "stand balance" (Egyptian Museum, Cairo)

THE THREE-STRING HYPOTHESIS

Neuburger (ref. 19) and later Spiegler (ref. 20) explain the triangle with middle line and plummet below the tip as three strings fastened at the beam and equipped at the tip with a plummet. In the beam's equilibrium all three strings are strained and deflections are detected by a slack string which allows the plummet to swing (Fig. 8).

Obviously for that purpose only two strings are necessary. Furthermore, an experimental re-examination showed that an appreciable effect can be observed only for large deflections which can be observed more easily by visual observation. Furthermore, in coloured drawings the triangle is painted showing

clearly a compact triangle.

ANOTHER TWO-STRING HYPOTHESIS

At the Dijon conference an arrangement was discussed consisting of a needle pointer and a plummet suspended by two strings, fed on opposite sides of the beam and in this way creating a triangle, in the middle of which the pointer oscillates. This idea, however, cannot correspond to reality with respect to the existing colored triangles and extended middle lines (ref. 21).

THE INDICATOR SYSTEM ACCORDING TO JENEMANN

As a result of an analysis of drawings and a consequent acceptance of the Egyptian drawing method, i.e. representation of details always from the most interesting side, Jenemann (ref. 11) supposes that the triangular pointer should also be turned 90 degrees. Thus, the tongue of the balance consists of a triangular sheet made of metal or wood, the flat side perpendicular to the beam. The plummet line is suspended from the beam as shown in Fig. 9. This would allow a parallax-free observation and, thus, a noticeable improvement of weighing with regard to sensitivity and reproducibility, in comparison with the observation of a tongue parallel to the beam as suggested by Feldhaus (ref. 14).

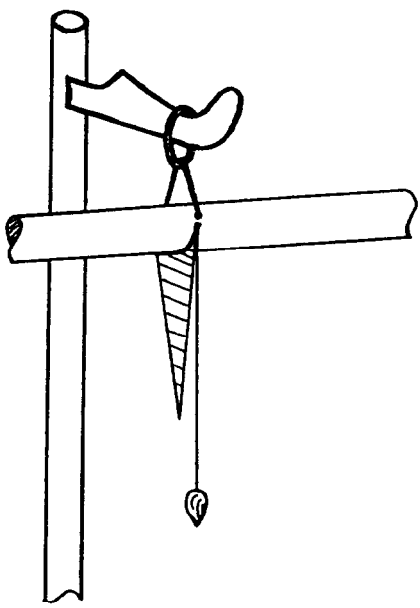

Fig. 9. Suspension and indicator system according to Jenemann

CONCLUSIONS

The suspension was made using a rope or a sequence of metal rings, for sensitive balances the axis most probably piercing the beam horizontally. Although Egyptian paintings in general describe clearly technical details the indicator system of balances remained unclear because of a variety of designs, unclear and incorrect drawings. For these reasons a number of hypotheses were created. An indicator system is only useful - compared with the visual observation of the horizontal beam - when it allows the observation of deflections smaller than one degree. This excludes some exotic propositions. With regard to the standard balance equipped with plummet and triangular pointer we agree it is a sheet of metal or wood fastened at the beam and a plummet suspended on a string in front of that sheet. On account of a parallax free observation this sheet should be arranged across the beam which is suggested by the method of Egyptian drawing.

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