A Multiple Colour Bobbin Winder: An Enhanced Accessory for Transforming Indigenous On-Loom Weaving

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Abstract

Indigenous hand weaving is an ancient traditional handicraft practised in many cultures across Africa, Asia, Middle East, Europe and Latin America. The looms and accessories are made from local materials and the mechanism for their operation involves simple technologies that are easy to learn. These traditional hand weaving looms mostly produce long, narrow strips of patterned woven fabric that are sewn together to construct cloth, carpets and other specialized end-user woven products. Bobbin winding is an integral aspect of weft preparation for weaving. Bobbin winders used by cloth weavers in the indigenous Ghanaian textiles industry have capacity to produce single bobbins only at a time, which lengthens the yarn preparation and weaving periods, and reduced productivity of cloth weavers. The bobbin winder described in this article is semi-automatic, capable of winding multiple bobbins with single or multiple coloured yarns of uniform tension concurrently within a short time for higher rate production of woven fabrics in direct contrast with existing bobbin winders. This bobbin winder was based on the Universal Design Methodology and constructed with the sole aim of resolving limitations of existing bobbin winders in order to transform the traditional weaving industry. Testing the bobbin winder for broadloom weaving by 58 textiles students proved the technology is simple, efficient and effective; easy to manipulate and wind multiple bobbins within a short time. This implies time saving in weft preparation and hand weaving for increased productivity in Ghana's indigenous textiles industry.

Keywords: bobbin winder; weft preparation; hand weaving; traditional loom; indigenous textiles industry

1. Introduction

Indigenous hand weaving is the main or sometimes the part-time occupation of people in many communities across the globe. Indigenous weaving is traditionally done by men in long narrow strips of fabric on narrow double-heddle looms that mostly have two or four heddles. The loom, which is the main equipment that is used for weaving is fundamentally a box-like wooden structure in which the weaver sits to weave. The looms consist of a simple frame that holds a set of threads in tension; they have no warp beam so weight is used to give tension to the warp yarns during weaving (Insert 1992 as cited in Ross 1998). The earliest looms date from the 5th millennium BC and consisted of bars or beams fixed in place to form a frame to hold a number of parallel threads in two (Encyclopaedia Britannica).

Woven fabric is constructed from sets of yarns interlaced at right angles in some established sequence or pattern. The yarns that run parallel to the selvedge or the longer diameter of a bolt of fabric are the warp yarns or ends; those that run crosswise of the fabric are the filling, weft or woof yarns, or picks (Weaving, 2012). Each filling yarn passes alternately over and under one warp yarn while each warp yarn passes alternately over and under each filling yarn (Kiron 2012). The simplest of all weaves is the plain weave, which is predominant in the indigenous hand weaving industry in Africa. Plain weave fabrics have an equal distribution of warp and weft floats; a typical example of plain weave fabrics produced in Africa is the *Akete* cloth produced by the Igbo of Nigeria (Nwachukwu & Ibebabuchi 2012). There are also indigenous fabrics that are made predominantly of weft yarns; examples of such weft-faced fabrics are *Kente* and *Kete* which are produced respectively by the Asantes and Ewes of Ghana (Obuba 2006; Amesimeku 2009).

Looms are incomplete without accessories such as the warp mill, beaming box, bobbin winder, skein winder and shuttle. Loom accessories aid the preparation of the warp and the weft yarns for on-loom weaving of fabrics. Bobbin winding is a critical component of the weft preparation and weaving process. As illustrated in Plates 1 and 2, bobbin winders and skein winders used by indigenous weavers in Ghana are manually operated by hand and capable of producing single bobbins at a time. This article however, describes the design and development of a semi-automatic bobbin-and-skein winder that produces many bobbins simultaneously with speed to enhance the local textiles industry in Ghana.

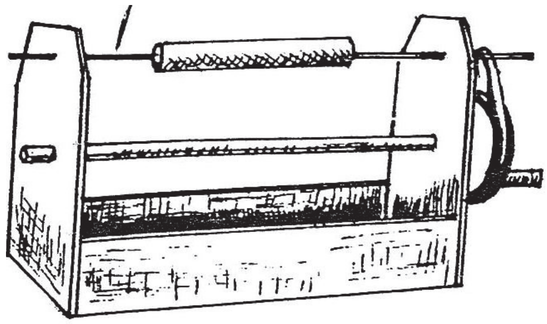

Plate 1. Bobbin winder

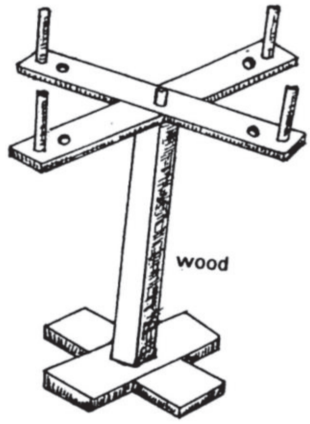

Plate 2. Skein winder

The existing traditional bobbin winder can only produce one bobbin at a go albeit with some challenges: it is unable to achieve uniform tension which sometimes results in yarn slough off; it is inefficient for producing multiple bobbins; and its slow rate of bobbin production contributes to low productivity in the indigenous hand weaving industry. In order to address these challenges, this project focused on design and construction of semi-automatic bobbin winder that has combined the bobbin and skein winders in one model. It has the capacity to produce two or more single colour or multiple coloured bobbins at a faster and efficient rate in comparison to the existing manual single bobbin winder in use. As part of the unit, tension devices have been incorporated to ensure uniform tension in the bobbin without any stress. The result is that, the device has the capacity to produce more than one single-colour or multi-coloured bobbins with uniform tension and higher rate of production in comparison with the existing bobbin winder. The aim is to address the setbacks in the manual bobbin winder by the introduction of certain mechanisms in the mode of operation in order to achieve the following:

- Uniformity in bobbin production with minimal skill and experience,
- Good tension needed to avoid yarn slough off,
- Increased rate of bobbin production. And
- Adoption of very simple technology that is easy to learn and use by the average member of the community.

This design-based research project adopted the universal research methodology (UDM), which involves experiments, working drawings, and prototype models from which the final work is constructed. Barab and Squire (2004) have described UDM as "a series of approaches, with the intent of producing new theories, artifacts and practices that account for and potentially impact learning and teaching in naturalistic settings".
The methodology enabled the design and construction of a semi-automatic bobbin winder that apprentice weavers could learn to operate without much difficulty, which can also be used by master weavers to generate numerous bobbins in a relatively shorter time as compared to the existing indigenous manual bobbin winder.
Three components contributed to the effectiveness of the prototype bobbin winder: 1) a number of tension devices were incorporated in the design to ensure uniform tension; 2) some control mechanisms were introduced to take care of even distribution and tapering of yarns at the extreme ends of the bobbin to achieve a conical shape to prevent yarn slough off during weaving; 3) an electric motor with a foot pedal was attached to regulate the speed of bobbin production. It must be emphasized that the existing manual bobbin winders lack all these features, which made it necessary to apply much creative and design experience and skill in order to arrive at an effective and efficient bobbin winder that works reasonably better than what is currently available to producers of indigenous fabrics. The essential feature was the number of bobbins that could be produced to hasten the weft preparation and weaving processes.
For organizational improvement, merging the various aspects of the traditional weaving industry would present ensure effective use of the resultant bobbin winder as it may apply to the respective weaving units. This multi sectoral view could provide a more reliable basis for developing innovative tools for the indigenous textiles industry. As Olaoye (1989) suggests for the indigenous weaving industry in Nigeria, innovations are required in the global weaving industry as technology and development abounds in recent times. It is appropriate therefore to explore the possibility of modernizing traditional crafts instead of abandoning them altogether. In this respect, the tools, equipment and operations of the traditional weaving industry in Ghana is also open to modernization for improved processes and products.
As Olaoye (1989) rightly states, there is also the need for small-scale technological improvements in the industry to be within the control of the weavers. Weft preparation primarily revolves around bobbin winding, which

essentially involves the use of a manual bobbin winder that enables the weaver to unwind yarns from their packages onto pirns. Bobbins or the yarns that are packaged on pirns are inserted into a shuttle and in the course of weaving, the shuttle traverses an open shed and leaves in its trail, the weft yarn that interlaces with the warp yarn to form a woven fabric.

2. Design Process

Design is the creation of a plan or convention for the construction of an object or a system. In formal terms, design has been defined as a specification of an object, manifested by an agent, intended to accomplish goals, in a particular environment, using a set of primitive components, satisfying a set of requirements, subject to constraints (Wikipedia the free Encyclopedia). Design could be viewed as an activity that translates an idea into a blueprint for something useful, whether it is a car, a building, a graphic, a service or a process. A design does not have to be new, different or impressive to be successful in the marketplace, as long as it is fulfilling a need; design methods do lead to innovative products and services (What is design 2013).

The design of this novel bobbin winder was modelled after the universal design methodology (Zeidman 2003) because the strategy offers opportunity to:

- Design a device that is free from manufacturing defects, that works reliably over the device's Lifetime and function correctly in a system.
- Design the device efficiently, using the least amount of time and resources, including personnel.
- Plan the design efficiently by creating a reasonable schedule that allows one to understand all the necessary resources and allocate them early in the design process.

The Universal Design Methodology (UDM) specifies steps that enable the designer to reach these UDM design goals indicated in Figure 1. Although the specifics of each step vary with each design, the steps essentially remain the same for all designs.

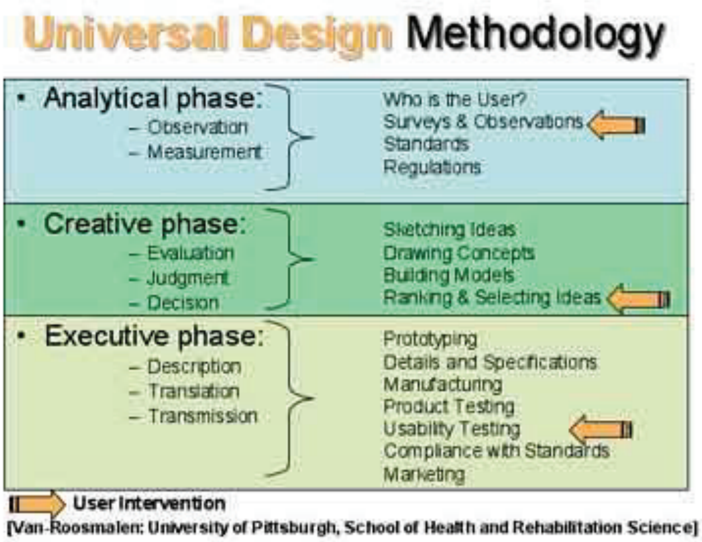

Figure 1. Universal design methodology

2.1 *Development Processes*
As illustrated in Figure 1, the Universal Design Methodology (UDM) comprises three phases: the Analytical, Creative and Executive phases. These phases were tackled as described in the following sections.

Analytical phase: This stage involved a field survey of bobbin winders used by indigenous cloth weavers in the Northern, Ashanti and Volta Regions of Ghana where hand weaving is a predominant occupation. Weaving centres visited were Daboya and Yendi in Northern Region; Bonwire and Adanwomase in Ashanti Region; and Agortime Kpetoe and Anlo Afiadenyigba in Volta Region. The survey revealed that weavers in these communities rely on manual single bobbin winders that had no tension devices and a means to control the winding process to achieve conical shaped bobbins that would withstand yarn slough-off. Dimensions of existing bobbin winders were recorded to serve as a guide to the design and construction of the intended semi-automatic multiple-colour bobbin winder to improve weft preparation in the indigenous cloth weaving industry.

Creative phase: This stage involved sketches, drawing concepts, developing of models and selection of the best design to develop for the project. Figures 2 to 5 show the lines, shapes and forms that were combined to translate the abstract ideas into design concepts.

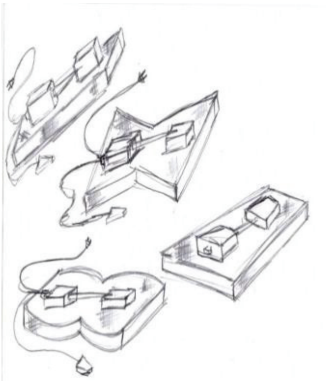

Figure. 2. Lines, shapes and forms

Figure 3. Stage one

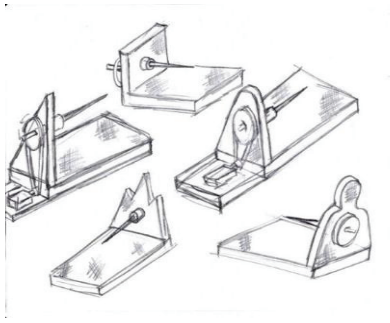

Figure 4. Stage two

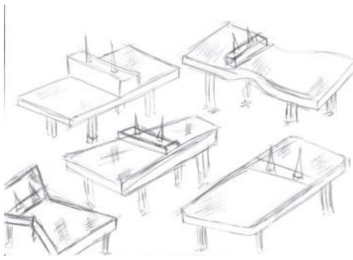

Figure 5. Stage three

As part of the designing process, three drawing concepts came up: the first two suggested the use of an electric motor to propel the bobbin to spin. The ensuing vibration made the system unstable so the third idea of mounting the motor on a table was adopted to ensure stability was achieved. This proved most appropriate for the intended semi-automatic bobbin winder.

Building models

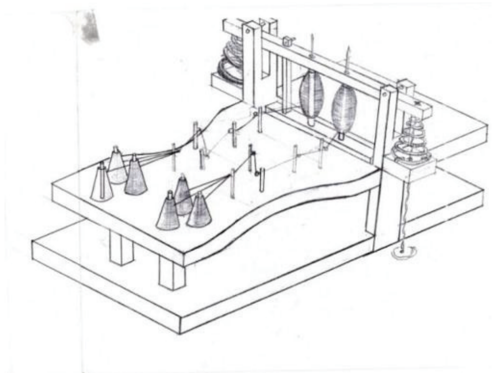

Figure 6. Model 1

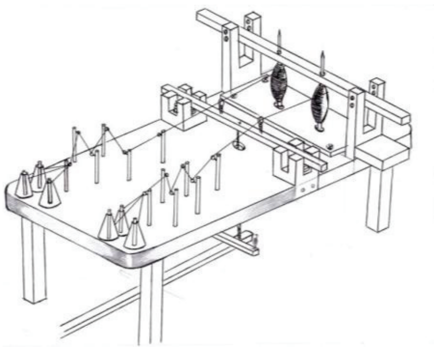

Figure 7. Model 2

A model is a three-dimensional representation of a person or thing or of a proposed structure, typically on a smaller scale than the original (Merriam-Webster 2014). As the different component parts of the design were put together (Figures 6 and 7), Model 2 (Figure 7) was adopted as the basis for constructing the prototype illustrated in Plate 2 to represent the three-dimensional perspective of the final device that measures 35cm x 25 cm x 15 cm. The design choice was informed by careful consideration of compactness, simplicity of operation, ease of handling; safety, appropriateness of technology and cost effectiveness.

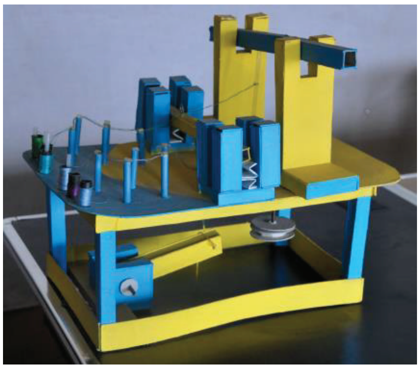

Plate 3. Prototype of selected model

Execution Phase: This stage of the project required imagination and creativity to produce something new (Oxford Advance Learner's Dictionary 2000). It involved description and explanation of the specific parts of the new bobbin winder.

3. Winding mechanism

The winding mechanism is the automated part of this project. It consists of an electric motor connected to two gears by means of a transmission belt. The gears were mounted on the main shaft that has grooves on its surface and fastened two inches below the ball bearing and secured with two nuts. One gear drives the other and causes the two to rotate at the same speed but in the opposite direction. The upper part of the main shaft is also connected to a metallic bar that serves as the bobbin shaft. The two bobbin shafts were mounted on the main shaft permanently so that the gears would drive them as they rotate. The bobbin shafts are the support on which empty pirns were mounted to prepare bobbins (Figure 8).

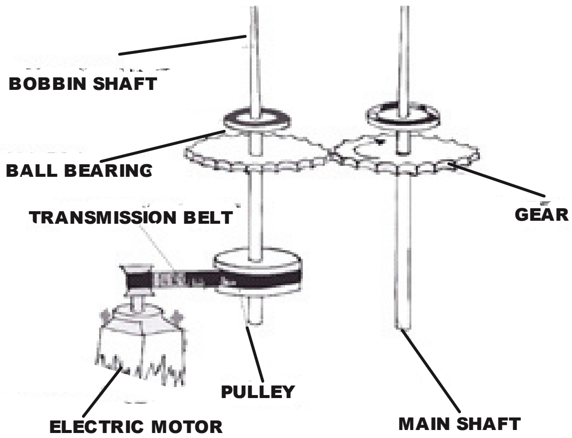

Figure 8. Shows arrangement of both gear shafts

The outer part of the ball bearing was fixed into a race board so it holds the spinning mechanism in place. This outer shell was also made to hold the main shaft whiles the inner part is made to rotate freely. A wooden pulley of about 8 inches in diameter and 2 inches thick was fixed below the gears. This mechanism allows the position of the pulley to be adjusted to correspond to the position of the pulley of the main motor, both of which are connected by the transmission belt. The motor is operated electrically and its speed can be regulated by means of a foot pedal (Plate 4).

Plate 4. Foot pedal

4. Double yarn regulating mechanism

This involves the action that facilitates the up and down movement of the yarn whiles in motion. It helps to lay the weft yarn in motion in an organized manner to achieve a uniform tension. This action permits easy unraveling of the weft yarn from the pirn in the shuttle during weaving. The up and down movement mechanism is made possible by two sets of ring-hand traveller bar that is attached to a treadle cord in the foot pedal. Depressing the pedal causes the traveller bar to be depressed against springs located in the two sockets mounted on the side of the bobbin winder, which also causes the upward and downward movements of the traveller bar. In addition to this, two travellers fixed in the middle of the traveller bar guide the weft yarn on the pirn. The downward and upward movement of the traveller bar causes the traveller to come into contact with the weft yarn, thus manipulating the yarn movement in an up and down manner (Figs. 10 and 11).

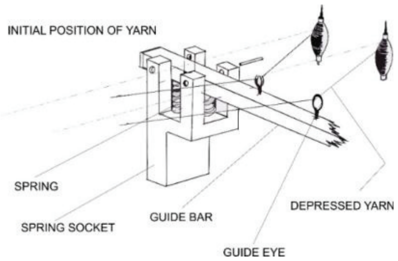

Figure 10. Position of traveller

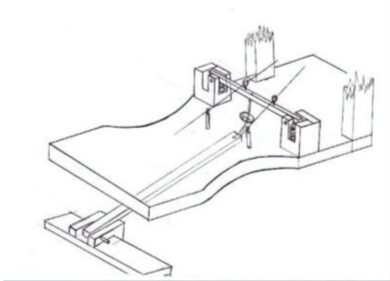

Figure 11. Arrangement of foot pedal and traveller bar

5. Assemblage of the parts

Due to the complex nature of the components of the new bobbin winder, the assembling process for achieving the single unit was done in three phases to link the constituent stages with their corresponding activities and what needed to be done at every point in time.

First phase: The first phase involved assembling the various parts of the device. As seen in Plate 4, the main frame of the bobbin winder consists of a wooden table that serves as the support unit. It measured 90 cm x 55 cm x 55 cm.

Plate 5. The frame for prototype bobbin winder

Second phase: This phase involved assembling of all the metal parts of the project that demands welding and other means of adhesion. The winding mechanism hinged on this. All the metal parts were purchased, arranged as desired and mounted into a single unit as shown in Plate 5.

Plate 6. The mounted gears

Third phase: This was the construction phase. It essentially involved drilling of holes, mounting of the tension props with metal rings and a cone stand, and construction of the traveler socket and treadles.

5.1 Mounting of tension props rings

The metal rings were mounted on the wooden props with white glue. A shallow hole was first created on top of the wooden prop using a nail; the metal ring was dipped in the white glue and fixed in the hole. Turning the metal rings several times enabled the grooved bar of the metal ring to sink into the wood (Plate 7).

Plate 7. Mounting of component parts

5.2 Mounting of the traveller sockets and treadles

Plate 8. The mounted treadle

In the construction of the treadle, the right sketch was followed and mounted. Afterwards it was positioned between the two legs beneath the tension mechanism of the main frame and was fastened together with nails.

Plate 9. Assembled frame

Plate 9 shows all the parts assembled together. The final phase of the project involved mounting the springs, the spinning mechanism through the race board, painting the metal parts and the wooden parts of the project to improve its aesthetical quality and appeal.

6. Mounting the spring and spinning mechanism

The springs that would facilitate the upward and downward movement of the traveller bar and also regulate the yarn were mounted in the two traveller sockets and locked with rectangular metal sheets. The complete spinning mechanism that comprises gears, ball bearings, the main shaft and pulley, were fixed onto the race board. To give it a good finish, the metal parts were sprayed with anti-rust paint while the wooden parts were done with lacquer. Plate 9 shows the complete proto type bobbin winder measuring 90 cm x 55cm x 55 cm.

Plate 10. The semi-automatic colour bobbin winder

7. Discussion of results and findings

The equipment is one composite unit that carries the cones that supply the yarns through the tensioners to the final bobbins. There are a number of props that serve as support for the cones. These make room for different coloured cones of yarn to be mounted for expanded capacity to produce several coloured bobbins concurrently. The path of the yarns go through a number of tensioners that are positioned at different angles to ensure uniform tension in the bobbins as well as control devices that enable the bobbins to be produced in a tapering manner to prevent slough-off during weaving. Unlike existing models of bobbin winders that produce one bobbin at a time, this novel bobbin winder can efficiently produce two or more bobbins simultaneously, creating an efficient and time saving means to shorten the duration of cloth weaving. The tests showed that this new bobbin winder can significantly reduce the labour-intensive nature of traditional weaving processes as well as the long man-hours required to complete the weaving of a male or female indigenous cloth. It also would improve the productivity and efficiency of weavers in the indigenous hand weaving industry in Ghana and wherever it is used.

To test the efficiency and effectiveness of the new bobbin winder, the prototype was made available to 58 final year textile students at the Department of Industrial Arts of Kwame Nkrumah University of Science and Technology in Kumasi, Ghana. Supervised tests involved the students using the device to help them complete their semester studio weaving project work. Feedback on the performance of the novel bobbin winder revealed that 56 of the 58 students (or 97.0%) were able to learn to manipulate the equipment for the first time to produce the number of bobbins they required at a go without much difficulty. This not only hastened the weaving process but the quality of bobbins they produced within the allotted time also enhanced the aesthetic appeal of the woven

fabrics. This was attributed to the bobbin winder's capacity to produce as many coloured bobbins as the frame would take so that the weaver had enough bobbins for a session on the narrow or broadloom.
The speed with which the device works also enabled the students to produce more bobbins where necessary even though 58 students used the new bobbin winder simultaneously. None of them complained of being slowed down by other users because a number of students could get bobbins of the required colours in groups at a time without wasting time. Each one of them could wait their turn and not feel left out. The two students who reported some challenges were those who could not combine the fast movement of the feet to control or sustain the speed of the motor that powers the equipment with the pace at which the yarns should be regulated to ensure that both synchronize to produce conical shaped bobbins that are ideal form to prevent yarn slough off during weaving.
With further guidance and demonstration, the two students were able to overcome the initial difficulties and master the movements after a few more tries. This suggests that constant practice will enable anyone using the new bobbin winder to tackle this initial slow aspect of yarn and weft preparation with ease. Appreciation of the appropriateness of the device and the quality of woven fabrics achieved with the woven fabric on the broadloom revealed the simplicity, compactness and feasibility of the new bobbin winder for its intended purpose.

8. **Conclusion**

Although the new bobbin winder was tested under studio conditions only, the outcome shows that apprentice weaver in the indigenous weaving industry can easily learn the simple technology it employs with little or no difficulty, and within a short time. The test results confirm Olaoye's (1989) desire for the development of appropriate small-scale technological improvements that are within the reach and control of the traditional weaver. The excitement with which the textiles students engaged the new bobbin winder and the fewer difficulties that were encountered even with its first time use attests to its usefulness to the indigenous textiles industry. The prototype bobbin winder could be further researched and engineered for mass production for the local market. The many dressmakers and garment manufacturers would also benefit immensely from its use. Exploring such possibilities could also help to modernize other culturally significant art forms and thereby resuscitate dying indigenous industries in Ghana and revive Africa's indigenous cultural heritage of art.

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