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
ACCOUNTING MEASUREMENT AND CAPACITY LIMITS OF TECHNOLOGICAL DEVICES*

Abstract: In this paper the capacity limits of technological devices used in ancient Egypt are used to explain the Biblical phrase that in accounting for grain the Egyptians ran out of numbers.

The Bible describes accounting for the quantity of grain that Joseph stockpiled during the seven years of plenty in anticipation of the seven years of hunger. "And Joseph laid up corn as the sand of the sea, very much, until they left off numbering; for it was without number" [Genesis 41:49].

The phrase "without number" is puzzling. How was it possible to run out of numbers? The set of numbers is unbounded. A larger number can always be created by adding one to the previous number.

A study of the ancient Egyptian numbering system [Gardiner, p. 191] confirms the impossibility of running out of numbers. The Egyptians had symbols representing the number one, ten, and all powers of ten up to a million [see Figure 1]. Symbols were repeated to show multiples of numbers. For instance, 152,123 was expressed as:  and 966 was expressed as: 

Furthermore, multiplication was occasionally employed to express larger numbers. For instance, 10,100,000 was expressed as $100,000 \times 101$:  and 470,000 was expressed as $(100,000 \times 4) + (10,000 \times 7)$:  In such a numbering system one cannot run out of numbers.

We suggest a solution based on the assumption that in Joseph's time the Egyptians used an abacus for numbering. This assumption has not been proven but there is some supporting evidence.

Herodotus [circa 450 B.C.E.] describes his experiences in Egypt and explains that "in the writing of characters and *reckoning with pebbles*, while the Hellenes carry the hand from the left to the right, the Egyptians do this from the right to the left" [p. 23, emphasis supplied].

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Figure 1

Egyptian Number Symbols

1		10,000	
10		100,000	
100		1,000,000	
1,000			

Source: Gardiner, Sir Allen. *Egyptian Grammar: Being an Introduction to the Study of Hieroglyphs*. London: Oxford University Press, 1969, p.191.

In his classical work on the development of numbers, Menninger [p. 299] claims that:

The problems and questions in Egyptian papyri offer some intriguing glimpses into the mathematical thought of Pharonic times, but the actual operations by which the Egyptians found or attempted to find the solutions must be laboriously deduced from the rules, and can often be only guessed at. We know the numerals used by all of these ancient cultures [the Babylonians, Egyptians, Indians, Greeks, and Romans]. These support the hypothesis that computations were performed on counting boards.

Given the assumption that the Egyptians used an abacus, it is possible to explain how they ran out of numbers. Joseph set up a multiple warehousing system under the control of a central administrator whereby each city warehoused its own food. As Joseph suggests:

Now therefore let Pharaoh look out a man discreet and wise, and set him over the land of Egypt. Let Pharaoh do this, and let him appoint overseers over the land, and take up the fifth part of the land of Egypt in the seven years of plenty. And let them gather all the food of these good years that come, and lay up corn under the hand of Pharaoh, for food *in the cities* and let them keep it [Genesis 41:33-35, emphasis supplied].

Joseph implements his plan. "And he gathered up all the food of the seven years which were in the land of Egypt, and laid up the food *in the cities*. . ." [Genesis 41:48, emphasis supplied].

Joseph must have estimated how much food would be amassed and distributed an abacus to each city for keeping count of the amount of grain stored. However, the amount of grain amassed far exceeded Joseph's estimate and was larger than the capacity of the abacus. If there was only one warehouse the problem could be solved by issuing a larger abacus with an extra digit or by re-defining the units of measure of the abacus. However, since the warehouses were spread all over Egypt it was impractical to implement a solution to this unexpected accounting problem.

The Bible, in stating that they ran out of numbers, is thus observing that the quantity of grain amassed was a magnitude greater than originally estimated by Joseph. The error the Egyptians faced may well be the first overflow error on a calculator.

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