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Mathematics Embedded in Akan Weaving Patterns

Contents

Introduction

Kente has become a well-known name synonymous with a certain kind of Akan and Ewe cloth. In this article, I intend to show, perhaps for the first time, the mathematical knowledge possessed by the original inventors of this method of weaving practised by the Akan and the Ewe. The reader will find herein mathematical patterns such as even and odd numbers, triangular numbers, “Pascal's triangle” and the binomial theorem. Most intriguing, and what certainly caught me by surprise when I first decoded this mathematical pattern, I will show that Akan weaving patterns embed the so-called Fibonacci numbers from which can be obtained the golden spiral (a kind of logarithmic spiral) and from which the golden ratio is also derived. I also show other mathematical patterns which I have identified but have not yet associated with any body of known mathematics. Perhaps further research will identify these number sequences. I also show the use of recursive triangular and rhombus patterns in kente cloth which suggest a certain level of fractal encoding as well.

I have specifically referred to these patterns as “Akan weaving patterns” because the original patterns used for this analysis came from Akan weaving patterns R. S. Rattray observed in Asante country, and which he meticulously recorded in his book “Religion and Art in Ashanti”. Rattray being a Virgo (with moon in Aquarius) was very careful and detailed when he recorded Akan culture “as is”, that is, as he literally experienced it while living among the Akan for about 35 years, at the turn of the 20th century. The Asante themselves credit their knowledge of weaving to the people of Gyaman (from whom they also obtained the fascinating Adinkra symbols). From the historical evidence Meyerowitz obtained from Akan elders, we know that the people of Gyaman, or Dia-man, migrated from the North (the North-East to be exact), settled in Timbuktu before travelling to the Northern parts of what are today known as Cote d'Ivoire and Ghana, eventually settling throughout regions of these two respective countries.

We can thus say that the weaving patterns Rattray recorded in his book belong to the heritage of Akan and perhaps even a wider African family, rather than being unique inventions of the Asante sub-group of the Akan people. The presence of encoded Fibonacci numbers and other fractal-recursive patterns in Akan weaving patterns may point to this knowledge having come from ancient Kemet (Egypt), Nubia or beyond.

Brief History of Weaving among the Akan people

Preceding the advent of European cloth and thread to the African continent, traditional African weaving made cloth out of tree bark. In Asante country, this bark cloth is known as “Kyenkyen” and is now sometimes associated with people who are too poor to afford modern cloth. As a curious aside, the word “Kyenkyen” is perhaps the source of the Akan expression “Kyenkyen-Ma” which means “old and outdated”. Apparently, hunters still sometimes dress in bark cloth.

Among the Akan, the loom is known as “Ɔdomankoma nsa dua Kofi”, which translates as “Kofi, the Creator's loom”. Among the Akan (and quite likely among the Ewe as well), weaving, like drumming, is a sacred undertaking which is accompanied by the appropriate rituals and where taboos are observed. So the Akan have their “Divine drums” and the loom can be called “Kofi, the Creator's loom”.

According to the Asante, during the reign of Oti Akenten, an Asante chief from an earlier period, one Ota Kraban journeyed to Gyaman (in present day Cote d'Ivoire) and upon returning, brought with him the first loom (known to the Asante). This loom was set up in Bonwire in Asanteman (Asante country) on a Friday. (Rattray, 1927, p. 220). The association with Friday is perhaps the reason why the loom has the Akan name “Kofi” as part of its name.

The taboos surrounding the use of Ɔdomankoma nsa dua Kofi, “Kofi, the Creator's loom” suggest that rituals are used by Akan weavers to infuse the loom with spirit. For instance women were not allowed to be weavers because of their menstrual periods. To the European observer ignorant of the workings of Spirit, such taboos may be seen as the illogical, childish predispositions of a savage race. This trend seems to be changing in current times however.

In his book “Cloth as Metaphor”, G. F. K. Arthur makes the case that Akan blacksmith, gold smith and weaving technology may have originated from the Bono Akan, a group of the Akan who are known to have had an ancient history long before the Asante rose to power as the strongest of the Akan groups in contemporary times, and who were close to the people of Gyaman. I think it is possible that the technology even predates the Bono Akan in the Brong Ahafo region of Ghana.

Mathematics in Akan Weaving Patterns Decoded

Between chapters 24 and 25 of Rattray's book (Rattray 1927, p. 251-263), in the section called "Patterns of Asante weaving", we see some of the weaving designs Rattray personally observed being done by Asante weavers all over Asanteman and particularly in Bonwire while he was living with the Akan-Asante people. I shall reproduce the pattern frames in this work (see Appendix A).

Triangular Numbers and Number Sequences in Akan weaving

When looking at the weaving patterns that Rattray recorded (see Appendix A), one has to pay attention to two things as far as the triangular patterns are concerned:

i) The patterns made by the black lines
ii) The patterns made by the non-black lines, which are found in between the patterns created by the black ones.

I have to point out at this early stage that the most interesting patterns I decoded were the ones in between the black lines, i.e. the non-black patterns. Later on in this paper I shall show how the Fibonacci numbers were hidden in these patterns between the black lines.

<u>Variation 1</u>
We shall begin with a common pattern that one can observe, primarily with the black lines (see Fig I in Appendix A). The weaving technique forms a pattern of lines that fit the form of a triangle:

number	woven design
1	I
2	I I
3	I I I
4	I I I I
5	I I I I I
etc	

One of the most common designs found on kente cloth is in the form of counting numbers used to create the triangle above. In mathematics, the 'counting numbers' are 1, 2, 3, 4,... basically they are the positive whole numbers greater than zero.

Summing up counting numbers

Counting numbers are interesting because one can find the sum of the first 'n' counting numbers with a simple formula. In other words, imagine you have a sequence of numbers: 1, 2, 3, 4, 5 . . ., up to the number "n" where "n" is the n^{th} number. This 'n' could be anything from for example the number 6 to say 10, 25 etc. In the case where n=10, we have the sequence 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

A well-known simple formula for summing up the first "n" numbers is [n x (n+1)]/2.

Therefore, if we follow the formula above, summing up the first 10 numbers where "n" = 10 is [10x11]/2 = 110/2 = 55. One can easily check on their calculator that this is the correct answer. One can also prove (by induction) that this formula will always work for any number "n". The formula can also be written as $(n^2 + n)/2$

Variation 2

One of the triangular patterns created by the non-black lines in Fig I (Appendix A) is the same as the triangular pattern shown above, only that it has a slightly different arrangement:

number	woven design
1	I
2	I I
3	I I I
4	I I I I
5	I I I I I
(etc)	

Variation 3

Still on Fig I (Appendix A), another pattern displayed by the non-black lines shows a triangular number pyramid that shows odd numbers:

number	woven design
1	I
3	I I I
5	I I I I I
7	I I I I I I I
etc	

The sum of the first "n" odd numbers:

$1 + 3 + 5 + 7 + \ldots + \{2n -1\}) = [1 + (2n -1)] \text{ x } (n/2) = n^2$

This is a curious sum, one that we can check out by looking at the first few terms:

1 + 0	=	$1 = 1^2$	(for "n" = 1)
1 + 3	=	$4 = 2^2$	(for "n" = 2)
1 + 3 + 5	=	$9 = 3^2$	(for "n" = 3)
1 + 3 + 5 + 7	=	$16 = 4^2$	(for "n" = 4)

etc.

So the formula seems to work for the first 4 terms. If we wanted to, we could prove by induction that it really does work.

Variation 4

The next triangular number pyramid (shown by the non-black spaces) we can investigate on Fig I shows a progression of even numbers:

number	woven design
2	I I
4	I I I I
6	I I I I I I
8	I I I I I I I I
10	I I I I I I I I I I
etc	

We then do what we have done with the last 3 examples: investigate the mathematics behind the pattern:

2 + 4 + 6 + 8 + 10 + , … + 2t (where n = 1, 2, 3, 4, …, t). This can be re-written as 2 x (1 + 2 + 3 + 4 + 5 + … + t) = 2 x [n x (n+1)]/2, which simplifies to n x (n+1), which can also be written as $n^2 + n$.

Let us test our formula with some examples as we have done before:

2 + 0	=	2 = 1 x (1+1) = 1 x 2	(for "n" = 1)
2 + 4	=	6 = 2 x (2+1) = 2 x 3	(for "n" = 2)
2 + 4 + 6	=	12 = 3 x (3+1) = 3 x 4	(for "n" = 3)
etc			

So the formula seems to work, as we expect it to. This completes the varieties of triangular number pyramids found on Fig I. This one figure has shown counting numbers (1, 2, 3, 4, …), odd numbers (1, 3, 5, 7, …) and even numbers (2, 4, 6, 8, …). This is remarkable, but there is more to come!

On Fig II (Appendix A), we see that the triangular number pyramids created by the non-black lines have the (1, 3, 5, 7, …) pattern as well as the (2, 4, 6, 8, …) pattern, however there is another triangular number pattern here as well, created by the non-black lines.

Variation 5

This triangular number pyramid increases by 4 units each time, starting with 3 non-black lines:

number	woven design
3	I I I
7	I I I I I I I
11	I I I I I I I I I I I
15	I I I I I I I I I I I I I I I
19	I I I I I I I I I I I I I I I I I I I
etc	

This is an interesting triangular number pyramid because each term is of the form "4n -1" for n = 1, 2, 3, 4, …. (it is made up of the {1, 3, 5, 7, …} and {2, 4, 6, 8} triangles placed back-to-back)

So that the first term 3 = (4 x 1) -1, since "n" = 1. Likewise the second term is (4 x 2) – 1 which is 7 and so on. The sum of the first "n" terms of this series
= (n/2) x (3 + 4n -1), which is the same formula as $2n^2 + n$.

Let us test our formula with some examples as we have done before:

3 + 0	=	3 = $2 \times 1^2 + 1$ = 2 + 1	= 3	(for "n" = 1)
3 + 7	=	10 = $2 \times 2^2 + 2$ = 8 + 2	= 10	(for "n" = 2)
3 + 7 + 11	=	21 = $2 \times 3^2 + 3$ = 18 + 3	= 21	(for "n" = 3)

etc

The formula works!

Variation 6

This time we switch back to the black lines (on Fig II) to observe an interesting triangular number pyramid pattern:

number	woven design
1	I
1	I
2	I I
2	I I
3	I I I
3	I I I
4	I I I I
4	I I I I
5	I I I I I
5	I I I I I
etc.	

In this case, summing the numbers amounts to (1 + 2 + 3 + … + n) + (1 + 2 + 3 + … + n) = [n x (n+1)]/2 + [n x (n+1)]/2 = n x (n +1) which can also be written as $n^2 + n$.

Possible associations with Pascal's Triangle

Observing the arrangement of black line patterns in the weaving designs, I could not help thinking that the cloth perhaps represents knowledge of the binomial distribution:

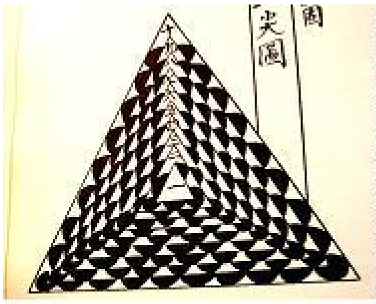
number	woven design	"Pascal's Triangle"
1	I	1
2	I I	1 1
3	I I I	1 2 1
4	I I I I	1 3 3 1
5	I I I I I	1 4 6 4 1
etc		etc

This triangular number pattern that has come to be known as "Pascal's Triangle" was known to the Babylonians and the Chinese according to L. Hogben ("Mathematics in the Making"). The Babylonians represented the numbers in Pascal's triangle in the following manner:

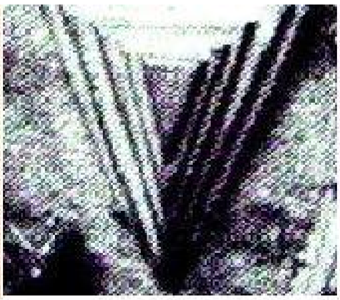
1	1	1	1	1	1 . . .	
1	2	3	4	5	6 . . .	
1	3	6	10	15	21 . . .	
1	4	10	20	35	56 . . .	(and so on)

The binomial theorem is represented in the form:

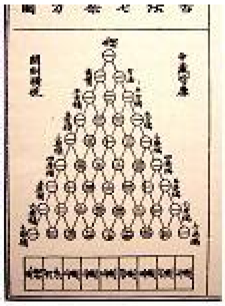
$(a + b)^n = a^n + (n/2)(n-1)a^{n-1}b^1 + (n/6)(n-1)(n-2)a^{n-2}b^2 + . . . + b^n$



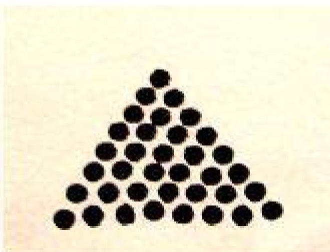
16th Century Chinese mathematician Chou Shu-Hsueh shows the packing of a pyramid with ten layers of spheres (L Hogben, "Mathematics in the Making" p.60)



Akan-Asante brass weight (Zaslavsky, "Africa Counts" p. 176)



Chinese version of "Pascal's Triangle", from a work printed in about 1303 AD (L. Hogben, "Mathematics..." p. 163



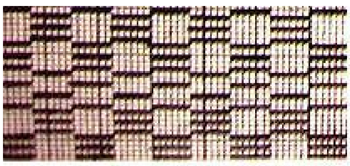
Akan "Adinkra" symbol known as "Sumpie" which is the 2 dimensional version of the 3-D step pyramid (G. F. K. Arthur, "Cloth as Metaphor" p. 142)

Fibonacci Numbers and the Golden Ratio in Akan weaving patterns!

Fig I (Appendix A) shows the following pattern among the non-black lines (see the black and white weaving design shown below this matrix of numbers):

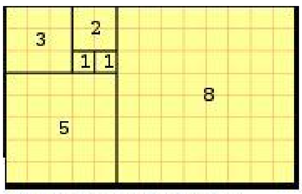
5 1 5 1 5 1 5 1 5 1 5 1 5 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 5 1 5 1 5 1 5 1 5 1 5 1 5
2 3 2 3 2 3 2 3 2 3 2 3 2 3
3 2 3 2 3 2 3 2 3 2 3 2 3 2
5 1 5 1 5 1 5 1 5 1 5 1 5 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 5 1 5 1 5 1 5 1 5 1 5 1 5 . . . . (and so on)

The Fibonacci numbers are a sequence of numbers in which the next number is derived by the previous 2 numbers. This is the sequence: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55… This sequence is generated by the recurrence relation $f_n = f_{n-1} – f_{n-2}$. What this basically means is that the n^{th} term, f_n, is obtained by adding the previous 2 terms, which are represented as f_{n-1} and f_{n-2}.

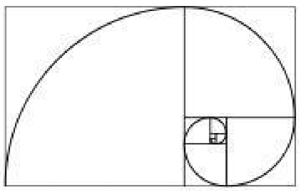


(From Rattray 1927, p. 253)

The Fibonacci numbers are in the non-black lines of each colums



Picture credit: Wikipedia



Picture credit: Wikipedia

Picture credit: Wikipedia

Inca Calculation machine with Fibonacci proportions

(On the woven cloth, count the spaces in between the black lines to find the Fibonacci numbers.)

The “Fibonacci spiral” shown in the figure above is an example of a logarithmic spiral. Fibonacci numbers appear in nature, it was to my great surprise, and delight, that such a pattern is to be found encoded in Akan weaving patterns. I think this is a new discovery, at least for non-weavers. I have not seen this been written about anywhere.

Other Fibonacci number patterns in the Akan weaving designs

In addition to the pattern above from Fig I, Fig II and Fig VI have these patterns:
5, 6, 2, 1, 1, 1, 2, 10, 6 (non-black lines) which adds up to 34, the 9th Fibonnaci number
9, 1, 1, 1, 2, 3, 2, 1, 1, 1, 7, 1, 1, 1, 1, 1 (non-black lines), which also adds up to 34

Here are more patterns in the cloth, this time they occurs in the black lines. Where there is a number such as 6, what that means is that there are 6 black lines grouped together, in between non-black lines:

[1]
6 4 3
2 4 4
6 4 3
2 4 4
6 4 3
2 4 4 (and so on)

Now, an astute observer will notice that 6 + 4 + 3 = 13. Once again we have a Fibonacci number. Below is a second recurring pattern:

[2]
7 6
3 3 2
7 6
3 3 2
7 6
3 3 2 (and so on)

So once again we have 7 + 6 = 13 and 3 + 3 + 2 = 8, both are Fibonacci numbers.

The Golden Ratio

This is the number you get between when you divide a Fibonacci number by the one before it:

Number	Fibonacci Number	Division
1	1	
2	1	1/1 = 1
3	2	2/1 = 2
4	3	3/2 = 1.5
5	5	5/3 = 1.667
6	8	8/5 = 1.6
7	13	13/8 = 1.625
8	21	21/13 = 1.615
9	34	34/21 = 1.619
10	55	55/34 = 1.618

As you may have guessed (or already know), the “Golden Ratio” is an approximate number, since the Fibonacci sequence goes on ad infinitum. For regular use, the value of 1.618 is assigned to the Golden Ratio, however this is an approximation, just as the transcendental number Pi can be approximated by the value 3.14.

It is remarkable that Fibonacci numbers should be found in Akan weaving patterns. The Fibonacci numbers must have been known in earlier cultures, in Egypt, since such numbers were used in Egyptian constructions. In the case of pattern [2] above, we are almost been given an approximation for the Golden Ratio, based on the numbers 8 and 13, in this case 13/8 = 1.625. Remarkable! This is mathematics embedded in weaving patterns!

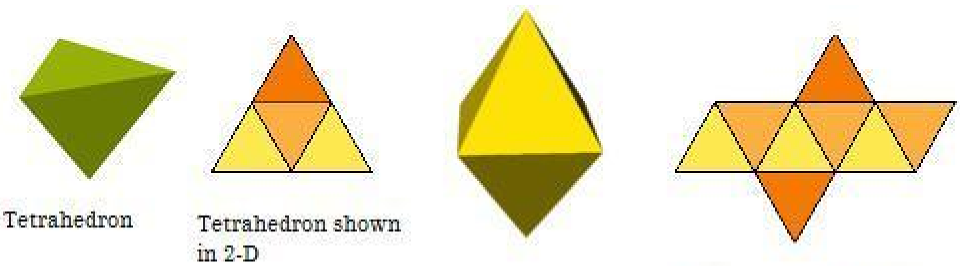
Geometric Shapes in Akan Weaving

Apart from the triangular number pyramids that obviously form triangles, another shape that appears in Akan weaving patterns shown in Appendices A and B is the rhombus. The rhombus is a special kind of parallelogram, which has all four sides of equal length, and opposite sides parallel to each other. Below we can see rhombus patterns in Kente cloth:

Nested rhombus patterns | Rhombus patterns | Triangles and squares | Nested (recursive) step pyramids | Step pyramid and triangular patterns | Multiple designs on kente cloth, including trapezium geometries.

One also sometimes sees trapezium shapes in some kente designs. A trapezium is a quadrilateral which has one and only one pair of parallel sides.

Octahedron and Tetrahedron as 3-D version of Rhombus and Triangle



Tetrahedron | Tetrahedron shown in 2-D | Octahedron | Octahedron shown in 2-D (i.e. spread out to show its faces)

The purpose for showing a tetrahedron as well as an octahedron is to emphasize the idea of a former being the 3-D abstraction of a triangle and the latter being a 3-D abstraction of a rhombus. The second and the fourth figures are what you get when you lay the respective solid figures bare, in effect causing them to become planar or 'flat' (i.e. 2 dimensional). The tetrahedron and the octahedron are important solids when dealing with energy focusing and direction (tetrahedron) and with spin of vortices (octahedron). When a pyramid is triangular-based it is called a tetrahedron. Pyramids can also be square-based or have any polygon shape for a base. Such pyramids will always have triangular sides.

Possible Association with Musical Codes?

Since geometry and music are well connected from what we know about the Pythagoreans (who got much of their knowledge from the Sirian initiation stream in Egypt and in Mesopotamia), I have a hunch that it is possible some of the number sequences in the non-triangular portion of these Akan weaving designs can be linked together in a musical way. Unfortunately (for me) my knowledge of music theory is limited so it may take a while to figure this one out, unless someone else possibly finds a way to investigate this possibility.

Similar Weaving Patterns Among other Indigenous peoples

Upon reading Dorothy Washburn's book “Symmetries of Culture” I was pleasantly surprised to find that the designs shown in Akan weaving patterns are shared not only by other African ethnic groups but also by other indigenous peoples from all over the world. In some cases, the designs were identical as some of the Akan ones, in other cases the similarity was almost uncanny.

I found identical weaving patterns created by the people of Fiji, the Marshall Islands, the Samoans as well as the Peruvians (Inca culture). Similar to almost identical weaving patterns have been created by the Maori and the Navajo. Akan pyramid art is identical to the step pyramid designs created by the Anasazi (ancient Pueblo) Native Indian people of America. These ancient Pueblo pyramid designs are especially similar to the ones I have seen in Akan art. Pyramid art similar to the ones created and used by the Akan are also used by the Okavango delta in Botswana. The Kuba culture of Central Africa and of Zaire uses an identical pyramid/triangle design to that of the Akan. Similar pyramid designs are also used by peoples of Cameroon and Rwanda in their art. Akan spiral art designs are similar (in some cases identical) to those I have observed in Hopi, Pima and Japanese art (perhaps due to the Pleiadian-Sirian influence shared by these cultures?)

Conclusion

There is probably much more going on in Akan weaving patterns found in Kente and other cloth than I have discussed here. The triangular and pyramidal patterns are clear, yet there are more complex patterns that may need further analysis to have them decoded.

REFERENCES

G. F. K. Arthur, *Cloth as Metaphor: (Re)-reading the Adinkra Cloth Symbols of the Akan of Ghana*, Af-oaks Printing Press: 1999

L. Hogben, *Mathematics in the Making*, Macdonald & Co. (Publishers) Ltd.: 1960

R. S. Rattray, *Religion and Art in Ashanti*, Clarendon Press, Oxford:1927

D. Washburn, *Symmetries of Culture: Theory and Practice of Plane Pattern Analysis*, University of Washington Press: 1988

C. Zaslavsky, *Africa Counts: Number and Pattern in African Culture*, Prindle, Weber & Schmidt: 1973

http://www.marshall.edu/akanart/kentecloth_samples.html

http://www.theakan.com

Appendix A – Akan weaving patterns used in this work

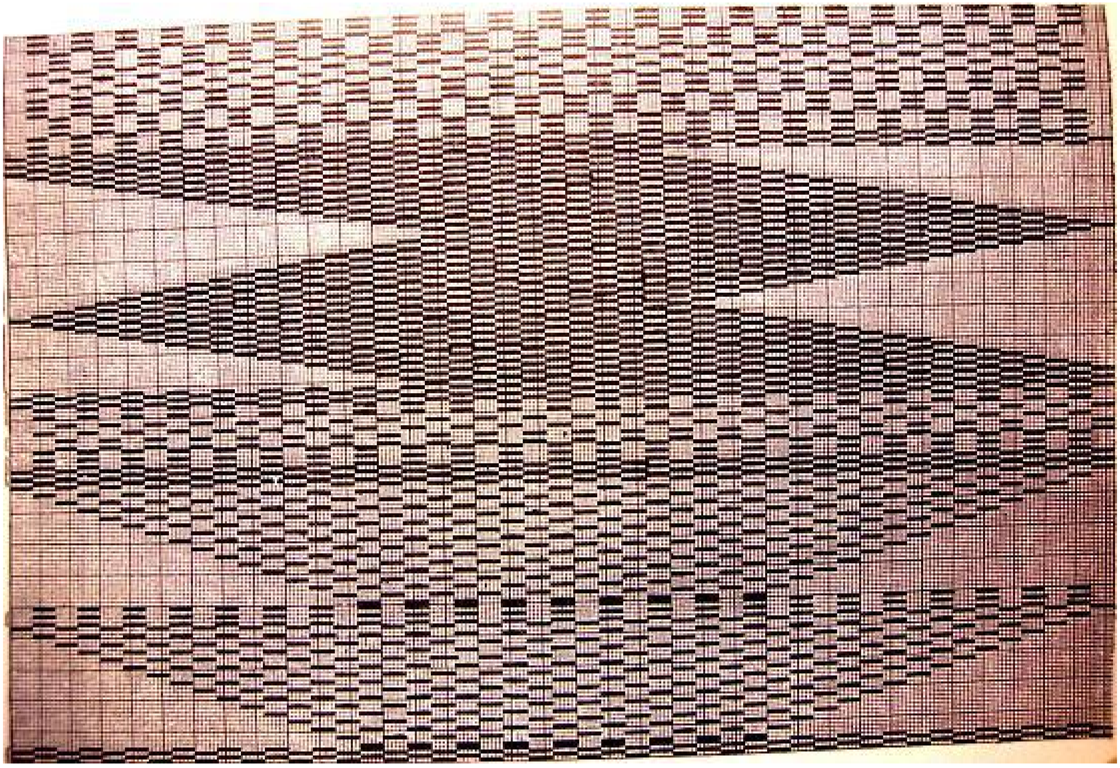


Fig I (Source: Rattray 1927, Fig 138.)

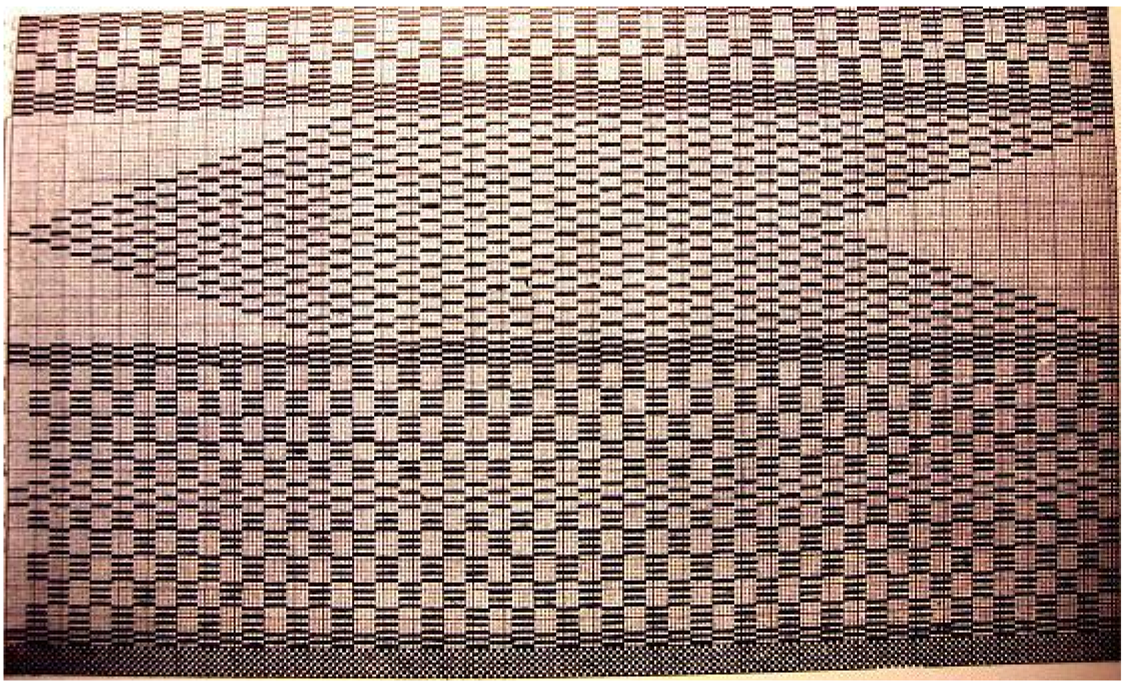


Fig II (Source: Rattray 1927, Fig 139)

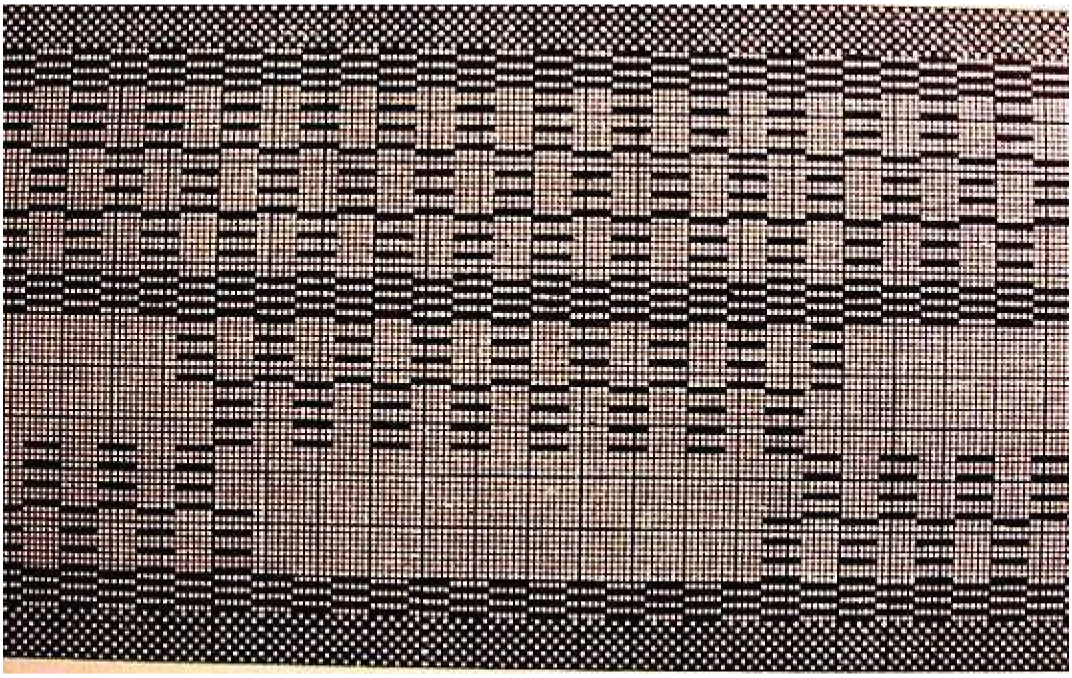


Fig III (Source: Rattray 1927, Fig 140)

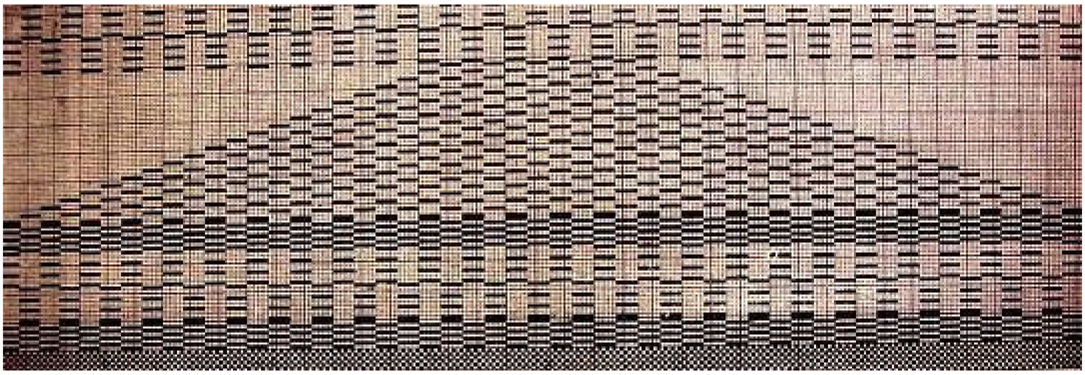


Fig IV (Source: Rattray 1927. Fig 141)

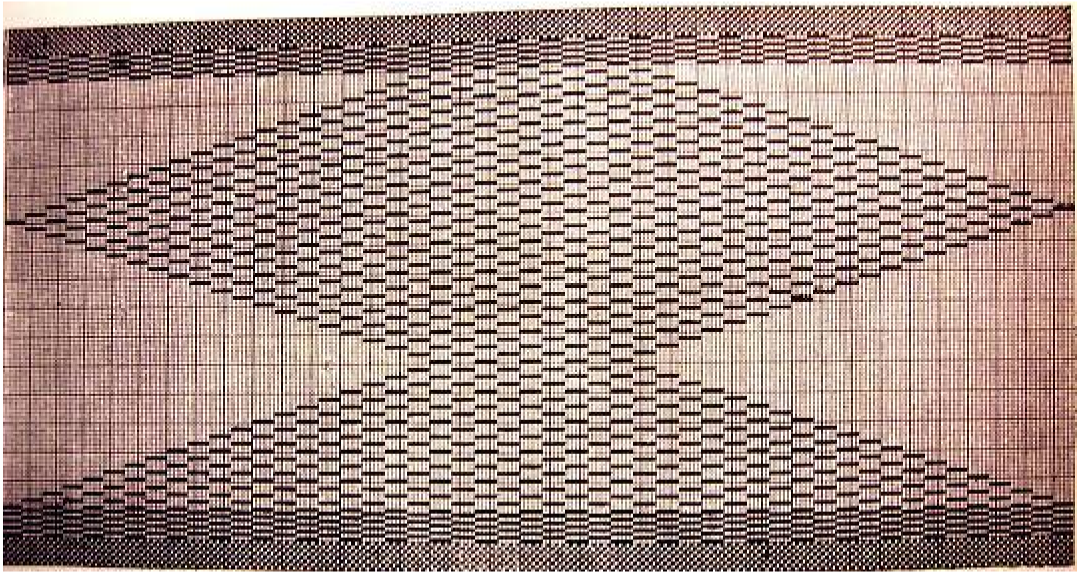


Fig V (Source: Rattray 1927, Fig 142)

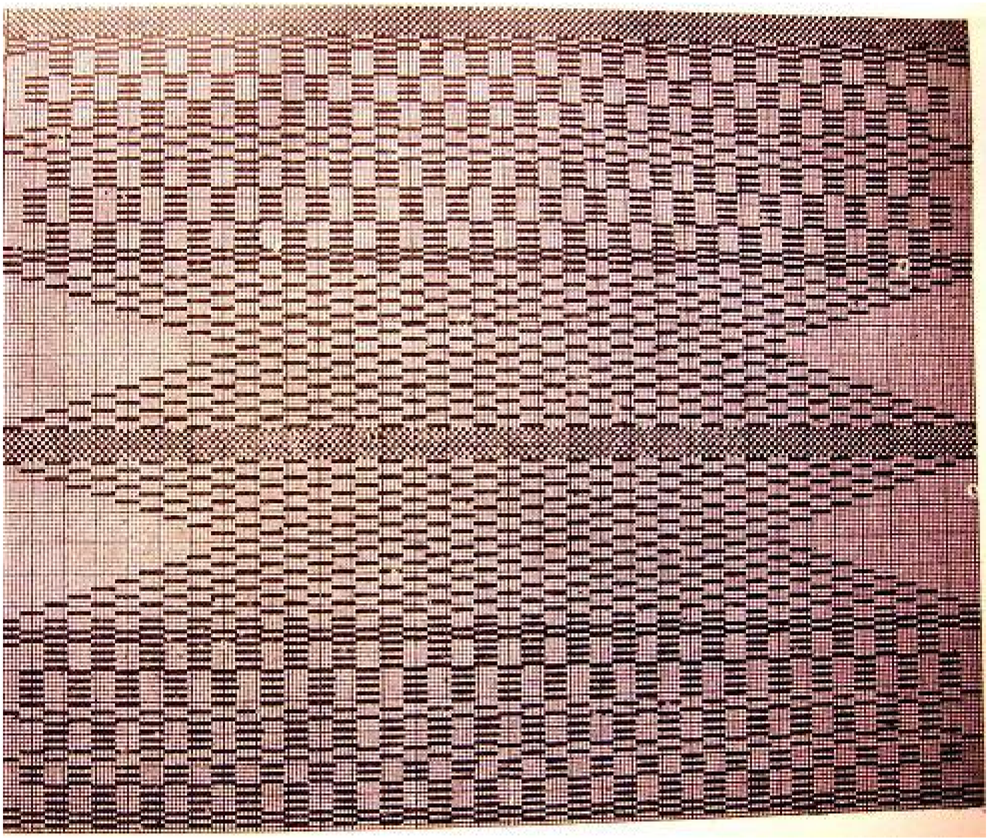


Fig VI (Source Rattray 1927, Fig 143)

Appendix B: Further Akan cloth designs

Fig VII (Rattray 1927)

Fig VIII (Rattray 1927)

Fig IX (Rattray 1927)

Fig X (Rattray 1927)