STRUCTURAL READING AND EVOLUTION OF THE INDUS SCRIPT VIEWED AS A COMPLEX SYSTEM. I: METROLOGICAL READING, PART B[1]

by

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This Part IB is a continuation of Part IA which was published in the Vol. 7, December, 1997, issue of RASK, pages 49-99. **The Abstract and References sections, as well as the Appendices A and B of that part are common to both** parts. Appendix A contains a sample of seventy-nine texts, noted by T.1., T.2, etc., and Appendix B contains a list of signs representative of the majority of the signs involved.

Very briefly, Section 1 of Part IA contains some introductory background to the script, together with an indication of the data and methodology of the paper. Section 2 gives a detailed analysis of the construction pattern of the texts, leading to the classification of the signs into five broad classes, noted by **C1, C2, C3, C4** and **(Extended) Roots**. The class C4 itself is classified into **C4a** and **C4b**, with **C4a** consisting of the signs formed by closely grouped strokes and **C4b** consisting of the signs of abstract linear forms.

Section 3 of the paper is devoted to the detailed characteristics and structural analysis of the texts, leading to the fitting of a possible metrology. After an introduction to the chosen approach and possible alternatives (Subsection 3.1), Subsection 3.2 analyzes the signs (called Linear Modifiers) of the class **C4b** and fits a basic numerology (the numerals four to ten) to them. Subsection 3.2 ends with the analysis of the man sign that it is used signify the meaning of measure or amount.

We shall now continue with the Subsection 3.3. It may be noted however that the reading of the present Part IB can be made sense of only when it is read as a continuation of Part IA.

3.3. Preliminary analysis of fitting metrical units

3.3.0

If the preceding interpretation is an option for the man sign, then the possibility that some of the roots have something to do with measure and amount cannot be excluded, since they are also ligatured with the

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man sign. This possibility is further strengthened by the fact that the root signs are extensively ligatured with those of C4 which have the possibility of numeral signification, as shown in Section 3.2. There are also several external suggestions. First, the roots and extended roots are mostly of either geometrical shapes or of stylized living beings. Several of the geometrical forms suggest, though vaguely at the moment, various units of measures. For instance, suggests a volume measure,  ,  ,  suggest bundles. The sign  suggests a land measure, and in fact one of the ancient standard metrical units has the lexical form *kani*, meaning land. Various other shapes resemble valuable objects or properties such as  , a bullock and  , a bow with arrow as is suggested by the ligature  . In fact, the bow has the etymology *vil* (DED, 4449) which is exactly the same (DED, 4448) for the word having the meanings such as: to sell, sale, price, cost, value, etc.; possibly the relation goes back to an archaic stage when things were 'priced' and traded in terms of most valuable objects possessed.

In this connection it is important to note that in a barter system of business transactions, measures and quantities associated with various services and commodities quickly take specific values in terms of measures of a single commodity, such as for example volume measures of grain. Thus the sign  , resembling a land measure, might actually stand for a volume measure. This need not mean that the intended volume measure will buy a certain area of land, but it might have stood at an archaic stage for the amount of grain required to sow a specific area of land for the purpose of cultivation. To give further examples, the root signs  ,  ,  and  already appear in the pottery of the pre-urban stage at Rehman-Dheri mentioned earlier, see respectively Rhd 81-93, Rhd 160-165, Rhd 205-210 and Rhd 213-216 of Parpola and Shah (1991: 352-378), and section 2.3.4 above. There, the root  appears to stand for a spear-head, since it is also represented in the form  . (Note that the form is a member of C1 in the Indus script under study, having a function different from the root . The graffiti on pottery from Rehman-Dheri are isolated potter's marks, possibly expressing the units such as the capacity of the pottery in terms of a basic unit, so that the necessity to differentiate between and might not have been felt). Certainly, a spear-head *(vēl)* made of copper or bronze must have been an object traded for grain. However, the intended signification might be more deeper, for the etymology of labour is *vēli* and this could mean

that the word value of labour was signified at an archaic stage by one of the objects employed for that purpose, in this case by a spear *(vēl)*, as it in addition stood for divinity. Thus the root might actually signify a unit of grain measure, as an equivalent of some other units associated with labour. In fact, an ancient metrical unit has the lexical form *vēli*. Similarly, the root , which is used to form extended roots such as , , , resembling dwelling places, might have stood for certain measures of grain traded, for instance, for a certain quantity of bricks, or a typical area of the land, associated with a dwelling place, whose lexical form, *manai*, also stands for an ancient metrical unit. Another root, , which does not seem to have the preceding apparent and immediate interpretations, will be discussed in more detail below in 3.3.2.

3.3.1

The preceding suggestions with respect to shapes of roots or extended roots are admittedly rather vague, but it will turn out later (in Section 5 of Part II) that many of the standard metrical units employed during historical periods represent appropriate roots or extended roots, confirming the preceding suggestions. However, a rather strong suggestion at this initial stage itself comes from the fact that many of the frequently used roots closely resemble some of the shapes of the type 3 objects (miniature tablets) and the related type 2 tablets, see Vats (1940) and Joshi and Parpola (1987: 215-217 and 226-230). These shapes are of the form

which in particular includes the fish shape. The sign also occurs in the form of tokens in the sense that there are type 2 tokens (see for instance M-496 - M-499 of the preceding reference) of cube shape with one or two of its sides completely covered by this sign. This suggests that when the sign forms of some of the roots are represented in the form of tokens, they might have had the possibility of having the iconic representations of the values implied either by the writings on the tokens or by the shapes of the tokens when no writings are involved. Note however that even though some of these signs themselves occur

on such tablets, there is no correspondence between the shapes of the tablets and the shapes of the signs inscribed on them. In particular, fish is one such shape, without doubt, and the fish sign,  , alone or in ligatured or modified forms, occurs with very high frequency (about 9.2 percent). This is a rather curious fact, for even if one assumes that the shapes of the objects of token type, without any signs on them, served in earlier stages the functional purpose similar to some of those of the seals, the reason why fish is one such shape is not immediately clear, even though one can come up with plausible reasonings with respect to a few other shapes, as is done above.

3.3.2

(*This section is included at this stage mostly for the purpose of illustration. Similar analyses for several other roots will be given later in Section 5 of Part II*).

For the preceding reason, we shall now analyze the involvement of fish sign. The etymology for fish is *mīn* or *mīnu* (DED, 3999). However, in an archaic stage, the basis for this etymology is likely to be *ma*, since *ma* is the etymology for animals in general (DED, 3917), and different animals might have been differentiated by incorporating additional signification elements such as, to mention only a few, *mīn* (fish), *mān* (deer), *māṭu* (ox), *eṟuma* (buffalo), *arimā* (lion), *karimā* or *vēlmā* (elephant), *varimā* (tiger), *āmai* (tortoise), *mayil* (peacock),etc.

REMARK : It is interesting to note that at a hunting and gathering stage, animals themselves might have been considered as one of the life supporting elements, being certainly a primary source of food, and many such elements have the etymology with *mā* as the basis, such as *mā* (cloud, (and hence sky), DED, 3918), *māri* (rain, cloud, DED, 3948), *maḻai* (rain, cloud, DED, 3893), *maṉ* (earth, soil, land, etc. DED, 3817), etc. There are also innumerable conceptual derivatives of these, such as *mati* (moon, DED, 3839), *miṉ* or *mīn* (star, DED, 3994), *mā* (great, possibly meaning 'as great as the sky'), *mān* (glorious). Since the fish and the star have the same lexical forms, some of the earlier investigators, in particular Heras (1953) have identified the fish sign to signify star through the rebus principle, an identification which has formed the basis of much of the interpretations of Parpola (1995).

As for a few of the examples involving *mā* as a basis in the context of measures:

(a) *mā*: This refers to an archaic metrical unit, in particular a unit of volume measure. Further, it is a frequently involved building unit, with the value 1/20, in the construction of words and phrases of fractions forming a conversion table that was used for reckoning either weights or measures or articles of one commodity to another in barter transactions. (See Section 3.4.1 below for further details).

(b) *māna*: This refers to dry capacity measures in general.

(c) *mūṭai:* This means sack-load, packed-bundle, a specific amount of grain packed in a sack, etc. (DED, 4134).

(We shall see in 5.1.2 of Part II that the lexical form *mā* fits  and the forms *māna* and *mūṭai* fit respectively  and). These discussions then suggest the possibility that the fish sign might have been used to signify a volume measure. In addition, it is also possible that in the context of units of commodities, the word *mā* in an archaic stage, being the word that stood in general for animals, might have stood for a suitable unit of edible flesh of hunted or domesticated animals, certainly an important commodity that might have been exchanged, which then later might have taken for instance the form of a volume measure of a grain, as is quite natural in the context of barter transactions.

It appears that the idea of 'phonetical transfer' is involved in using the fish sign to signify the measure having the word value *mā*. Unfortunately, such straightforward interpretations do not have the support of logical reasonings with respect to an evolutionary process. There are many other signs having similar difficulties. We shall take up the problem at the final stage of the paper in Section 6 of Part II, even though answers to such problems are not essential to this paper.

3.4. Analysis of fitting a metrological system with multiplicative operation

3.4.0

Now, if the roots and extended roots have the possibility of representing various units of measures, as is demonstrated by the previous step, then the construction units formed by the roots and extended roots, with signs in C4 as appropriate modifiers, have the meaning that various units of measures are multiplied by appropriate numbers and new units are formed, since the signs in C4 have numeral signification. The structure of the principal block is that these newly formed units are put together in a syntactic order. The next question then is as to the meaning of the principal block as as whole. The possibility that the constituent construction units represent units of different items can be excluded since it leads to several contradictions. For instance, since the texts are very brief and seals are intended for repeated use, it would be more practical to use different seals for different items. In addition, several principal blocks have repeated occurrences in several texts, either forming part or whole of a line, with the same syntactic order. Then the question arises as to why different items were represented by the same syntactic order. Further, a text representing more than one item cannot be used for the general purpose of tagging individual items.

Thus we shall proceed under the possibility that different construction units of the same text represent a single commodity. Similarly, the possibility that the principal blocks represent abstract counting of units of measures, analogous to the present decimal system, or the sexagesimal system of Sumerian, can be excluded since too many signs are involved and the syntactic structure is much more complex; see 3.4.1 below for more details. In fact, the structure is analogous to the structure involved in the construction of phrases of the spoken language. For instance, the construction units have preferences to align with certain other well chosen construction units. Thus, we shall look into the possibility of the principal blocks representing words and phrases associated with various units of measures, which had their own evolution in the spoken language starting from the stage when the humans faced the necessity of employing various metrical units together with counting and other operations associated with them.

3.4.1

To indicate the possible structure involved in such words and phrases, let us first recall a few of the phrases associated with the Sumerian numeral system: *u* = 10, *gesh* = 60, *gesh-u* = (60)(10) = 600, *shár* = (60)(60) = 3600, *shár-u* = (3600)(10) = 36000, *shár-gal* = (3600)(60) = 216000, *shár-gal-u* = (216000)(10) = 2160000, *shár-gal-u-nu-tag* = (216000)(60).

These are just a few of the available phrases. Many more similar phrases can be found, for example, in Ifrah (1985). Here, the mathematical structure involved is a certain form of stage by stage accumulation process, and is formed within the spoken language. At each stage the amount of the previous stage is accumulated a certain number of times. More specifically, at each stage, the 'items' of the previous stage are 'measured' analogous to the manner in which measures are used, except that the quantity of the previous stage is treated as a suitable lower unit of the measure used at the current stage and the measurement is done in terms of the lower unit. Thus, for instance, if the previous amount is A, and since one pound is equivalent to 16 ounces, 'pound of A' can mean the amount A is taken or counted sixteen times.

It may be noted that the numbers specified above are constructed from only two basic numbers, 6 and 10, through the accumulation process. It appears that these two numbers, in Sumerian, were evolved from concrete counting and metrical measurements, see for instance Friberg (1978). It is also interesting to note that there was an archaic stage in the evolution of the numeral system where the numerical operations were done basically through various concrete metrical units, and the numbers could be defined (that is, formed part of the spoken language) only in terms of such operations.

In the case of Indus, we have to search for the evidence analogous to the preceding one in different ways. The excavations of Indus sites have yielded stone weights of excellent finish in two series, binary and decimal, in the ratio of 1, 2, 4, 8, 16, 32, 64; 5, 10, 20, 40; 160, 200, 320, 640, 1600, 3200, 6400, 8000 and 12800, see Mackay (1938). It has been observed (see, for example, Venkatachalam (1986)) that weights equivalent to these weights have been in use in India, at least in certain parts, until the recent past. In addition, a conversion table (the significance of which for the present context will become clear below) containing fractions, precisely in the preceding denominational ratios,

was in use for reckoning measurements of one commodity to another, in the barter system of trading and business. Each fraction in this table is assigned a name in the form of a word or phrase. The fractions with words are: *oru* = 1, *arai* = 1/2, *kāl* = 1/4, *vīcam (ma-kani)* = 1/16, *mā* = 1/20, *kāni* = 1/80 and *muntri* = 1/320.

Examples, to mention only a few, of those with phrases are: *arai-k-kāl* = (1/2)(1/4) = 1/8, *arai-vīcam* = (1/2)(1/16) = 1/32, *arai-k-kāl-vīcam* = (1/8)(1/16) = 1/128, *nān-mā* = (4)(1/20) = 1/5. *kīl-nān-mā* = (1/320)(1/5) = 1/1600, *kīl-arai-k-kāni* = (1/320)(1/2)(1/80), *kīl-arai-k-kāni-e-arai-mā* = 1/102400.

These phrases have the accumulation structure similar to the one involved in the preceding Sumerian system, that is, each higher unit is formed from the lower units through a type of accumulation process indicated earlier.

In connection with the above words and phrases it may be noted that the fractions such as *mā* = 1/20 initially might have stood for a suitable 'relationship' between the measure *mā*, see 3.3.2, and a suitable lower unit, that is, it is possible that 1/20 originally stood for the relationship that '1/20th fraction of *mā* is equivalent to a specific lower unit'. Thus, it is possible that *mā* initially stood for a unit of (grain) measure, as was indicated in 3.3.2, as well as the number 20. This is possibly the reason that the fraction *vīcam* = 1/16 has also the alternative phrase *mā-kāni* whose value by the multiplication process is given by (1/20)(1/80) = 1/1600. Similarly, the multiplication process associated with the last of the preceding phrases gives the value 1/2048000, which is different from the one stated above, which only corresponds to the phrase obtained from the same phrase with the last word *mā* ignored.

In support of the preceding possibility and to indicate the significance of the above table, it may be mentioned here that in India, throughout the 'historical period', there were three related systems associated with numerology and metrology, namely the decimal place value system of counting, the system of fractions, and the system of metrology. As far as we can determine, the basic structures of these systems were essentially uniform throughout India, though the specific lexical forms differed to some extent. In addition, the system of fractions and the system of metrology were closely related in the sense that both had the same structure and used the same lexical forms to a considerable degree. Thus the lexical forms such as *mā, kāni, vēcai* involved in the above phrases, and many others involved in similar

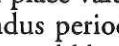
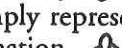
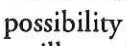
phrases not mentioned here (see for example Venkatachalam (1986)), stand for standard metrical units employed during historical periods. Note that these forms are the same as the ones suggested in 3.3.0. It is also important to note that each one of these generally stood for more than one form of metrical unit, such as weight, area, volume, in addition to fractions or numerals, and the specific values varied with respect to temporal and geographical differences. These facts indicate that these lexical forms must have had a long process of evolution in the barter system of business and trade. As was already indicated in 3.3.0, the possibility of identifying many of these lexical forms with the possible word values of appropriate roots will be dealt with later, in Section 5 of Part II.

It follows from the preceding discussions that elaborate units of various measures were evolved, in the barter system of business and trade, through the accumulation process, in the form of words and phrases of the spoken language having also the meaning of appropriate numerals. It is possible that the standard quantities or numerals signified by such phrases were also added, not in the text but in actual use, that is, combined using additive operation; but it is not clear if the resulting quantity was signified as a whole in the spoken language, except in those cases where the resulting quantity of measure either came to be established as standard or could be expressed in terms of standard phrases through the multiplication process. The situation might have been analogous to the various denominations of present systems of currency, where the amount of any value can be obtained by adding suitable denominations, but addition of arbitrary denominations may not coincide with any of the denominations.

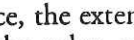
However, so far as the numeral signification aspect is concerned, it appears that in the case of Indus, the system of counting might have had a course of evolution different from the preceding system, eventually resulting in the present decimal place value system. In fact, we shall see below that the signs having the values 10, 100 and 1000 are also employed in the texts; while these values have etymologies associated with concrete counting, the decimal place value system of counting is completely absent in the texts. But it is generally believed by scholars that the *form* of the decimal place value system we currently employ originated in the Indian sub-continent, see for instance Ifrah (1985), (though the decimal system itself would have been of independent use in various forms among other cultures). One of the conclusions of this paper is that the system of metrological units

employed in India during the historical periods originated from the Indus period. Assuming this for the moment, one can then argue for the possibility that at least some restricted form of decimal place value system of counting might also have existed during the Indus period. Such a system, or even the current form of decimal system, would have been far less efficient in representing the quantities represented by standard phrases indicated above, since those quantitiers were evolved through a multiplication process. In addition, words and phrases that correspond to the counting representation will be different from those that actually represent the quantities of measures involved so that an additional conversion process and familiarity with it are required.

With the preceding evidences, there is then a strong possibility that the construction units are put together so that each principal block as a whole corresponds to an accumulation (multiplication) process. Another strong reason for the possibility of a multiplicative nature of the system is that any known system that is dominated by the additive operation, and that is not tied to any specific concrete situation, employs not too many signs. This is because any systemization involved in such a process needs to take account of the fact that an additive operation allows to segment any unit into a suitable combination of a relatively few standard units, as is the case in the decimal place value system and the sexagesimal system of Sumerian. Further, such systems are associated with the system of counting. It is true that they are used in the context of specifying the amounts of measures, but the system that corresponds to the counting part can be isolated from such contexts, as is the case for instance in Sumerian accounting tablets, where one can 'see' that it is usually made easier to identify, at least for those who used the system, the part involving the counting system from any other possible system involved in the same tablet. Now, as is clear from the previous steps, a definitive systemization is involved in the texts. This will then exclude the possibility of a place value additive system for the text as a whole, since the number of signs involved is too large, though this fact need not exclude the possibility of the domination of additive operation. However, such an additive operation is inconsistent with some of the internal evidences. First, recall that a typical text is of a single line only, and there is no reason to believe that the principal blocks involve more than one system. Now note that in several texts there are reduplicated occurrences of the same root or extended root, such as the forms  (with frequency 70) and  . Such occurrences are consistent only with the

accumulation process (unless they are treated together as a single sign, which is however not the case), since if the underlying operation is meant to be additive, they could have been simply represented in the forms  and  , since the combination forms a stable combination, and combinations similar to the first one also occur. The same type of contradiction arises for combinations similar to the pair  , since has the possibility of numeral signification. In fact, a glance at the concordance will reveal that combinations such as this form a substantial part of the structure of the texts.

On the other hand, ambiguity appears to exist (in our analysis of the texts) as to which one of the construction units, when more than one are involved in the principal block of a text, is treated as a unit of measure, with the remaining ones treated as numerals in a suitable concrete sense. Such ambiguities might be due to the conventionalizations inherent in the evolutionary nature of the script. In this connection, it may be recalled that the structure of the writing, which is uniform for all the texts, corresponds to the spoken language and the construction units have the tendency to align with high chances with a few other well chosen units, as a glance at the concordance would reveal (see also the texts given in Section 4.3.0 below). Further, the texts have open-ended use. That means, especially if one takes into account the temporal span of the corpus of the texts, they involve predominantly either standard and familiar units of amounts, or composed by such ones. Thus the ambiguity in question is inherent only in our analysis of the rules of the writing, but not for those who actually used them. These same preceding points also lead to emphasize that the character of the texts we are dealing with is different from that of the Sumerian accounting tablets or the analogous ones of Linear B in the sense that these contain self-contained informations, at least for those who used them, whereas those involved in the present analysis acquire appropriate meanings only in the context in which they are used. In other words, the texts we are dealing with are analogous, in a suitable sense, to the various denominations of a (single) currency system, whereas those of the accounting tablets use a similar system as a tool in recording appropriate informations which might involve other systems also, at least implicitly to be understood by the users. In this connection, a substantial number of burnt clay tags recovered at Lothal (Rao (1979)) containing multiple seal impressions, may be recalled.

It should also be emphasized that by these discussions, we do not mean to imply that additive structure is completely absent in any form. In fact we shall see later, for instance, that when the combinations are formed within the linear modifiers of C4, the structure involved is additive, but note that such combinations again serve only as modifiers of roots or extended roots in the formation of construction units. To give another instance, the extended root  or  might mean three times the value of the root  . In general, additive operations can occur only within the construction units, as will become clear later in 3.6.3.

In such an accumulation process, then, each construction unit acquires two meanings, depending on the convention and the place of its occurrence in the principal block: either the meaning of a specific numeral in a concrete sense or the meaning of a specific unit of measure. In this way, a certain amount of commodity is specified in the form of a word or phrase or a combination of these. There is no reason to suppose that the nature of this commodity differs from text to text, since all the texts have the same functional purpose. The most likely commodity is some kind of grain, but we shall return to this point later. *However, it is important to note that since the system evolved in a barter system, it is unlikely that grain measures were always consciously perceived whenever the texts were in use.*

3.5. Further analysis of fitting numerology

3.5.0

With the preceding understanding of the nature of the principal blocks it would be now convenient to study the functional nature of the signs in C1 - C3 as well as other unclassified signs. First let us take up the class C3a. The signs in C3a occur mostly in the form a single occurrence at the right side of a principal block, with a conventional sign from C2 forming a bridge between the principal block and the sign from C3a. Since, as noted earlier, these signs also occur within the principal blocks having the character of a linear modifier as well as, depending on the context, the character of an extended root, the possibility that they stand for numerals, at least in a concrete sense, cannot be excluded. In fact, if one further looks closely at the external forms of the signs

the first two of these correspond to etymologies of ten, and the third one to hundred.

To see this, first let us list some of the words that have both the sound value as well as the meaning approximating that of the numeral ten.

(a) *pattu* (DED,3236) = ten

(b) *pattu* (not listed in DED) = to flock (the herd)

(c) *paṭṭi* (DED,3199) = cow-stall, sheepfold, hamlet, village

(d) *paṭi* (DED, 3187) = a specific weight, an ordinary measure of capacity, fixed daily allowance for food.

(e) *paṭi* (DED,3188) = step (at the entrance of a room or house), stair.

(f) *paṭai* (DED,3195) = army, crowd.

(g) *piṭi* (DED, 3412) = to catch, collect

(h) *pāṭi* (DED, 3347) = town, hamlet, pastoral village

(i) *peṭṭi* (DED, 3600)= box, chest, basket

(j) *poti* (not listed in DED, but see 3686) = bundle

A meaning or concept that can be derived as common to these words, except (e), roughly is 'collection'. Regarding the exceptional case (e), it is possible that both the place where cows or sheeps were herded, as well as the entrance or gate to that place were not differentiated lexically at the archaic stage. Thus, one possibility is that the numeral ten evolved from the concrete counting of herds or people or objects, and initially might have just referred to 'one herd' or 'one collection'

Now, let us look at the word for hundred, and a few other words having sounds and concepts similar to hundred.

(a) *nūru* (DED,3090) = hundred

(b) *nūru* (DEd, 3089) = to break, crush, etc. in pieces.

(c) *ūru* or *ūr* (DED, 643) = village, town, city.

(d) *ūru* (DED,648) = gather (as milk in the breast, toddy in palm flowers), to spring, flow (as water in a well), etc.

(e) *ūr* (DEd, 642) = extend over a surface (as spots on the skin), flow (as juice from the sugarcane).

(f) *u̲ru* (DED,609) = to be numerous, abundance, multitude.

(g) *u̲ru* (DED, 608) = come in contact with, touch, love, friendship, relationship, to crowd, be close together, place of residence, etc.

A general concept that can be approximately associated with (c) - (g) is 'close gathering' or 'gather closely'. The difference between (a) and (b) is not much in the sense that depending on the context 'a hundred' can be used, possibly with a change in tone, to have the meaning in (b), that is, to 'make it hundred'. This suggests the possibility that *on-ūru* or *aṉ -ūru* → *nūru*, meaning 'one-gathering'. Similarly it appears that *ā-ūru* → *āyuru* → *āyira(m)*, where the rightmost side currently means thousand, and the left side can be taken to mean 'big-gathering', with *a* possibly signifying 'big', since *a* is associated with admiration, wonder, etc. (DED, 281).

With these preliminaries, let us now look at the signs  ,  ,  . The last one is a ligature of the first two, so that the first two must have different meanings. The one that appears to be a layout of a city or town is the second one so that, based on the preceding etymology and since we have already shown that the sign has the numeral meaning, it might have initially stood for one hundred in a suitable concrete sense and then might have evolved into signifying the numeral one hundred. In that case, the third sign represents a unit next to one hundred, and the first one possibly represents a unit less than one hundred. In

addition, in analogy with the second one, the first one has the appearance of an enclosure  with a gate  , initially possibly signifying the enclosure where the domesticated animals were herded; it has the meaning of a 'collection' and has the sound value approximating that of ten, according to the preceding etymologies. This possibly means the sign initially represented a collection of ten animals, and then evolved into representing 'a collection of ten'. Then, the third one must stand for one thousand. (Note that is not to be associated with the root , see the remark 1 of Section 2.2.2.)

In this connection, it may be noted that a sign in the form was used by Sumerian to signify sheep, and a similar sign (in the impressed form of a deep circle) to represent ten, on archaic clay tablets. We have already seen a similar analogy with respect to six, see Section 3.2.2. We have not attempted to identify and analyze other possible similarities. Regarding the metrological analysis of the Sumerian archaic tablets, see for instance Damerow and Englund (1987).

Now, let us look at the sign  , which also occurs in the form . This is the most frequent single-occurrence sign of C3a, having the frequency 376, occupying the right end position with frequency 298. Recall that we have already mentioned the possibility of certain numerals having concrete significations with respect to both concrete counting as well as to a suitable concrete volume metrical unit. In this sense, there are several suggestions to the possibility that might stand for ten, derived in a suitable sense from the root , or its variant , in connection with a volume measure. In this connection, see the item (d) of the words listed above in connection with ten. It is also important to note that signs and occur within the same texts only twice, in spite of the high frequency of their individual occurrences, where appears to have the meaning of an extended root. These points will become more clear later in 5.1.3 of Part II, where we shall derive the possible sound value of the root , which will also suggest the sound value of to be approximately that of ten, accounting for the difference in forms between and .

3.5.1

Now, let us look at the remaining signs of class C3 :

Since these occur within the principal blocks with the dominant character similar to that of linear modifiers of C4, it is clear that they have numerical meanings, but unfortunately we have been unable to find any clues as to their precise values. However, one can make the following observations (whose plausibility will become clear below in 3.6.3.) First, the sign  is one of the frequently employed signs on pottery of the pre-urban phase. It is possible that it is derived from the bow sign  , which has the character of a root. In this connection the compound sign  , which occurs twice, may be noted. Recall that the etymology of bow, *vil* (DED 4449), also stands for the word (DED, 4448) having such meanings as price, cost, value etc. Now, the sign  is a derivative (double occurrence) of and possibly has the same value as that of ; these two do not occur together within the same texts. Further, it is possible that is a combination of with another sign,  ?. The sign is possibly a conventionalized or concretized form of which stands for the combination and is employed in the pottery of the pre-urban phase, see Parpola and Shah (1991: 358-360), and section 2.3.4 above. The meanings of the two signs , are less clear. First, the possibility that they are variants of one another can be excluded since they occur within the same texts with reasonable frequency. However, there is a possibility that they are composed of other signs. For instance might possibly stand for the composition such as of the sign . Similarly, , which has variants such as might stand for the combination . It thus appears that the signs so far discussed are composed of two signs, and . The precise nature of the operation, additive or multiplicative, involved in such compositions will be discussed below in Section 3.6.3, where further arguments regarding the preceding possibilities are given. Next, the sign forms a stable combination exclusively with the root , except in two instances that involve numeral modifiers. The sign appears to be related to the sign in the form of a

slanted line that occurs regularly in ligatures such as  and , see Section 2.3.3.

3.5.2

Now, with the numeral meanings for the signs in C3, together with the meaning of suitable amounts for the principal blocks, the possible role of the conventional signs of C2 that bridges these two is clear. That is, the amount specified by the principal block on the left of the conventional sign is 'multiplied' by the number signified by the sign sequence on the right side, so that the conventional signs have the semantic meaning 'the previous amount is counted or repeated or valued' a certain number of times. (It is rather curious to note that in the case of the conventional sign , the part , is often identical with the sign of C3 having the meaning 'value', as noted above). The reason why such a multiplication operation was not always incorporated as part of the principal block by introducing one more accumulation stages might be that the phrase form corresponding to the principal block could have become standard or established in the spoken language. In addition the principal blocks in general are bounded on the left side by a sign from C1, so that incorporation of an additional stage of accumulation process within the principal block might change the established form of the sequence. In general, it appears that there was considerable difficulty in introducing the abstract multiplication operation, unless it is already inherent in the evolution of words and phrases, in the form of concrete background that corresponds to an accumulation process, possibly in view of the fact that the texts were intended to be of use to the wider public, somewhat analogous to our present currency, which is understood by the wider public, including illiterates. The introduction of the conventional signs needs to be understood with this difficulty in mind.

3.5.3

Understanding the preceding difficulty will also help us to grasp the functional purpose of the sign , which, as was noted earlier, occurs predominantly in earlier stages, that is in types 3 and 2 objects, taking the leftmost position of a line and having a sign from C1 at the

right side of it. In addition, this sign appears to play the role of , which is a linear modifier having the numeral base five, in several instances of ligaturing, in particular with roots and extended roots. A few of the clearly visible among such instances are

Thus, it is possible that when this sign occurs at the leftmost position of a line, it has the meaning that a succeeding amount is counted five times, that is, both the number five and the semantic meaning 'count' are incorporated in the sign . One can also support this possibility by a certain etymology. First, note that this sign appears to be a row of lines, which has the etymology *varicai* (DED, 4310), possibly evolved in the form *vari-kai→varicai*, where in the left side *vari* means order or arrangement (of lines, stripes,etc) and *kai* means hand as well as five. Thus *varicai* initially possibly stood for the approximate meaning 'arrange or count by hand'. Often, the semantic meaning is strengthened by placing the man sign between and the signs from C1. As we have already seen, the man sign has the meaning 'measure' or 'amount'.

Another sign which is used in the beginning of a line, similar to , is . As remarked earlier (see the remark in Section 2.2.2), this is a ligature of the root by . It has been already derived that the sign is a linear modifier of class C4b. This sign is one of the frequently occurring signs in the pottery of the pre-urban phase of Rehman-Dheri, see Parpola and Shah (1991: 352-378, in particular p. 366), and section 2.3.4 above. One possibility is that might have evolved as having the numeral meaning (ten) of , with the concrete background excluded. The reason is that the linear modifiers have no concrete background, as they are classified with numeral modifiers, and all the remaining linear modifiers have been identified with numeral bases four to nine. (Also recall that the interpretation for the outer form of which we derived earlier in Section 3.5.0 is an enclosure with a gate (suggesting the place where animals were collected), with the sound value of the word for a gate being approximately the same as that of the word for ten, see the etymologies in Section 3.5.0). Thus has the possibility of standing for the numeral base ten, as a continuation of four to nine, with no concrete background. We shall also see below how several signs, with no

concrete background, have been frequently used to signify ten. Note that having more than one form for an (abstract) numeral is not unusual; the reason for this will be discussed in greater detail below in Section 3.6.2.

The following signs are related to : = plus one, and = plus two (= and two).

3.6. Analysis of operations between numerals

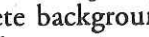
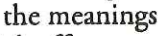
The next few sections (3.6.0-3.6.3) will be devoted to the analysis of operations between or among the numerals of classes C3 and C4, as well as to important conventions associated with such operations.

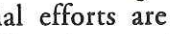
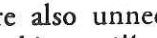
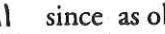
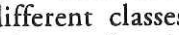
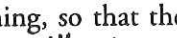
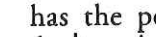
3.6.0

To begin with, let us take up the question of possible nature of operations when stable combinations are formed within the class C4. First, when the combination consists of two numeral modifiers, with the distinction between them clearly made, the operation must be multiplication. For instance, in the stable combination , the interpretation that additive operation is involved does not make sense since that would mean that a numeral sign consisting of ten strokes is represented in the preceding form of combination, which clearly cannot be a possibility.

Next, when a stable combination is formed between a linear modifier and a numeral modifier, the operation must again be multiplication. For instance, if the combination is meant to be additive, then it has the same value as , which occurs with high frequency (70). Also, the question arises as to why a certain number is represented in the form of a sum of two numbers with one of them signified by a linear modifier and the other by that of a numeral modifier.

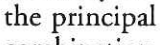
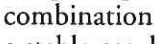
On the other hand, there are several suggestions to the possibility that the operation involved in a combination formed between two linear modifiers is addition. To see this, first consider the stable combinations and . These combinations occur with respective frequencies 101 and 40. Here is a ligature of and . Also recall that the man sign has the meaning of 'measure' or 'amount'. This means the combination has

the possibility of having the meaning 'four is measured five times' or 'the amount four is taken five times', that is, the resulting meaning is twenty. That such a special effort is needed when multiplication is intended appears to be clear, since the linear modifiers stand for numerals completely disassociated with any concrete background. If the concrete background is implicit, such special efforts are unnecessary since the meanings such as measure or amount would then be inherent. Special efforts are also unnecessary in the combinations such as  since as objects,  and may be considered to belong to different classes, even though they have the same numerical meaning, so that the combination can be taken to mean 'the abstract object is counted or taken four times'. Thus the combination  has the possibility of standing for the meaning 'sum of  and '. Note that the resulting sum is ten, explaining the high frequency of the combination. The reason why many forms of ten are employed will become clear in 3.6.2 below and in 5.1.1 of Part II, where further reasonings in support of the above possibilities will be offered.

To give a few more evidences for the additive nature of the operation, consider the lines of the form  or  , which occur in seven texts forming the entire texts. Here, if the multiplication operation is intended in the combination involved it would appear to be a mathematical textbook exercise rather than the signification of a quantity, especially since the sign has no concrete background. The reason why this form is used instead of the form  is possibly the availability of the space and to obtain a better visual appearance of the seal. As another example, consider the principal block  . Here  is a ligature of and . Since has only the semantic meaning and since , , have characters of class C4, the combination  has the character of C4, which combined with form a construction unit. The combination cannot be made sense of in terms of only one type of operation, either addition or multiplication, since then the involvement of the man sign cannot be explained. This means, both operations are involved, with signifying multiplication (see above), that is, is multiplied by  . (If is taken to stand for ten, then the combination represents 128). One more illustration may be provided. In the compound sign  , it is clear that the root  is modified by the combination  . The possibility that multiplication

is the operation involved here will make it difficult to understand the intended meaning of the combination since the signs have no supporting concrete backgrounds.

3.6.1

It may be noted at this point that on a few occasions some care is necessary in deciding on the combinations involved. For instance, in the principal block  , it is to be understood that the combination  is combined with , since form a stable combination, as is clear from its high frequency (76). This will then have a meaning different from the interpretation that is combined with the combination since this means the quantity is multiplied by the sum of , and , whereas the correct interpretation is that is multiplied by the number obtained by multiplying with the sum of and . One can also ask as to why the combination was not represented by . The reason might be that the form does not introduce any noticeable simplification in this context.

Also, in combinations such as or , it appears that first linear modifiers are added and then the result is multiplied by the numeral modifier . On the other hand, the operation involved in appears to be plus . The idea here is that if the numeral involved is somewhat large, then it is divided into two parts, if equally feasible, and then each part is represented in the usual manner using modifiers and then added. Note however that combinations such as these occur very rarely. Also note that no systemization, such as in the system of decimal counting, is involved here. This point is discussed next in more detail.

3.6.2

We have seen in the previous sections that there is no apparent systematization or unique way in the construction and the use of the numeral modifiers in forming the construction units with (extended) roots as the bases. For instance, several forms of ten are constructed and used, see below. Similarly, the stable combination involves the linear modifier whereas the stable combination involves a

numeral modifier. In spite of this, a careful analysis shows that deliberate efforts have been made to preserve certain conventionalities, even when the texts can be greatly simplified if the operations are viewed as expressions of abstract mathematical operations. In order to discuss this point in some detail it may be noted in this connection that the sign forms for one to eight are fixed and the form for nine is represented additively (and). Also, the numerals, other than 10, 100 and 1000, associated with the sign of C3 are not many. Hence, in the formation of construction units with a suitable root as a basis, it would become necessary to form new numbers from the preceding numerals with the help of additive and multiplicative operations. For instance, consider the text . Here, the principal block represents sixteen and represents five with a concrete background, so that the text as a whole represents eighty. One possible explanation for this is that at a certain time period, the unit served as one of the standard ways of representing sixteen on the seals, and then, using this familiar quantity as a basis, the number eighty was formed in the above manner. This does not mean other forms of representation of eighty were not used in the context of writing on the seals or in other systems such as the system of counting.

In this connection it may also be noted that only certain specific, well-chosen numbers can have been involved in the combination with root signs; several conventional factors might have been involved in their representation on seals. To see this, consider the case of ten, where we have indicated that many forms are used. Of these, and have concrete backgrounds and hence might not have been preferred in the construction of construction units. In fact these are mainly used as a multiplier after the signs of class C2. Some other forms, with no concrete backgrounds, are or , , . As we have seen above, the sign is also a possible candidate. These forms are not picked at random and used. For instance, the combination has frequency 101, with which it occurs at the beginning of a principal block, occupying the immediate right side of the sign of class C 1 in most of the cases. Later in 5.1.1 of Part II, we shall see in detail that the combination , which begins the text or line, might also have some auspicious phonetical reading. The same remark applies with respect to the combination , representing twenty, where the sign occurs at the beginning of principal blocks, always preceded by from C1.

Thus, when the numerals ten or twenty are involved at places other than the beginning of a principal block, they can have different representations. For instance, the form for ten occurs in the form . The reason might be the influence of the form of the stable combination .

3.6.3

Now, regarding the signs in C3, we have already seen that they share characters similar to extended roots, but also have dominant characters similar to D4 in their relations to extended roots. We also saw in 3.5.1 that many of these signs are combinations obtained from a few basic signs, but in some cases the combinations have been concretized, if they do not already have such forms, or have the appearance of having concrete backgrounds. Regarding their combinations with C4, they occur mostly with numeral modifiers of C4a, in which case the operation is multiplication.

Regarding other possibilities, first let us look at those that have reduplicated occurrences. One such occurrence is of the form , having the frequency 9. If, as was derived earlier, stands for ten with a concrete background, the operation involved is multiplicative, resulting in hundred. There is also a linguistic evidence for this possibility: *pattu* = ten, *paṅ-pattu* = (10)(10) = 100, (DED, 3236). Note that this character for , which is closer to extended roots, is different from the one for linear modifiers since a combination within linear modifiers induce additive operation, as we have seen in 3.6.1.

On the other hand, the operation within the combinations such as or , forming a *single sign*, formed by , appears to be additive. That is, the representations and represent the same value. It may be noted that is one of the earliest signs to occur in the pottery of the pre-urban phase (see Section 2.3.4), where the reduplicated occurrences of this sign is common. The occurrence of a multiplicative sign in such a context at a very early stage is unlikely since it would take a very complicated abstract form, which is inconsistent with our suggestion that the multiplicative operation is obtained only either with a concrete background or in a simple way of combining with modifiers of C4. In particular, possibly does not have any concrete backgrounds. Thus it is possible that stands for double the value of . Note that here the alternative representation

does not induce any further simplification. That is possibly the case for the sign , but now the combination is concretized. Thus the purpose of imposing concrete backgrounds for some of the signs is possibly to impose the character closer to the extended roots, in particular inducing multiplicative operation when they are combined with C4, including the linear modifiers. The ones in C3 that do not have the evidence of having concrete backgrounds are only a few, such as . Unfortunately, their operation with linear modifiers is not clear, though there are internal suggestions to the possibility that it is additive. For instance, if the sign is viewed as a combination of and , as was suggested in 3.5.1, then an additive operation is suggested, since both the signs have no concrete backgrounds.

Further, in general, when the *reduplicated* occurrence is transformed into a *single sign*, the operation is possibly additive, and such forms were possibly conventionalized in earlier stages. For instance, in the case of or , it is clear that is duplicated three times in the form of a single sign. We have seen above such a possibility for the cases such as . Similarly for the case of , if it is taken to be the reduplicated occurrence , obtaining the value 16, as was suggested in Section 3.5.1 where it was also suggested that might stand for the double the occurrence of , obtaining the value 32. Note that these two reduplicated occurrences are concretized. *One of the important reasons for suggesting an additive operation here is that it gives a progression of standard numerals analogous to the progression of the denominational ratios of Indus weights given in 3.4.1.* According to 3.5.1, the sign is also possibly involved in obtaining such a progression, but unfortunately we are unable obtain reliable clues as to the numerical value of this sign. (However, it is interesting to note that if is given the numeral value 12 with no concrete background, then several remaining numerals in the indicated denominational ratios, such as 20, 24, 48, etc. are obtained by the combinations suggested in 3.5.1).

Also, the compound signs such as , having frequency 17, appears to be a representation of = fourteen times the value of . Similarly, the compound sign , with frequency 24, appears to be a representation of the combination , that is, it is a ligature of with . Note that, if the preceding compound is viewed as a combination of with , then the value will be different, but such a possibility is unlikely since it does not hold with respect to the compound sign .

3.7. Further analysis of some compound signs

3.7.0

Now, we shall consider certain ligatured forms of the fish sign where the exact nature of the ligatures is not clear. First, let us give some statistics regarding the clearly identifiable ligatures or stable combinations;

, , , , , , , , , .

These have respective frequencies 67, 20, 4, 0, 16, 1, 9, 76, 216, 13. First, note that the combination has the zero frequency, whereas the combination has the frequency 76. This is to be expected, since both combinations have the same value and only one form is consistently employed. The same is true with respect to the combination = , since combinations such as do not occur. The combination has the frequency of only one and its alternative form is not employed either. This possibly means that the value implied by this combination is not employed or it coincides with a value involving some of the other roots. The combination that has the next lowest possible frequency, 4, is . Further, its alternative form does not occur explicitly. Thus, one possibility is that the value associated with this combination has an alternative representation involving an another root. On the other hand, if one wants to match with a ligature or stable combination, the preceding facts also imply that the most plausible candidate is , that is, this combination is simplified into . It is also interesting to note that the signs , , have high frequencies, respectively 67, 279, and 216, and the numerals involved, 2,4 and 8, form an arithmetical progression. Another numeral involved with high frequency is 5, corresponding to . In this connection, note that these numerals are the ones involved in the denominational ratios of the Indus weights given in Section 3.4.1.

Next, regarding the modified form , with a stroke-like sign inside, we are unable to understand if the modification is intended to modify the metrical value. The possibility that the single stroke just signifies the word value of the numeral one cannot be excluded since such a word is often inserted in the construction of the metrological

phrases. We face similar ambiguities with respect to the form  and several of its variants as given in Mahadevan (1977: 785). In fact, Koskenniemi and Parpola (1979) take the normalized form of this to be the variant  instead. These forms appear to be ligatures of respectively with the sign in the form of slanted line and the sign  , but the meanings of other variants of these two ligatures are even less clear to us.

3.7.1

Now let us look into the signs which occur in infilled forms, such as , , etc. With so much evidences gathered as to the numeral meanings of the signs, it appears to us that such modifications, with so much consistency and high frequencies, are likely to have numeral meanings. If this is true, then the only possibility we can suggest is that they are intended to be ligatures of the respective empty forms with or , both inducing the same change in value. The possibility that straight numerals are involved in the ligature can be excluded since no attempt is made in general to isolate the possible numeral modifiers or to indicate the number of lines used to fill in the empty forms. That is, the infilling form has taken the form of a convention, with its unambiguous meaning. With this interpretation we shall later derive the word value of that will account for a familiar and important metrical unit *(vīcai)* used during the historical period. We shall also be able to account for many of the standard numerals involved in the denominational ratios of Indus weights given in 3.4.1.

3.8. Analysis of divinity signs

3.8.0

Finally, it is now easy to obtain the precise functional character of the signs in C1. As was noted earlier, either one of these signs occurs like a rule or established convention, at the left end of a principal block. (See section 2.1.1 for a detailed discussion, from which it follows in particular that they do not have any characteristics common to other

classes.) There are external suggestions indicating that both of them signify divinity.

First, the sign  has been analyzed extensively by previous investigators for the identification of its possible sound value in connection with their attempt at phonetical readings. There appears to be no unanimous agreement as to the concrete object represented by this sign, though quite a few identify it with a vessel or container, an identification which we shall now show to be plausible on several grounds. First, note that this sign is represented in the same way as the root sign or many of its ligatures, except for the part that looks like handles, whenever these occur within the same text. We have already identified the root with a vessel or container signifying a volume measure. Second, containers in the form of volume measures are certainly one of the objects of worship, at least among the agricultural communities (of India). Third, some of the well-known etymologies for vessel, such as *aṇṭai* (DED, 110), can be taken to mean 'possessing divinity'. Further, the base *aṉ* has penetrated into innumerable concepts such as glorious, god, ancestor, mother, father, elder brother, brahman, religious mendicant, manliness, bravery, love, etc., see DED (53, 96, 112, 126, 154, 298, 342), suggesting that *aṉ* is an archaic form of signifying divinity.

The other sign, , is a spear which is well-known to signify divinity; the same is the case with respect to its word value *vēl*. Further important support of the preceding facts will be derived in 5.1.1 of Part II, where it will be shown that the word values of these signs are used to obtain suitable phrases, at the beginning of texts, having auspicious meanings.

4. Structural metrological reading and possible functions

The primary purpose of this section is illustrate the structural reading for the texts given in section 4.3.0 below, using the results of the previous sections, and to discuss a few other related points. One of the points that will be indicated, and will be dealt with in detail in Part II, is the possibility that some of the basic signs might also have been used for the appropriate sound values derived from their word values, for the purpose of a different, but related, phonetical writing system in general, though the mediums in which such writings might have been written have not survived, so that the structural reading and other conclusions

of this paper are applicable only to the class of texts under consideration. It is convenient to start with a summary of the results, in particular the classification of the signs and the construction procedure of the texts, derived in earlier sections. We shall also use different terminologies that will convey the meanings derived directly. We would like to emphasize that the summary given below gives little or no indications of the detailed logical reasonings of the previous sections, and therefore a familiarity with them might be necessary for the correct understanding of the facts.

It is also important to note that even though the system derived is a restricted one, it will have all the characteristics (see for instance Saussure (1959)) of the general linguistic system under which it functions and forms a subsystem. For instance, in the case of the numeral five, that we have identified its sign form to be the depiction of a hand simply means that five shared a common conceptual background with hand, an underlying reason for the evolution of the sign form whose *functional nature* with respect to the system itself will have largely nothing to do with hand.

4.1. Description of the system of metrology and associated numerology

4.1.0

The signs which were earlier called linear modifiers (Section 2.2.2) will now be called FIRST ORDER NUMERALS. A distinguishing property of the first order numerals is that they are used to internally modify what was earlier called (extended) roots through the process of ligaturing to form new signs having the character of extended roots. The etymology of five is hand, having evolved from concrete counting (Section 3.2.1); that of six is vessel, evolved from a capacity measure (3.2.2); that of seven is work, evolved from a unit of work or time (3.2.4); that of eight is step, evolved from length measure (3.2.3); that of ten is collection, evolved from concrete counting (3.5.0). Nine is viewed as the sum of eight and one in deriving its sign forms, though the etymology is possibly derived subtractively from ten. The details of the evolution of the sign forms of the first order numerals can be found in the respective sections mentioned above.

Their sign forms and numeral values are as follows: (four),  (five),  (six),  (seven), (eight),  (nine) and  (ten).

When a combination is formed between a first order numeral and a straight one, the operation is multiplication and the result takes the form of a first order one. Combinations within the first order ones are also formed, but predominantly in the form of stable combinations (see Section 2.2.0 for the definition of a stable combination) or in the form of reduplicated occurrences such as , and the operation involved is addition. The result takes the form of a first order numeral. In this way more than one form for ten are derived and used, for instance  =  ,  ,  , see 3.6.0 - 3.6.2 for this and other important related details. Note in particular the combinations are occasionally simplified in the form of single signs, such as  = 12 ,  = 18 ,  = 15 .

Next, the signs of C3 together with will now be called SECOND ORDER NUMERALS. These are

Many of these have concrete backgrounds, in the sense that if a combination is formed between a second order one with a concrete background and a numeral of the previous types, or among the ones with concrete backgrounds themselves, the operation involved is multiplication and the result takes the form of a second order with a concrete background. The majority of the combinations are however between a second order one and a straight one, in which case the operation is multiplication without ambiguity, and the result takes the character of that of the second order one involved. There are some second order ones, such as  which appears to have been intended as having no concrete background. See 3.6.3 for further details, in particular of the operations involved in the signs such as  .

The first four signs of the preceding list stand respectively for five, ten, hundred, and thousand, with concrete backgrounds corresponding to concrete counting, see 3.5.0, where it is also shown that the fifth one in the above list also has the possibility of standing for ten. We have been unable to derive the numeral values of the remaining ones of the above list with equal confidence, but see sections 3.6.3 and 3.7.1 for important observations. In particular, by 3.7.1, when a first or second

order ones are infilled, for instance , the operation involved is the multiplication by five and the result takes the form of a second order one with a concrete background.

Thus, = = five times the value of = 30. A few other examples are and = 80. The sign = 40 has a similar character, see Section 5.1.2 of Part II.

Next, what was earlier called roots and extended roots will now be called METRICAL NUMERALS.These are listed and discussed in 2.3.3. As discussed there, many of these metrical numerals are derived from a relatively small number of basic ones, either in the form of a modification, or in the form of a ligature mostly with first order numerals. The following are some of them, where the equivalent interpretations are based on the results of the previous sections; *in this respect it is also important to take into account the remark made in Section 2.2.1 in connection with the decomposition of compound signs.* Uncertain interpretations, but consistent with the system are accompanied by a question mark ? :

(where in particular the signs and are taken to play the same role and value when they are used to modify the (extended) roots).

Note that combinations among metrical numerals themselves are also turned into a single sign.

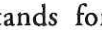
It is also possible that some of the metrical numerals, such as for instance , that have been listed as basic ones are actually derived from other basic ones, as was indicated in 2.3.2 and as is discussed in detail later in 5.1.2 of Part II, but we face the script at a stage where they have acquired their own life and their conventionalized forms do not give unambiguous indications of the basic ones involved.

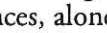
Each one of the metrical numerals stands both for a suitable unit of capacity measure and for the value of a numeral, taking either one of these characters depending on the convention and context. When these are paired with the numerals of the preceding types, the operation involved is multiplication. A metrical numeral, either by itself or in combination with the preceding types, forms what was earlier called a CONSTRUCTION UNIT. These construction units are put together in a syntactic order to form what was called PRINCIPAL BLOCKS. The operation between adjacent construction units is multiplication, in the concrete sense that a construction unit measures (counts) its adjacent unit, the number times counted is the numeral value of the construction unit. Also it is possible some of the metrical ones are used mostly or only in the form of second order ones, but such ambiguities will have no consequences. Similarly, occasionally it would also be convenient to treat the second order numerals as extended roots. The details of the derivations of these facts are given in earlier sections, see in particular 2.3.0 - 2.3.3 and 3.3.0 - 3.4.1. As noted there, and as will be explored in 5.1.2 - 5.1.4 of Part II, some of the basic metrical numerals have possible identifications with the standard metrical units employed during the historical periods.

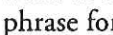
The two signs , that formed the class C1 will now be called DIVINITY SIGNS, since they stand for divinities, see 3.8.0. Either one of these is placed at the left end of a principal block. Note that also occurs in the forms , , , but these often occur at the right end of sign sequences that have the character of principal blocks. In addition to the meaning of divinity, these possibly have the values of the straight numerals involved. For instance, the possible value of the combination is simply . Also recall that (3.8.0) this sign actually stands for a vessel, so that might also stand for the value of . Also, the sign , which stands for a plough and which occurs mostly at the left end of a principal block and in the form of the

combination  , might possibly have the additional meaning of divinity, see 3.2.4 for the details.

Standard amounts specified by the principal blocks are also multiplied, mostly by a few of the second order numerals, typically by placing the multiplier at the right end of the line and by placing the conventional sign of class C2 in between the multiplicand and the multiplier. Note that if the texts are viewed as abstract mathematical constructions, the multiplier can be simply placed at the left end of a principal block. For the reasons as to why this is not always done, see 3.5.2. Also, mostly when the principal block is bounded on the left by a divinity sign, the multiplier is also placed at the left end of the divinity sign, but this is done only in a limited way, mostly by the sign  , which stands for five with a concrete background (3.5.3), and occasionally by the sign  .

The man sign  has the word value, derived by 'phonetical transfer', meaning 'amount' or 'measure' (3.2.6). It does not appear to have any concrete value since it does not clearly classify itself into any of the preceding classes of numerals. The reason for its overwhelming occurrences, alone or in the form ligatured with other signs, is possibly that the word or morpheme meaning 'amount' is often attached to the word or phrase forms of many of the metrical numerals, or it might be part of the text itself. It is also used often to impose a concrete background on a sign (see, 3.6.0), or to strengthen an already inherent one. Another reason among others is that all the numerals have evolved with respect to appropriate concrete backgrounds, whereas the word value and the functional characteristics of the man sign do not appear to allow such an interpretation. Similarly, some of the signs are occasionally employed with a single vertical stroke attached to them, such as  , the reason possibly being that standard units often come with the word meaning 'one' attached to them. For this same reason, the straight numeral of a single vertical stroke is also combined with other numerals. These points will be illustrated when we give structural reading of the texts.

Note that the preceding classifications do not include all the signs, but most of the remaining signs are related in one way or other to the signs involved in the preceding classifications, and the nature of their classifications will usually be clear once we have illustrated the structural reading of the texts, though the exact meaning of them may not always be clear. For instance, the signs  with frequency four and  with frequency 22 (these two are probably just variants of

each other) are clearly related to , but their meanings are not very clear. Some of the signs also occur occasionally in the forms such as  , where the intended value is simply  , though it might also have additional semantic meanings having no values with respect to the amount specified.

4.2. Possible functions, the direction of reading and the typology of writing

4.2.0

Before making attempts at structural readings it is essential to have a clear understanding of the possible contents and the purpose of the texts, as well as the precautions that might be necessary to observe. (In connection with the present discussion it would be convenient for the readers if in particular the detailed discussions presented in the course of the analysis of Section 3.4.1 are kept in mind). First, as has already been analyzed (3.4.1), the texts specify certain amounts of a commodity, possibly a grain. The nature of the grain is not specified, but it possibly remains the same for all texts. The structure of the construction of the texts corresponds to the construction of the words and phrases of the spoken language. In fact, construction units have the tendency to align with certain other well chosen construction units, a fact which corresponds to the conclusions of the earlier investigators that the bulk of the texts can be divided into probable words and phrases based on stable sign combinations. This means certain standard words and phrases evolved in the spoken language, possibly in the barter system of business and trade, have been used as building blocks of the texts, and the texts were possibly understood in terms of such familiar words and phrases directly, when they are involved, rather than in terms of the construction units themselves. In addition, we have seen that in the formation of construction units with metrical numerals as bases, no systematization can be clearly isolated in the formation numerals that are used in the process of modifying the values of the metrical numerals, except for attempts to preserve certain established conventionalities, see 3.6.2 for the details. These facts are consistent with the fact that texts are intended to be used and understood by the wider public, somewhat similar to the manner in which our present currency is understood by the wider public. In fact, we have already

seen that the texts in the form of seal impressions on clay bullas tagged to bales of goods were used in the context of trade and business. The texts also occur in the incised or impressed forms in objects such as bronze implements, and other objects that might have been used to carry the commodities of trade such as large storage jars and other pottery vessels. A plausible conclusion that can be drawn from the preceding facts is that the texts were probably used to price various goods and services, in terms of the amounts of a grain, the common currency. For instance, suppose a bundle of copper or bronze implements is exported from a workshop to a distant place. Then it is natural to specify the price involved in the form of a tag or in the form incised on the surface of one of the implements. In this context it is unlikely that each implement was incised with its individual price, since a transaction involving only one item normally happens between the seller and the buyer personally. On the other hand it is not clear to us if the seals and related objects functioned similar to our currency in the sense of having iconic values. However, in view of the possibility that type 1 objects evolved from the type 3 objects, such possibilities cannot be excluded. It may also be noted that in a barter system, a substantial part of the economic activities at a local level can be done without the use of any form of currency system, for instance based on the primitive localized redistributive system in which the prices of various goods and services obtained during various times of the year will be paid at the time of harvesting, but this cannot work well if, for instance, a farmer needs to obtain some essential 'industrialized' products from a distant place. Even if one assumes that the industrialized products were brought into the place of consumption periodically, it is unlikely the payment would have been accepted in the form of a grain itself. In addition, a form of currency system together with the associated redistributive system appears to be essential for the normal functioning of industrialized and trading centers. It is not clear to us if the seals could have played any role to ease such complexities, but such possibilities may not be excluded for types 3 and 2 objects and hence for type 1 seals also. We also do not know clearly how similar problems in other ancient cultures were handled. In this connection it may be noted that large granaries occur at the major sites Mahenjo-daro and Harappa (but we do not know if they are essential components of other major Indus sites also); as to what functions such granaries played in connection with the preceding complexities, we do not know the answer.

4.2.1

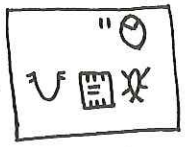
Note that we have not so far suggested any possible direction of reading or understanding of the texts or the possible classification under which the writing system on the seals falls. Regarding the direction of reading it is customary to begin by invoking divinity. Since the divinity signs are placed at the left end of a principal block, the syntactic order in which the principal blocks are intended to be generally understood is possibly from left to right. We have also identified elements of phonetization at few instances. We shall analyze such possibilities more systematically in Part II, which will also indicate a left to right direction. However, note that the amounts specified in the texts can be made sense of operationally in terms of the construction units even if they are read from right to left, but the corresponding phonetical reading will make sense in only one direction. In this connection, we have already seen the possibility that the texts were being understood in terms of words and phrases that were familiar in the spoken language. We have also indicated, as will be explained in more detail in Part II, that some of the numerals are so constructed and placed at the beginning of a principal block as to have the phonetical reading that might also give additional auspicious meaning at the beginning of the reading.

REMARK : As indicated in Section 1.2, the view that many authors are inclined to accept regarding the direction of reading is that of right to left, which is opposite to the one suggested above. For this reason we would like to demonstrate that the arguments given by the earlier investigators do not disprove the possibility of a left to right direction. First, as was indicated in Section 1.2 and as was more thoroughly discussed in Mahadevan (1977) with appropriate data, the arguments based on external suggestions support equally either one of the directions. (For an instance of the arguments based on external suggestions, see also the ones in Parpola (1995) based on the texts presented there in Figs. 4.9-4.11 and 4.13, p. 65).

Regarding the arguments based on 'internal' suggestions, it is enough to consider only those of Mahadevan (1977, section 10.13, p. 13), since this is a source most authors appear to rely on. (The remarks below also applies to the arguments of Parpola (1995) based on a single text (Fig 4.12, p. 66) relying on the disposition of only the divinity sign ). Mahadevan's analysis is based on a unique example which is split into two lines, but also occurs as a single line

elsewhere. Assuming that the first line is read first, he then draws the conclusion that this text is read from right to left. This conclusion then leads, through a study involving the order of sign occurrences, to the general conclusion that the texts are read generally from right to left. *It is important to note here that if the direction of the unique text in question is concluded to be that of a left to right, then the same identical arguments will lead to the left to right direction for the corpus in general.*

Thus the entire conclusion is based on a single text, and the assumption that its first 'line' is read first. There are several other texts having similar split sequences, but they are not taken into account, unfortunately. The assumed reason for this seems to be to avoid bias, since these sequences occur with iconography, on the main body of the seal, which may be suspected to have influenced the nature of the splitting. (In fact if such sequences are taken into account then Mahadevan's arguments will show that either one of the directions is equally a possibility.) Thus the unique example from which the conclusion is derived is a seal (Mackay 1943, Plate L1, 12) with only a text, in the form: [The form without splitting :



Now if one takes into account of the structural understanding and other results of the present paper, one can also argue that the main part of the text containing the principal block (multiplicand) is given the dominant display and the multiplier is displayed separately. In view of the brevity of the text and since the text possibly represents a familiar standard amount of a grain, as it in principle occurs three times in the corpus (but the principal block (the second 'line') itself occurs with high frequency; in fact it is one of a small number of principal blocks that occur with reasonably high frequencies), the issue as to whether the multiplier is read first or at the end would have been clear, and the exact place where it is written would have no serious consequence. To prove this claim, note that among the texts with split sequences indicated in Mahadevan (1977), one can see that the multiplier (that is, the part which normally occurs at the right end of the lines, and is supposed to be read first according to Mahadevan's conclusion) is written in either way, below or above the principal block. (The ones

specifically similar to the text in question but with the multiplier written below the principal block have identifications 2696, 5119, and 6108 in Mahadevan (1977, see the footnote 15, p. 26), but note that there the multipliers are recorded as the first line in order to be consistent with his conclusion.) Even though such texts may have bias with respect to the nature of the splitting as indicated above, they do certainly prove the fact that no difficulty was faced in identifying the part which is supposed to be read first by those who used such texts. Thus, even if one assumes that valid conclusions can be drawn on the basis of a single text, the text in question does not disprove the left to right direction.

One can also question, unfortunately, the statistical logic of the basic assumption of Mahadevan that the first 'line' is read first only in the text in question, but not necessarily in other texts with similar split sequences, since the disposition of the iconography need not be the only reason for the nature of the splitting. For instance, since the seal in question does not have iconography, the main line of the text consisting of the principal block and the divinity sign might have the possibility of playing the role of the iconography. While this argument does not prove anything, the suggested possibility is not in any way inconsistent with the results of at least this paper.

4.2.2

As far as the reading of the amounts specified on the texts is concerned, the typology of the writing may be classified as logographic (word writing), in the sense of Gelb (1963), since each sign has individual meaning in the form of a word or morpheme value, a fact which was already suggested by Smith (1931), but 'phonetical transfer' and construction appear to have been involved in the construction of many such words. This indicates that some of the basic signs might also have been used for the appropriate sound values for the purposes of phonetical writing in general. In fact, it appears that in the construction of word values of some of the compound signs or the construction units, only appropriate skeletons of the word values of the individual component signs are involved, and it also appears that the order in which such skeletons are to be read in order to obtain the word involved might vary and is governed only by certain conventions, such as for instance the convention of representing a compound sign to

resemble a concrete pictograph that will be suggestive of the intended meaning of the compound sign. It should also be emphasized that there are construction units whose possible word values are unlikely to have been always derived from those of the component signs involved. A systematic investigation presented in Sections 5.1.0 - 5.1.4 of Part II shows that the nature of the phonetical writing employed for purposes other than to represent the amounts on the seals might be more evolved than that of word-writing, though the materials on which such writing might have taken place have not survived, and *as a system such writing needs to be viewed distinct from the one under consideration. Also, one cannot ignore the possibility of the same signs having been used for other systems such as for calendaric and similar astronomical purposes, but the texts do not give any such indications, since, as far as we could determine, all the texts under consideration belong to a single system.*

4.3. The structural reading of selected texts

4.3.0

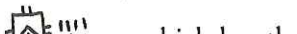
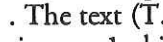
We now illustrate the structural reading for the sample of texts presented in the Appendix A of Part IA.. (Recall that there they are identified as (T.1), (T.2), etc. In what follows, the same identification is used.) The sample is not a random sample, but is purposively selected in order to illustrate certain points, though they appear to be representative of the corpus to some extent. Note however that we have already discussed several texts in the previous sections in the process of illustrations. Those are not generally repeated here, so that the illustrations below do not cover many important points already illustrated. It may also be kept in mind that the varied texts probably belong to a temporal span of at least about 600 years. Further, the structural reading will not give much indication of the nature of the phonetical reading, but a rough idea of the general nature of it can be obtained from the phrases listed in 3.4.1 and the remarks that follow them. Although we shall analyze the texts in terms of what we have called construction units, and the texts themselves probably evolved in terms of such construction units, we shall indicate that the texts might have been understood in a much simpler way in terms of further combinations of such units, since at each stage of incorporating a construction unit, the combination of the units of the preceding stages

might have become a standard amount in the form of a standard phrase in the spoken language. We shall also use the results of the previous sections without further mentioning. Note that in the presentation of the texts in Part IA (Appendix A), the principal blocks are indicated by a horizontal bracket,  , and further subdivisions,  , give the construction units involved.

First consider (T.1)-(T.4). In (T.1),  is a divinity sign, and  is a metrical numeral which is multiplied by the straight numeral seven, so that the principal block consists of only one construction unit. In (T.2) the amount of (T.1) is multiplied by the second order numeral , which stands for five. In (T.3), the metrical unit associated with (T.2) counts the amount  , the number of times counted is the numerical value associated with (T.2). Note however the text (T.2) occurs at least twice in the corpus and, in addition, it forms a part of other texts such as (T.4). This means the text (T.3) probably represents a familiar quantity in the form of a standard phrase in the spoken language, so that it might have been effectively treated as a single unit by those who actually used it. In (T.4) the principal block consists of five construction units. However note that the combination has the frequency 44 and the combination , together with its variant , has the frequency 23, so that they can be taken to be stable combinations. Thus, again, the text (T.4) might also have been understood in a much simpler way than in terms of the construction units. Note that the number of signs involved in (T.4) is more than average.

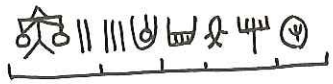
A class of texts similar to (T.1) - (T.4) is (T.5) - (T.9). In (T.5) the sign is a second order numeral, so that the metrical unit involved is either left implicitly or implied by convention. The text (T.6) has only one construction unit since only one metrical numeral is involved. In (T.7) and (T.8) the amount of (T.6) is multiplied by the second order numerals , , both standing for ten. Similar to (T.4), (T.9) might have been understood in a simpler way, possibly as a single unit.

Next consider (T.10) - (T.43). The texts (T.10) - (T.12) share a common principal block, which also forms a major component of (T.13) and (T.14). Similar character can be noticed in the remaining texts also. In (T.16) the reason for pairing the straight numeral with instead of with is that the combination has the frequency 14, having the character of a stable combination, whereas the combination occurs only in the context of this text (T.16). The same remark applies in (T.15) with respect to the combination

 , which has the frequency 27. Note that (T.16) involves two lines, occupying the same side of the object, of which the second line forms a part of the first one. The question as to whether different lines are to be treated as different blocks of the same line, or whether they represent different amounts intended to be added, will be discussed below. Also note that in the first line of (T.16) the amount of the principal block is multiplied by the numeral value of the metrical numeral  . The text (T.17) occurs, either separately or forming part of other texts, in type 1 objects, whereas (T.18) occurs in type 3 objects (with frequency 8). Similarly, the texts (T.21), (T.22) and (T.23) occur respectively in type 1, copper tablet and type 2 objects. In (T.26) the amount of (T.24) is multiplied by one thousand. In (T.30) note that  does not contribute any concrete value since its numerical value is one. Apart from the fact that it stands for divinity, we are unable to see other possible functions of it. It may be noted that occurs in such positions with high frequency 177. Note that in (T.31) we have taken the combination  as a unit since is a stable one and stands for the first order numeral seven, that is, the former metrical numeral is multiplied by seven. Similarly, in (T.33) the combination  is multiplied by  , which is a combination of and . In (T.32) the sign  stands for the combination  . The structural interpretations of (T.34)-(T.43) are analogous to the previous texts.

(T.44) - (T.55) are aimed at explaining the man sign  . In (T.44) the metrical numeral involved is  . Since the combination occurs with high frequency, 70, we have treated it as a single unit, with the understanding that the operation between the members is multiplication. Now recall that the man sign stands for word value meaning amount, and does not have in itself any concrete value. The main reason among others is that all the numerals have evolved with respect to appropriate concrete backgrounds, whereas the word value and the functional characteristics of the man sign do not appear to allow such an interpretation. Thus the sign  stands for the value 'one-amount'. It is not clear if this was read after or before the reading of the combination . We face such an uncertainty in general within the construction units. In (T.45) the amount of (T.44) is multiplied by the numerical value of  (= ten times the numerical value of .) In (T.46) the sign  also possibly has the meaning 'one amount', and the numerical value of the sign is . In (T.47), the sign  means 'eight amount'. Note that, as already noted in

2.4.3, this sign is suggestive of the act of stepping, the corresponding word value is same as that of = eight. In (T.49), stands for 'three amount', and the value of is equivalent to the combination . In (T.50) different principal blocks are put together, that is, the amount involved is

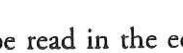
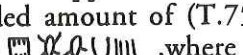
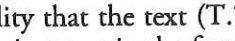


consisting of five units. Note however that the combination occurs both individually as well as part of longer texts. The combination also occurs as part of other texts. Thus, in spite of its length, this line might have been understood in a simpler way than in terms of construction units. In (T.51) - (T.53) the man sign again has the meaning 'amount', that is, the whole line is a sort of being ligatured by it. In (T.54), the pair simply means 'two amounts', written in this form possibly to have a symmetric appearance of the text. Also recall that the sign stands for the combination having the value ten. In (T.55) the man sign is attached to to have the meaning 'amount', in addition to suggest that the pictorial form is a bow with an arrow.

The next class of texts (T.56) - (T.63) illustrates clearly how the construction has proceeded stage by stage. The text (T.56) occurs, both in types 1 and 2 objects, with frequency 12, and therefore it would have been treated as a single unit, though we have analyzed in terms of three units. Note that the divinity sign is attached to the unit at the left end. Analogous to the previous texts, the remaining texts can be easily understood structurally. Note that in (T.61) we have treated the block as a single unit, since it has the possibility of being used as a separate text, though it does not occur in the corpus. Similar remarks apply to other longer texts of the class.

Let us give another class of texts (T.64) - (T.69) similar to the preceding ones. The text (T.64) forms part of the remaining texts, so that it would have been understood as a single unit. Thus the texts (T.67) and (T.68), which appear long, might actually have been understood in terms of only two units.

The texts (T.70) - (T.76) are of type 3 objects. They are chosen to see the possible nature of the operation between different lines occupying different sides of the object. The amount involved in the second line of (T.70) is rather trivial, so that the intended amount

appears to be read in the equivalent form  . Similarly for (T.72) and (T.74). In fact such possibilities are already suggested by the second line of (T.76). Next note that the first and third lines of (T.75) are combined in the second line of (T.73). Further, the amounts of these lines appear to be not too significant. Thus it appears that the intended amount of (T.75) is to be read in the approximate form  ,where note that the combination takes the alternative form  in later objects. Now note that the second and third lines of (T.71) are combined in the second line of (T.76). The possibility that the text (T.76) was also intended to be read as a single line, for instance in the form  cannot be excluded, though it cannot be decided on, since such compound texts are common in type 2 objects, which possibly immediately succeeded, as well as partly overlapped with, the type 3 objects, as the instance of a line (T.77) of type 2 suggests

We face the same type of uncertainty with respect to some of the texts of multiple lines of type 1 objects. (Out of 1232 objects of type 1 from Mohenjo-daro, we counted only about 85 cases with multiple, mostly double, lines.) Note that since the operation between different units of the same line is multiplication in the form of a single phrase, one may feel free for convenience to represent the phrase fairly arbitrarily into more than one line. In such a case not all lines will have the character of a text. In fact there are texts of this type. On the other hand, there are very few texts where the intended operation between the lines appears to be additive. This is the case for instance when the lines on different sides are identical. As an another example consider (T.78), which appears to be the longest, clearly legible text to occupy a single side of type 1 object in three different lines. Here, each line has the character of a complete text of more than average length, with no indication of the connection between different lines. The possibility that these lines are intended to be a single line or phrase does not have anything common with the rest of the texts of a single line. As an another example consider the longest text (T.79) with three different lines occupying three sides of a type 2 object. Here, note that since a type 2 object is not intended for making impressions, the functional value at any single instant of use does not differ from the previous case where all three lines are represented on the same side. The characters of the lines also remain the same. Further note that the combination occurring in the first line appears to have been used as a variant of the combination  =  in type 3 objects. Also note that in

the third line, the construction involves, except for , only numerals other than metrical, but the construction units can be formed by treating the second order numerals as metricals, as indicated earlier.

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