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WEIGHING DEVICES IN ANCIENT INDIA

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The article attempts to document the history of weighing devices in ancient India, on the basis of evidence provided by archaeological artefacts, literature, numismatics, sculptures, and painting. The study reveals early utilization of the principle of lever in the form of equal arm balance and one pan balance *i.e.* steel yard balance. The study further reveals that equal arm balances were in use in most of the ancient civilizations probably independent of each other. However, India appears to have a priority in innovating single pan balance.

Weighing devices are an important part of modern metrological system and work on the principle of lever of first order. In this article an attempt has been made to trace the history of weighing devices in ancient India. To draw up a coherent picture evidences from archaeology, literature numismatics, sculptures, and paintings have been taken into consideration.

In India balances are reported right from the Harappan period (Fig.1). These balances consisted of metallic beams (copper or bronze), from the ends of which the pans were suspended, probably by means of cotton thread. Beams from Harappa[1] and Mohenjodaro[2] are comparatively thick in the middle and tapering at the ends, while the beams reported from Chanhudaro are thin in the middle and have thicker or rounded edges. None of the beams excavated from the Harappan sites has fulcrum hole in the centre. A string was tied to the middle portion of the beam for holding it during weighing. The differentiated ends of the beam provided safe suspension of the pans by means of strings. The length of the beams varies between *c.* 10.3 to 24.0 cm. The pans had two or three holes for suspension. Pans having three holes were suspended with the help of three pieces of strings, while those bearing only two holes were probably suspended by means of four pieces. Scale pans of copper or bronze are reported from Mohenjodaro[3] and Chanhudaro[4], whose diameter varies between 5.5 to 8.25 cm.

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Excavations at Mohenjodaro has also yielded pottery scale pans (diameter *c.* 5.5 to 7.0 cm). Scale pans of terracotta were excavated from Lothal.[5]

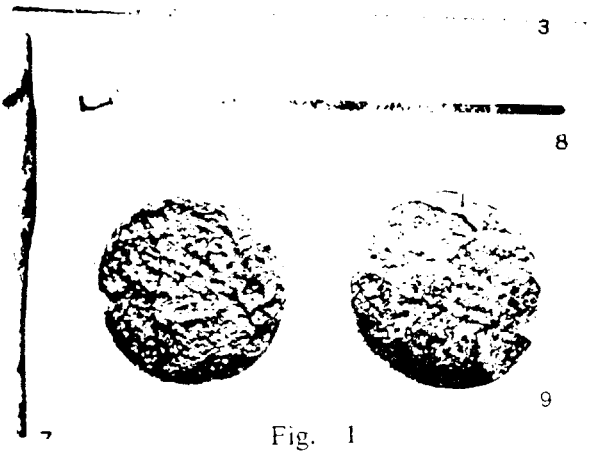

Fig. 1
Scale Pans (From Mohenjodaro)

The small size of scale pans and beams and microweights (0.8903 to 1.218 gm) reported from Lothal indicate that these small sized balances were used for the weighing of gold dust and other precious metals, gems, and beads. In view of the heavier weights of Harappan period (max. 11.4675 kg), it can be said that large sized balances having wooden beam and basketry or wooden pans were used for the weighing of grains and other commodities of daily use. Due to the use of wood and basket these balances have not survived. Some weights reported from Mohenjodaro and Lothal bear holes which suggest that during this period balances were counterpoised too, obviating the use of pan on the other side.

The ancient Indian name for balance was *tulā* which is also in use in modern time. The literary evidences of it can be gleaned from the literature like *Vājasaneyī Saṃhitā* (30/17), *Śatapatha Brāhmaṇa* (2/2/7/33), *Vaśiṣṭha Dharmasūtra* (19/1823), *Āpastamba Sūtra* (Vol.II, Pt.I & II 6 & 9) and *Aṣṭādhyāyī* of Pāṇinī (4/4/51).[6] On the basis of these literary accounts and weight standard of the period, it can be said that equal arm balances of different sizes were used during this period which could weigh from about 0.05 gm (1 *māṣā*) to 1000 kg (1 *āchiti* ; 25 maund).

In the Mauryan period we find for the first time the state control over weights and measures. State appointed *Pautvādhyakṣa, i.e.*, superintendent of weight and measure, whose responsibility was to check the accuracy of balances. Kautilya in his *Arthaśāstra* has given detailed descriptions about the mechanics of sixteen varieties of balances.[7] On the basis of their working principle he divided the balances into equal arm and steel yard types. The steel yard balance

was an innovation of this period, which is still in use and works on the principle "equal weights at unequal distances are not in equilibrium but incline towards the weight at the greater distance".[8] The beam of a steel yard balance bore graduation marks, and a metal ball was tied at one end of it. The pan was suspended from the other end. The weight of the required object was ascertained by moving a fixed weight on the marked beam (Fig.2, a reconstruction).

Fig. 2
Reconstruction of Steel Yard
Balance on the Basis of
Kautilya's Arthaśastra

Beginning with a lever of six *aṅgulas* in length and a weight one *pala* in the weight of its metallic mass, Kauṭilya has mentioned about ten varieties of steel yard (2/14/11-28), whose length and weight increased progressively.* He has divided equal arm balances into six types which are *vyavahārika* (public balance), *bhājanī* (servant balance), *antapur bhājanī*, *āyamānī*, *parimāṇī* and *samavṛtta*. Accuracy of balances was considered as an important factor and according to Kauṭilya, Government was to check it after every four months. *Sannāmini* (of bending arms), *Utkarṇikā* (of high pivot), *Bhinnamastaka* (of broken head), *Upakaṇṭhī* (of hollow neck), *Kuśikyā* (of bad string), *Sakaṭukakṣyā* (of bad pans) and *Pārivellyānta* (combined with magnet) are the types of balances which were considered as falsified.[9] Manu and Yājñavalkya have also provided strong support to the accuracy of balances. We find mention of weighing house in *Yājñavalkya smṛti* and *Mahānārada Kassap Jātaka*, where a line was drawn on the wall of the house to ensure the accuracy of balance.

*Length - 6, 14, 22 ..... 78 *angulas* : Weight - 1, 2, 3 ..... 10 *palas*.

During the post-Mauryan period scale pans of copper, bronze or iron are reported from Taxila, which have two to three suspension holes. Diameter of these pans (*c.* 2.2 to 11.0 cm) indicate that these were parts of small sized equal arm balances which were used for the weighing of medicine and gold dust.[10] Depiction of steel yard balance on the coins (Figs. 3 & 4), obtained from Ayodhyā

Fig. 3

Steel Yard Depicted on Ayodhya's Coins (2nd Century B.C.)

Steel Yard Depicted on Taxila Coins (1st Century A.D.)

and Taxila [11][12] provides strong support to the view that during this period steel yard balance was in regular use.

In post Christian period literary evidence of balance can be seen in the *Amarakoṣa* (9/187). Steel yard balances have been identified in the sculptures of Nāgārjunikoṇḍā, Amarāvatī[13] and Gāndhāra (Figs. 5 & 6). A relief on the

back side of the Mīra temple at Ahar shows a grocer using a balance (*Arts Asiatiques*, 1965 ; XI 63-64, Pl.6-7). A trader weighing with the help of an equal arm balance (Fig.7) can be seen at Ajantā in cave no.17 (Fig.7)[14]

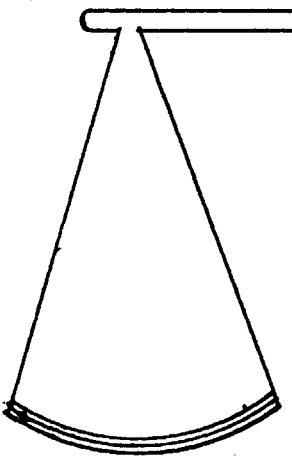

Fig. 5

Steel Yard Balance in Amaravati Sculpture

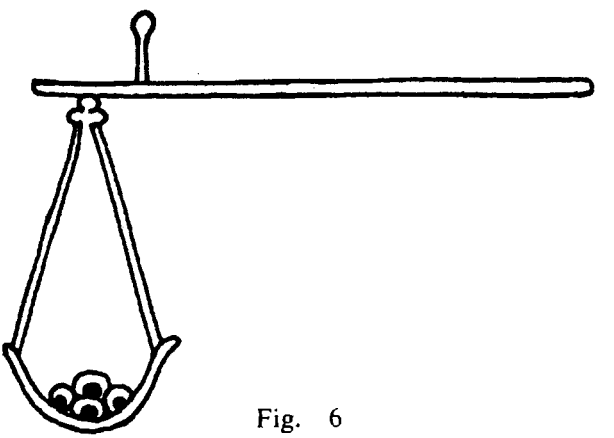

Fig. 6

One Pan Balance in Gandhara Sculpture

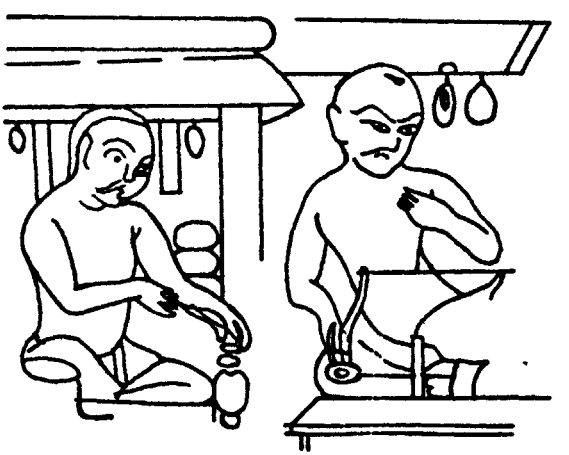

Fig. 7

Equal Arm Balance in Ajanta Painting

Archaeological excavations at Arang and Sirpur have yielded beams of steel yard balance, which can be dated back to the eighth century A.D.(Fig.8). On

the basis of detailed study of a modern specimen,[15] it can be presumed that these balances could weigh from about 2 *tolas* upto 4 *seers*. Al birunī has mentioned about the regular use of steel yard balance in India.[16]

In *Mānasollās* (a Sanskrit literature of twelfth century A.D.), we find detailed description about a developed equal arm balance which was made of

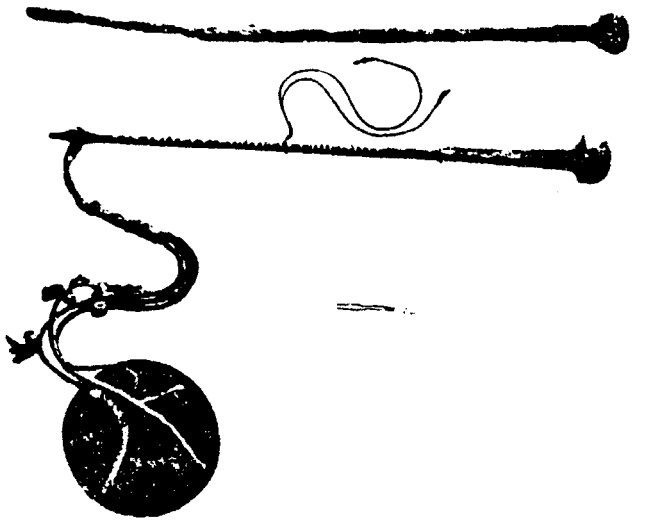

Fig. 8

Steel Yard Balance Excavated from Arang (8th Century A.D.)

bell metal. The beam of this balance bears two rings at the two ends for the suspension of pans. The pans bear four holes and were suspended by means of four strings. A central rod was placed under an arch and the arch was held by a string. The vertical position of the rod determined the exact weight of any object.[17]

CONCLUSION

Unfortunately the comparative history of the balance has not yet been put together. As we know, that both types of balances work on the principle of lever (Fig.9) which was theoretically proposed by the Greek philosopher Archimedes (287-212 B.C.). However, archaeological evidence of the use of equal arm balance during the third millennium B.C. indicates that technologically this principle was independently anticipated by ancient civilizations of Egypt, Sumeria, and India. An equal arm balance of limestone (8.5 cm length) has been reported from the prehistoric Egyptian site Naquada (Fig.10). On its basis the credit of origin of equal arm balance has been given to the Egyptians. But the stratigraphical level from which the balance is reported is not very clear and it

can be only loosely dated around, say, third millennium B.C. rather than fifth millennium B.C. as mentioned.[18] Well established use of balance in Egypt is reported only from 3rd-2nd millennium B.C. onwards.

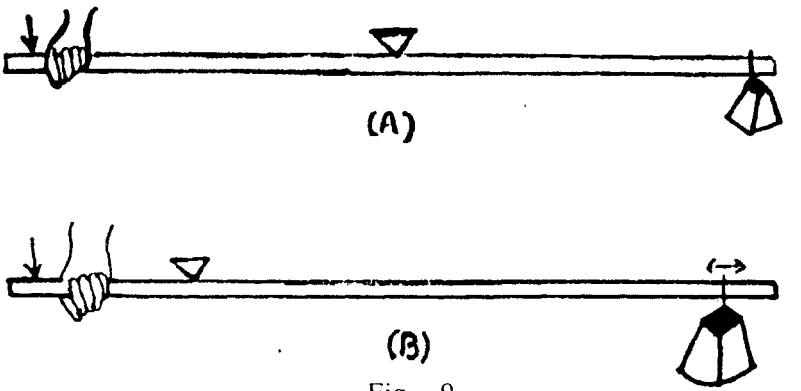

Fig. 9

Principles of Working of Equal Arm (A) & Steel-Yard (B) Balance

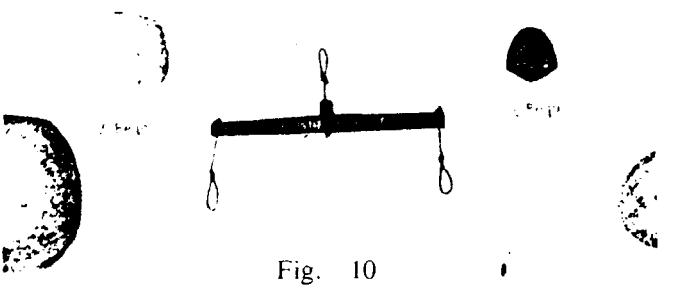

Fig. 10

Egyptian Prehistoric Equal-Arm Balance (Excavated from Naquada)

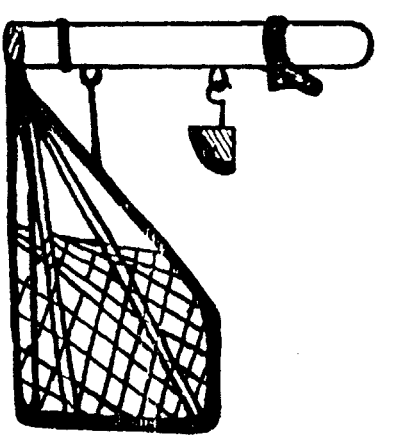

Fig. 11

Steel Yard Depicted in the Gallo-Roman Carving
(Now at Txier-2nd Century B.C.)

The idea of invention of steel yard balance is generally attributed to the Romans,[19] but this credit should rather be given to the Indians because in India its earliest evidence can be traced back to fourth century B.C. and its regular use can be seen from this period onwards. While in Rome its earlier example comes from Campania and from Neumagen in Gallo-Roman carving (*c.* 2nd century B.C.) now at Trier (Fig.11). In China its origin can be traced back to the Han period (2nd century B.C. to 2nd century A.D.).[20] It is difficult to say whether the innovation of steel yard balance has been independent in these three cultural areas. Taking literary and numismatic evidences together, there looks to be a fair chance of Indian priority in origin and its early diffusion to East (China) and West (Rome).

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