ANTHROPOLOGICAL PAPERS

OF THE

American Museum of Natural History.

Vol. XII, Part III.

PERUVIAN TEXTILES.

BY

M. D. C. CRAWFORD.

NEW YORK:
Published by Order of the Trustees.
1915.

American Museum of Natural History.

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PREFACE.

The object of this paper is to give some idea of the technical side of the fabrics found in the graves of Coastal Peru. The nature of design and color will be considered only in this relation. As far as possible, the analyses will follow the same lines as though the cloths were the product of modern looms. First, the nature of the fabric will be considered, that is, the manner in which the design is produced. Under this head will come the manner in which warp and weft cross each other, also the number of each contained in a square inch. Next the yarns themselves will be examined, first, as to the nature of the fiber; second, as to twist and ply. And lastly, the chemical properties of the dyes with relation to fastness and possible physical nature will be treated.

The fabrics selected to illustrate the different styles of weaving have been chosen solely to give the clearest examples in point. All of them are in the possession of the Museum, but not all of them are on exhibition. Most of the pieces in the cases are in nearly perfect condition and the rather rigorous nature of the analysis made the fragments, though unfit for exhibition purposes, much better adapted to the purposes of this paper.

Where this article treats of the analysis of any fabric or yarn, the observations have been carefully made and the statements are subject to proof. A microscope and a thread counter of the latest design have been used and in cases of great fineness, counts have been ascertained by picking off a full inch of weft under a dissecting microscope. In order to have clearness throughout, the counts of yarn have been determined by comparison with modern cotton yarns of known count, and, of course, refer only to comparative diameter. This system was applied to the wool and bast yarn as well as cotton. It was impossible to make the customary tests by weight and length. It was equally difficult to obtain the number of turns per inch on the modern machines for this purpose. The finest yarns being generally too tender, the method employed was to take a photomicrograph of yarn at a given multiple of the diameter, count the number of turns per inch and multiply by the number of times the original was magnified. I am aware of the objections to such a course, but no other presented itself and the wonderful evenness of these yarns makes such a test quite reliable. In selecting fibers for the photomicrographs an attempt was made to get an average staple.

One part of this paper deals with the actual mechanical movements required to produce the yarns and the fabrics. An effort has been made to reconstruct a technique that has been buried for centuries. Accounts of primitive spinning and weaving are extremely rare and seldom written by technical experts and such as I have read differ in essential particulars from the case in point. References in the Spanish commentaries are very meager and unscientific. Therefore, the only possible method has been to study carefully the tools found in the graves, consider the absolutely essential movements, and endeavor to ascribe to each its proper function. When it is borne in mind that certain of these yarns and fabrics have never been excelled, and that almost every known method of decorating a web of cloth has been used, the difficulty of such a task must be evident.

So far as known to the writer no one has yet taken up the study of Peruvian textiles in this way. Mention may be made, however, of some work by William H. Holmes, *Textile Fabrics of Ancient Peru*, Washington, 1889, and a paper by Max Schmidt, *Über Altperuanische Gewebe mit Szenenhaften Darstellungen*, "Baessler-Archiv," Band 1, Berlin, 1911. In the latter are several detailed drawings of looms and schematic diagrams of design technique. Yet, these investigators were concerned with other problems than those of textile technique using the latter only as an incidental means to an end. Hence, it seemed best for the writer to take the specimens themselves and subject them to the same methods now used in the critical evaluation of modern fabrics. In this he claims the indulgence due to a pioneer. If these lines arouse the interest these truly marvelous fabrics deserve, to the end that each phase of the subject be studied by experts, their object will be fulfilled.

So comprehensive is the range of Peruvian fabrics, that the writer did not feel competent to pass on all points. For this reason certain specialists were consulted. Thanks are due to Messrs. Douty, Boyé, and Lamb of the United States Conditioning and Testing Company for the photomicrographs of yarn and fiber and for Mr. Lamb's chemical report; to Mr. John Kimberly Mumford for information as to Oriental technique and fabrics which his great knowledge of the manufacture and history of rugs so amply qualifies him to give, and to Mr. A. J. Guthrie and Mr. M. C. Andrews of the John S. Brown Sons, manufacturers of fine linens in Ireland, who kindly examined the bast fiber cloths and furnished the analysis used in the text. Finally, the writer wishes to acknowledge his great obligation to Mr. Charles W. Mead, the Curator of the Museum's Peruvian Collections. We first took up this investigation at his solicitation and its progress has been in a large measure due to his kind and unfailing assistance.

June, 1915.

CONTENTS.

LIST OF ILLUSTRATIONS.

Text Figures.

INTRODUCTION.

In order that certain textile terms to be used later may be intelligible to readers unfamiliar with them, a brief description of modern spinning and weaving is given.

The actual processes, except such differences as the nature of the fiber entail, are the same in cotton as in wool. The cotton boll is a tangled mass of fibers attached to seeds. In fact, from two thirds to three quarters of the weight of the boll is seed. The first process is the removal of these seeds. This process is known as ginning and is performed in two ways. In the saw, or Whitney gin the bolls are placed upon an iron platform. Through slits in this platform revolve circular saws. These interstices are too narrow to allow for the passage of the seeds and as the rapidly revolving saws tear the fibers away a revolving brush cleans the teeth and removes the ginned cotton. This method is used with the great bulk of cottons, but the finer grades are ginned by a process slower in action and less destructive to the fiber. This is known as the roller gin. It removes seeds by the action of passing cotton between two cylinders back of which a moving blade gently presses out the seeds. Generally speaking, the finer cottons are the smooth seed varieties in which the staple clings less tenaciously to the seeds than in the common hairy seed species, and therefore allows for less destructive methods of ginning.

The next step, omitting bale opening, is picking, or scutching. Here the object is two-fold: removal of coarser dirt, broken seeds, sand, etc., and also the separation of the individual fibers from their natural tangled condition. This is accomplished by passing cotton over lattices, or grids, and beating it by rapidly revolving blades. Through these grids is driven a current of air sufficiently strong to force the cleaned and open staple forward, but not of sufficient strength to prevent the foreign matter from falling into the dust boxes below the grids. The product of the picker is a roll of cotton called a lap.

Cotton comes from the picker well opened and free from the larger impurities, but containing minute dirt and full of little tangles caused by broken and immature fiber, called nebs. Also the fibers are in a matted condition. The next process removes the last traces of dirt and nebs and also straightens out the fibers in approximately parallel relation to each other. This is called carding. The picker lap is placed before the card, where a rapidly revolving three-bladed knife, called the licker-in, draws the

cotton over a grid as in the picker, thoroughly cleans it, and then offers it to the action of the card cylinder and apron. The cylinder is covered with a cloth containing a great number of wire teeth. The same kind of teeth bent in the same direction are on the apron which is, in fact, an endless chain. The cylinder revolves at greater speed than the apron. Thus the cotton is gently pulled straight. The greater part of the nebs are taken up by the apron and removed by brushes revolving at the back. The carded cotton is removed by a smaller cylinder called the doffer, passes between a pair of rollers, through a trumpet-shaped guide, and is coiled in cans preparatory to the next process. The product of the carder is known as a sliver.

The object of the foregoing process is to thoroughly clean the staple and place the fibers in the same general direction. The next process is to attenuate the soft thick rope of fiber known as a sliver. The machines for this purpose are called draw-frames. They consist of three or four pairs of rollers. Sometimes both are fluted metal, sometimes the bottom roller is leather-covered and the top fluted metal. The speed of revolution of these rollers progressively increases until the last pair revolves nearly six times as fast as the first. This difference in speed attenuates the sliver and increases its length, but reduces its circumference. This attenuation is called draft. The product of the draw-frames is known as a drawing.

The next process is the first in which twist appears. The machines are known as fly frames. The drawing passes through a set of rollers which insert draft, then through the hollow leg of the flyer, and lastly are fastened to the bobbin. The bobbin and flyer are the same in principle as the spinning device on the old Saxony spinning wheel. That is, the wishbone-shaped flyer revolves around a revolving bobbin. Each is driven independently and one must exceed the other in speed. This causes the fibers to be twisted around a common center. There are three or four sets of fly frames. The amount of draft gradually decreases and the amount of twist gradually increases. The final product is called a roving.

When the fiber has reached this condition its final conversion into yarn may be effected by either the ring frame or the mule. The former is so unlike hand spinning that the description is unnecessary in this connection; but, in the mule the stages correspond so nearly to the primitive method that a cursory examination of its technique may be of value.

The actual machine is very complicated and divided into numerous parts, but as this description is merely to show the principle, only two parts will be considered, the creel which holds the bobbins of roving and the head which contains the spindles of completed yarn.

The roving passes from the creel through a set of drawing rollers and is attached to the spindles. The head then moves away from the creel while

at the same time the rollers deliver the roving. As the head moves, the spindles revolve rapidly. Draft is created by the drawing rollers and the moving head and the rapidly revolving spindles insert the twist. The head travels in all about sixty inches, and when about fifty-four inches have been covered, the rollers cease to deliver roving and the head moves the last six inches without additional roving. At the same time the number of revolutions of the spindle increases. This last stage is very important. It stretches the roving into even yarn and allows the final degree of twist to be inserted. The head then travels back to the creel and the spindles wind up the completed yarn.

From the brief description above it will be seen that spinning is divided into three stages: 1. The cleaning of the fiber; ginning to remove seeds; picking or scutching to disentangle fibers and remove large impurities; carding to remove fine dirt, broken fiber, etc., and to place the fibers practically parallel to each other. 2. Attenuation of card sliver, or draft by the draw frames. 3. The gradual decrease of draft and the gradual increase of twist in fly frames, and the spinning mule.

The processes prior to spinning with the old spinning wheel were, of course, much simpler than those described above. The cotton seeds were removed by hand and the wool washed to remove grease and dirt. The fibers were then beaten with little switches to open them up and were finally drawn over a comb in order to lay them approximately parallel to each other. Using modern terms, they were ginned or scoured, scutched and carded.

Next the carded fibers were rolled into short soft boluses. These would correspond roughly to draw slivers. From the ends of these boluses a few fibers were withdrawn and twisted into a soft, rather thick filament, resembling a modern roving. When the wheel was used this roving was attached to the bobbin and over the lower hook of the flyer. Next, the bobbin was caused to revolve by pushing down with the foot the treadle attached to the large driving wheel. Both hands were constantly engaged in the withdrawal of fiber and the continuous formation of roving which the bobbin and flyer twisted into thread.

A still more primitive method of spinning that was practically universal was known as the whorl and distaff method. Here the prepared fiber was held in some convenient position and a roving formed as above. The spindle was a stick of wood or metal about twelve inches in length, near the lower end of which was a circular weight of which the spindle formed the axis. The roving was attached to the top of this spindle which was caused to spin by a sharp twist of the thumb and finger and released. The roving was gradually paid out as the revolving spindle descended. The weight and the spindle inserted the necessary draft and twist.

Still another form of spinning, rarer than the above, was performed by causing the whorled spindle to revolve in some smooth receptacle and skilfully feeding it roving to be twisted into thread. Spinning was also carried out, in a way, by rolling fibers on the naked thigh.

The power loom of today is simply the Asiatic foot treadle loom to which power has been applied. Its principal difference from the earlier hand looms lay in the manner in which the warps were separated in what are termed sheds, for the insertion of weft. These sheds were formed by means of heddles connected with the treadle operated by foot power. The heddles were wooden frames with holes or loops in them for the yarn. At least two such heddles were required to make plain cloth. Through one of these heddles the even numbered warps were drawn, through the second the odd. They were attached to the treadle in such a way that when one treadle was pushed down, it lifted one heddle and consequently every other warp. The triangular space so produced is called a shed in weaving and is the space between the divided warps through which the shuttle containing the weft thread is inserted or thrown. The weft bobbin is placed inside of a smooth hollow wooden receptacle called a shuttle. The yarn is drawn out through a hole in the side, fastened to the first warp on the near side of the loom and thrown or slid through this space or shed from hand to hand. The reed is a solid frame containing fine wire or split reed (hence the name). This is placed over the warps in such a manner as to allow them to be divided in convenient equal groups between the splits. After each pick of weft is inserted this reed is drawn sharply forward and drives the weft yarn up to form a compact fabric.

By using a number of heddles and thereby being able to lift warps in almost any preconceived order, it is possible to produce a great number of pleasing designs. What the reader should bear in mind is that the design is here produced by *warp* manipulation alone. Weft must always travel, as the shuttle delivers it, straight through whatever shed the heddles form. This is the fundamental of modern fancy weaving, the highest mechanical expression of which is the Jacquard loom.

Yet, the still earlier form of loom to be described in this paper is the same as used today for the production of textiles that have an art value, such as Oriental rugs and true tapestry. Here the feet are not employed and the shedding devices are most rudimentary. The thrown shuttle is unknown; weft is carried on an uncovered bobbin and passed from hand to hand through the shed. Here design is produced almost entirely by *weft* manipulation, is in fact, a kind of darning, and the entire operation is under much greater control by the artist.

The primitive type of loom just described embodies all the essential

weaving processes and every mechanical addition to this primitive loom has been for the purpose of increasing production. Aside from this, nothing has been added to the loom. When textiles became a necessity and ceased to be wholly insignia of rank or savage ornamentation, the demands exceeded the scanty yardage possible by this tedious method and gradually, through an evolution not too difficult to trace, the fertile ingenuity of the human mind produced the mechanical marvels of the modern mill. But the complete philosophy of the craft had been worked out long before such economic pressure made itself felt, and this paper deals with the examination of a most extraordinary textile development of a prehistoric people preserved in a surprisingly complete condition by the sandy deserts of Peru.

THE FIBER.

Three of the four great classes of textile fibers are found in Peru: cotton, wool, and a bast fiber (probably maguey). Only silk is absent.

There are two kinds of cotton, the white and the reddish brown variety. The latter is claimed by some authorities to be a sport of the former and not a separate species, its reddish color being an indication of a reversion to a wild type. The seeds of both are smooth, but in regard to lint, they are quite distinct. The white is very pure in color, perhaps one quarter longer on an average, very much evener in diameter, and contains a greater number of convolutions per inch than the brown. The photomicrographs [1] show this very clearly (Figs. 2 and 3). The white averages from 1 to $1\frac{3}{4}$ inches in length, the brown perhaps $\frac{1}{2}$ an inch less.

The average length of wool fibers is as follows: vicuña from $1\frac{3}{4}$ to $2\frac{1}{2}$ inches; alpaca from three to five inches; llama from five to seven inches depending on what portion of the fleece they had been taken from. The human hair used was black and rather coarse, but very long.

The wools are by no means as good for spinning purposes as the camels' and goats' wool of Asia. Seldom could they get staple in a white natural shade for dyeing. However, the vicuña has a beautiful natural luster that caused the old Spanish writers to compare it with silk, both for sheen and feel.

Very little can be learned as to the preparation of wool fibers for spin-

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[1] Sixteen samples were examined by Mr. K. B. Lamb, six of which we have taken as typical.

Fig. 1 is a sample of very fine 1 ply yarn. The magnification of this photograph is seventy-five times. This is a most remarkable piece of work. The twist figures out about 225 times to the inch and is higher than we have ever found in modern yarns. The fineness and closeness of the yarn is remarkable.

Fig. 2 is a sample of white cotton. The photo shows the cotton fiber magnified 150 times. The appearance is fair but the fibers are not as uniform nor have they been as well ripened as our modern cottons.

Fig. 3 is a sample of dark brown cotton magnified 150 times. The same may be said of this sample as of Fig. 2. In addition, the fibers are slightly coarser than our modern cottons.

Fig. 4 is a bast fiber from cloth magnified seventy-five times.

Fig. 5 is a sample of wool, vicuña. This shows the wool fibers magnified 150 times. Their appearance would seem to indicate that the fibers had good spinning and felting properties.

Fig. 6 is a sample of woolen yarn, two-ply, magnified seventy-five times. This sample shows twenty-five turns per inch and a very even twist.

The photomicrographs were made with a Bausch and Lomb photomicrographic camera using a Bausch and Lomb microscope and an artificial light (arc light). Two magnifications were used depending on the nature of the sample, i. e., 75 diameters and 150 diameters.

ning. They are found in the baskets, in grease and tangled, and in a cleaned and carded condition. Perhaps the only processes were thorough washing in water for removal of animal fats and a gentle pulling apart as in cotton, to straighten out the fibers. The wool used in the best Oriental rugs receives little more preparation, but after being washed it is packed with meal to absorb any surplus grease. This may have been the practice in Peru, but there is no evidence to prove it.

When the cleaning and carding were finished, the fiber was drawn through a slit on the top of a short stick (Fig. 7). A ribbon attached to this stick allowed the spinner to fasten it in a convenient manner. This distaff resembles those used in Europe before the introduction of the spinning wheel. In Peruvian spinning it serves the same purpose as the cotton cone — presents the fiber in a carded condition to the spinner.

The human hair was used to form braids, sometimes to form very open meshed fabrics, and very often when black was used in the design. It probably had little preparation except washing for the removal of grease.

The bast fiber of Peru is a kind of hemp, the *Agave americana*, or maguey, derived from the cactus leaf.[1] It appears most frequently in twines, in certain nets, and in lace bags of considerable fineness. However, certain fabrics resembling the mummy cloths of Egypt are made from this fiber. Of its preparation little is known. The nature of this class of fiber requires that the leaf from which it is derived be broken up in some manner into fiber of a greater or lesser degree of fineness. This process is known as heckling. Bundles of the fiber previously immersed in water or dew until the pith and outside matter have been removed, in other words retting, are drawn over a number of sharp points and thus split. No such device appears among the implements used in Peru. There is, however, an interesting bundle of maguey fibers, the untied end of which plainly shows some kind of heckling (Fig. 8). Such fibers are prepared by the natives in Mexico today by first allowing the leaves to ret in the dew and then scraping off the fatty matter. The individual fibers are then obtained by pounding or rolling between stones. This seems reasonable enough for the coarse fiber of the twines, but leaves some doubt as to a similar method for the delicate fibers of the lace bags and the fine cloths since these fibers show a degree of fineness almost incredible in bast of this class.

It cannot be said that the spinners of Peru were particularly fortunate in their staples. The fine cotton of ancient India, the camel and goat wool of Persia, and the true flax of Egypt were certainly superior in spinning

[1] "Those Provinces were most charged with the Assesment for Shoeing where Hemp grew in most plenty, and was made from the Stalk of a Plant called *Maguey*." Garcilasso de la Vega, Book V, Chapt. VI.

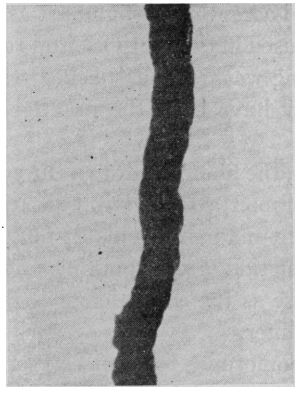

Fig. 1.

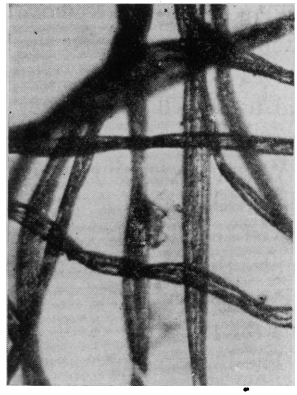

Fig. 2.

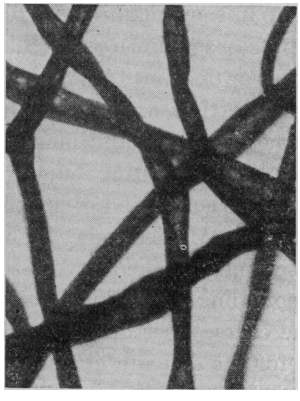

Fig. 3.

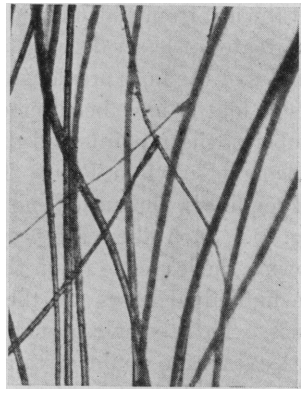

Fig. 4.

PHOTOMICROGRAPHS OF COTTON AND BAST FIBRES.

Fig. 1. Finest Yarn of Brown Cotton, 75 diameters.
Fig. 2. White Cotton Fiber, 150 diameters.
Fig. 3. Brown Cotton, 150 diameters.
Fig. 4. Bast Fiber, 75 diameters.

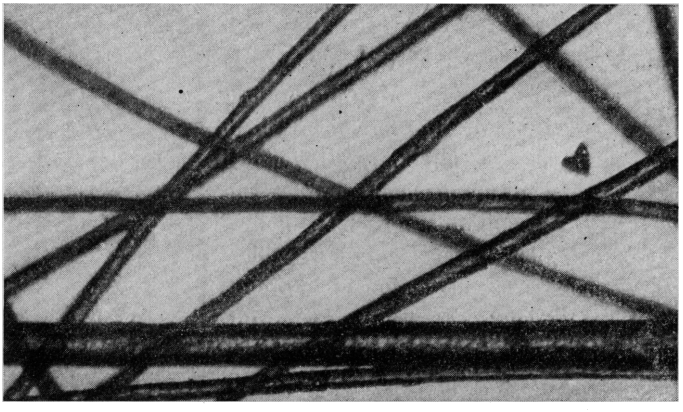

Fig. 5. Vicuña Wool, magnified 150 times.

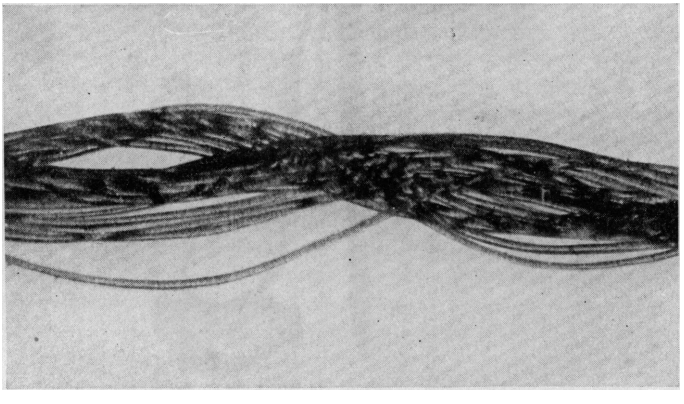

Fig. 6. Finest Two-ply Vicuña Yarn, magnified 75 times.

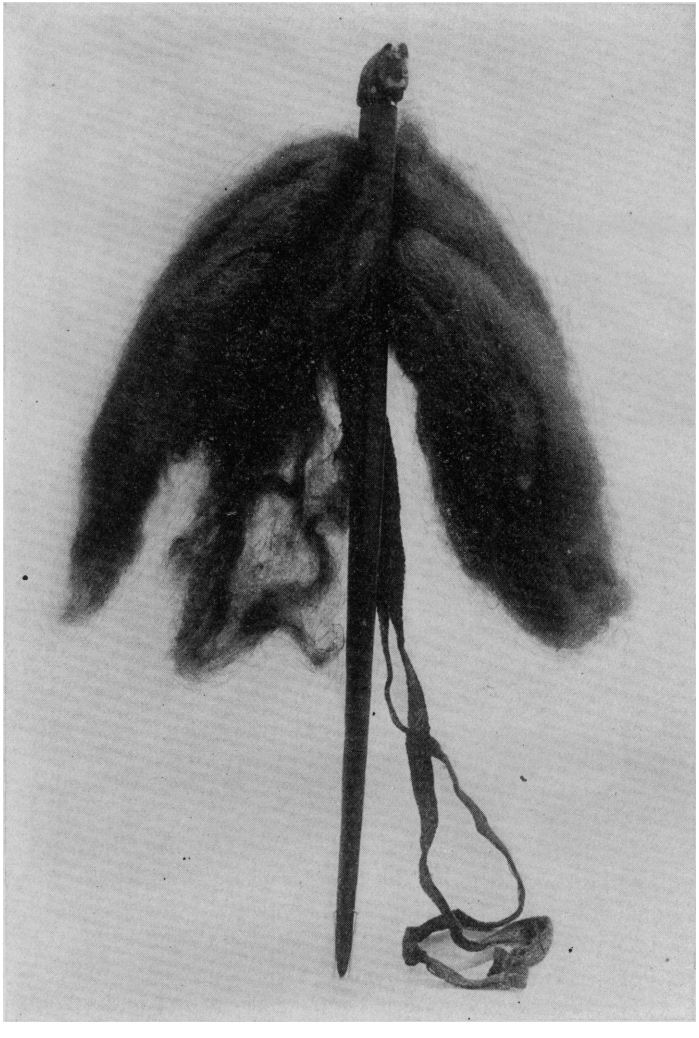

Fig. 7 (B–7768). Wool Distaff. Length, 31.5 cm.

qualities. The same fibers exist, with little change, in modern Peru but in no case, with the possible rare exception of vicuña, are they used in the making of really fine textiles.

Both the cottons are very wiry, and considered by modern standards, of inferior spinning qualities. At the same time, they show certain characteristics of cotton grown by irrigation, such as the comparative freedom from dead and immature fiber. The cotton examined from Nasca was rather inferior to that from Pachacamac. Perhaps this may have been due to irregularity in the water supply of the Nasca Valley.

The white variety is very much better than the brown. However, in the finer fabrics of Peru, the brown is more generally used, perhaps from some superstitious reason or because the color was more desirable. Brown cotton is referred to in the literature of the subject as having been saved for the rulers. If they had a preference for this color, such as we entertain for white, its appearance in yarns of great fineness is comprehensible, because,

Fig. 8 (B-3472). Bundle of partially heckled Maguey Fiber. Length, 49 cm.

great dyers, though they were, this one color seems to have bothered them. Of all the shades, it is the only one which is not up to the high standard they set for fastness.

As we have noted, between ripe cotton fiber and yarn there are at least three indispensable operations: the removal of the seeds, the separation of the individual fibers, and the laying of the fibers in the same general direction, that is, ginning, scutching, and carding. It was the custom, according to Garcilasso de la Vega, for visiting ladies to ask for cotton in the boll, and while carrying on a conversation to remove the seeds by hand; but of the other equally important though perhaps less obvious tasks nothing is mentioned, except that they were by hand.[1]

[1] "They combed cotton and fine wool with their fingers, for want of cards wherewith to card it." Book IX, Chapt. XXX. Garcilasso de la Vega.

So direct information having failed us, let us see if we cannot reconstruct the processes. Cotton is found in the work baskets from Peruvian graves, in the boll, scutched, and felted into a ribbon and in a cone-shaped bundle, resembling a miniature beehive (Fig. 9). The peculiar feature of this cone is that fibers withdrawn from the large open end are parallel, that is carded and quite ready for spinning. Just how these cones were made was not quite clear until a number of soft thick ribbons of cotton were found (Fig. 9d). Upon investigation, the fiber in them was discovered to be in a carded condition. This ribbon was broken up into proper lengths and from these the cone was formed. From the collection, it appears to have been the custom to save the small tightly bound points of the cones. This may have arisen because, owing to their compactness, it was difficult to draw fibers from them for spinning as the binding thread is much tighter and more closely wrapped at the apex.

From the data at hand we infer that the processes were as follows: The seeds were first removed by hand. The fibers were next separated from their tangled condition. Little tufts were then gently pulled apart between the two hands. They were held just firmly enough to cause the fibers to separate but not break, just as a cotton tester pulls apart again and again a sample of staple when determining the length of the fiber. As each little tuft was thus carded it was felted into the ribbon above described. No tools that could be connected with these processes have been found, not even small bundles of switches for scutching. All we know is that it is referred to in the literature of the time as the labor of the lower classes; yet the fiber in our collections is remarkably clean and well carded.

The animal fibers are vicuña, alpaca, llama wool, and human hair. These first three resemble camel's hair. These animals belong to the camel family. The wool scales are very fine, almost imperceptible even under a microscope. They range from the fine soft vicuña, alpaca next, to the rather coarse llama wool. Different parts of the fleece yield different grades of staple; the finest alpaca is better than a coarse vicuña and finest llama better than alpaca. But grade for grade they range for fineness as follows: vicuña, alpaca, llama.

Owing to scarcity, perhaps as much as poor spinning qualities, they are little used by the trade today. The name, vigogne, French for vicuña, is applied to a rough yarn made from cotton, short staple wool, and silk noil or sometimes shoddy and cotton. The name alpaca is applied today to a fabric woven from goat hair weft and cotton warp. The actual fibers are still used in native weaving of ponchos, suggesting in technique, the ancient masterpieces.

SPINNING.

The natives of modern Peru spin with the whorl and distaff method described in the Introduction. Among the archaeological relics from other parts of South America whorls of stone and pottery are quite common, but in Peru they are very rare, although spindles evidently made on a different principle are among the commonest relics of this interesting country.

There is some record by the Spanish historians of sticking a lemon or small potato on the end of the spindle to take the place of the whorl, but

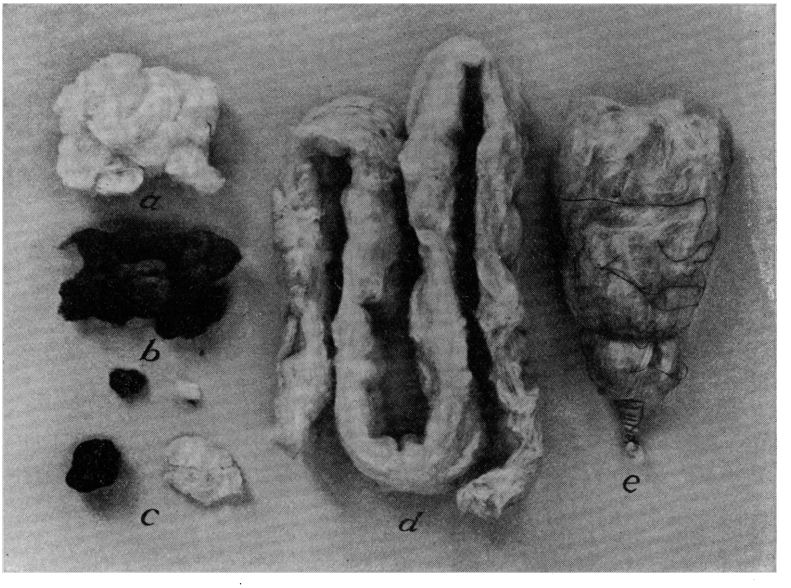

Fig. 9. Stages in the Preparation of Cotton Fiber as found in Peruvian Work Baskets. In logical order they are: 1(c, B–8746), Bolls of white and brown cotton; 2 (b, B–8746), Seeds of white and brown cotton with lint attached; 3 (a, B–8746), White and brown cotton in scutched condition; 4 (d, 8742), Ribbon of carded cotton; 5 (e, B–834), Cotton cone.

this seems a rather unlikely makeshift for a people who had such a penchant for tastefully painting their spindles and carving their spindle bands. The few true whorls found may have been intrusive in ancient times or belonged to a much later period. Almost every woman must have been a spinner and if whorls were used they should be very plentiful in our collections. Gar-

Fig. 10 (B–8405). A Vase from Pachacamac, Peru. Height, 20 cm.

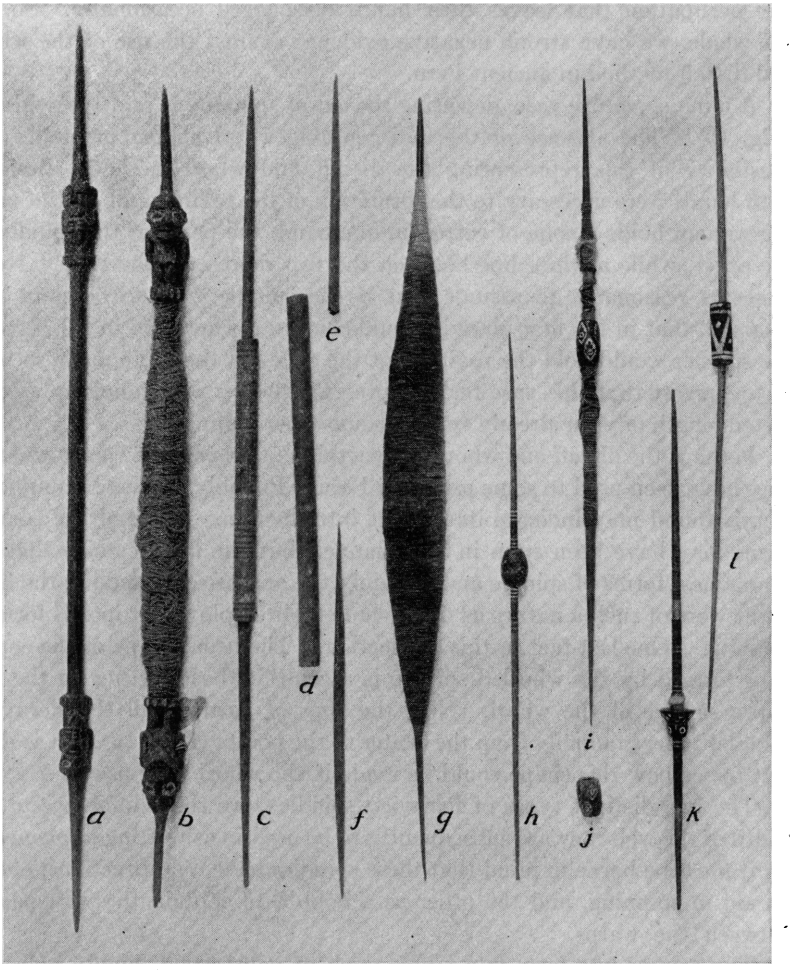

Fig. 11. Types of Peruvian Spindles. *a* (B–8123) Doubler spindle, empty; *b* (B–8132) Doubler spindle containing yarn; *c* (B–8742) Tri-part spindle, empty; *d, e, f* (B–8749) Parts of tri-part spindle; *g* (B–712) Tri-part spindle containing yarn; *h, i, k, l* (B–8745, 8747, 8745, 8742) Different types of banded spindles; *j* (B–8741) Pottery band removed from spindle. Length of *a*, 42 cm.

cilasso speaks of the women walking about doubling and twisting two yarns together but makes no reference to ambulatory spinning. Now, where the whorl and distaff method of spinning is used women spin while engaged in any occupation that leaves their hands disengaged occasionally. So, on the whole, we have strong negative evidence against the use of the whorl and distaff method in ancient Peru.

A famous picture vase, depicting the act of spinning is positive evidence (Fig. 10). The absence of the indispensable whorl almost precludes the possibility of this representing the distaff and whorl method. Besides, both hands were necessary to the formation of the roving, and on the vase, the woman holds a cone of cotton in one hand, the point of the spindle in the other, while a white line between the two represents the yarn. Now, it seems reasonable to assume that if the spindle were to be spun and dropped, that in the first place it would contain a whorl and in the second, the spinner would hold the roving, not the cone. I therefore make so bold as to suggest that this vase really represents the act of winding up a completed length of yarn already spun in some other manner.

Perhaps the distaff and whorl, so general in other parts of South America may have been used to some extent in Peru. Possibly the small number of whorls found may indicate its earliest introduction. Some of the coarser yarns may have been spun in this manner, but the fact remains that the commonest forms of spindle and certainly the ones used in making the finer yarns were of such a nature as to preclude their employment in this form of spinning. One last fact in this connection. The usual shape of the cop of yarn formed by the whorled spindle is a cone, its base resting on the flat upper surface of the whorl. Now the cops of yarn on all the Peruvian spindles taper gradually from the center to the points (Fig. 11g). It is difficult to see how this shape could be made if the whorl were used.

The two distinct types of Peruvian spindles owe their difference to the width of the web they are subsequently to be used in as wefting implements, for it must be borne in mind that these spindles have dual functions, one as an aid in spinning, and the other as a bobbin to contain the weft passed between the warps.

The commonest form is a single stick of palm wood, highly polished, pointed at both ends, and having an ornamented pottery (sometimes hollow cane or copper) band in the center (Fig. 11h, i, k, l). The lengths and diameters of these spindles vary from the size of a large darning needle to ten or twelve inches in length and perhaps quarter of an inch in diameter. As a general rule the more delicate the spindle, the finer the yarn. If the weight of the pottery bands (Fig. 11j) did not preclude their use as whorls their position on the spindle would. This position is thoroughly established by the

size of the holes and the fact that most spindles are decorated with rings of paint to indicate the position of the band. The function of this band was far from being purely ornamental. It prevented the cop of yarn from slipping off the spindle when it was being used in weaving and at the same time being covered with yarn offered no resistance to the tightly stretched warps. For the sake of clearness, I shall refer to this type as the banded spindle. Certain spindles belonging in this class have a short section of hollow cane in place of the pottery band, but the spindle is one piece of wood. (Fig. 11 l.)

The second type is in three parts. (Figs. 11c, d, e, f.) Two pieces of polished and pointed palm are stuck in the ends of a piece of hollow cane. The idea, apparently, was to make a weaving bobbin of greater length. It must be borne in mind that the bobbin is passed from hand to hand through the warp sheds, not thrown as is a shuttle, and greater length would be a distinct

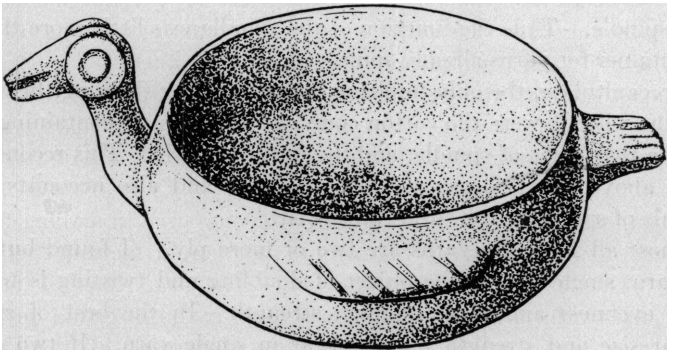

Fig. 12 (B–8743). Spinning Bowl.

advantage when weaving wide fabrics. Perhaps it was difficult to make a bobbin of sufficient length or it may be such long pieces would have a tendency to warp out of shape. Whatever the cause may have been the use of these bobbins is quite obvious. To distinguish them I have termed them tri-part spindles.

A large number of pottery bowls, resembling in size and shape deep saucers are found in the work baskets. (Fig. 12.) It is extremely probable that these were used as rests for the points of spindles. Among savage people today sea shells and cocoanut shells are often used for the same purpose. The ends of Peruvian spindles show great smoothness, the natural result of such friction. It is well known that damp fiber spins to better advantage than dry and perhaps some of these bowls may have contained water to moisten the spinner's fingers.

From these facts we shall try to reconstruct the actual mechanical movements of this wonderful spinning. It can be nothing but the barest outline, as the little tricks, and craft secrets of so old an art, must defy all analysis. The spinner placed the mass of fiber to be spun in some convenient position, perhaps stuck in the belt, or under the arm. From this the proper number of fibers was withdrawn, forming what may be styled a drawing. A slight amount of twist was next inserted, corresponding to a roving. This was twisted about the center of the spindle. Certain partially empty spindles in the collection contain short fragments of this process. Then more fiber was withdrawn, twisted, and attenuated. The point of the spindle was placed in a pottery bowl, the other tilted away from the direction from which the yarn was being formed. The spinner then gradually, with thumb and finger, inserted the desired amount of twist. Little imperfections, nebs, and foreign matter were next removed by gently rubbing with thumb and finger.[1] Perhaps the final twist was inserted as the yarn was being wound on the spindle. Thus the function of the spindle was little more than that of a container for yarns already spun.

To recapitulate, the only implements for spinning (barring the doubtful use of the whorls) were the cotton cone and wool distaff containing carded fiber, the two forms of spindle, and the pottery bowls. This reconstructed process above ascribes uses to each of these, and also accounts for the essentials of spinning, i. e., draft and twist.

Almost all Peruvian yarns are two or more ply. (I found but once a wool yarn, single-ply.) The object of doubling and twisting is to obtain greater evenness and more uniform strength. In the best of spinning, irregular size and strength must appear in single yarn. If two or more singles are combined it is very unlikely that this unevenness of diameter and strength should appear in the same spot in the several yarns, for which reason it is better to have double and twisted yarns than single-ply yarn of corresponding count.

The implement used for this purpose is a piece of hardwood, longer and thicker than the ordinary spindles. There is no pottery band to prevent the yarn from slipping, but at either end about 1½ inches from the point are raised carvings (Fig. 11 a, b). It appears that the yarns from two spindles were wound on these doublers. The spinners then drew them out and twisted them together. The last few inches on some specimens still plainly

[1] "Their spindles were made of canes as we in Spain have them of Iron, they were crooked, but not hollow at the point as ours are: with their thread they made a kind of Filleting, which they wound in upon their spindles, twisting it with the fingers of their left hand: their Distaff they carried in their left hand, and not at their girdle; being about a quarter of a yard long, and held between two of their fingers, and then with both hands they formed the fineness of their thread, and cleared it of foulness." Book IV, Chap. XIII. Garcilasso de la Vega.

show this process. None of these doublers have more than two yarns on them, and yet many cotton tapestry warps are either three or four-ply, and at least one, seven-ply. Perhaps the product of two doublers for four-ply or a doubler and a spindle containing single-ply for three-ply may have been combined. One rather confusing circumstance is that no doublers containing warps have been found. Peruvian warps show a very high knowledge of spinning, great evenness of diameter and regularity of twist, but even in the face of not finding them made in this manner, there are no other tools which could have made them, and therefore they must be the product of the doubler.

To sum the matter up, the spinning tools were the banded and tri-part spindles, and the doubler-spindle, the cotton cone and wool distaff and whatever form of distaff maguey and human hair may have been used in, and the spinner's bowl. Yet that no other tools than these primitive implements, were employed in making such wonderful yarns seems incredible. The yarns are the best ever produced. Almost every degree of twist appears, the purpose of the yarn being taken into careful consideration. No machine yarns, however excellent can approach their perfection.

YARNS.

The basis of all good weaving is good spinning and the excellence of yarn is a truer guide to textile development than is the woven fabric, for in the latter, the design plays an important part, and this is governed solely by location and national taste. The use to which a fabric is to be put may be so widely different either in point of years or geography that a proper estimate of its merit may be difficult to appraise, but yarn is a fixed quantity; every class of weave, lace or embroidery, requires certain well understood qualities, and in a measure, we may say, that there is a fixed, standard towards which all spinning tends.

William S. Murphy in his "Textile Industries" speaks in the highest terms of Peruvian yarns. No words of the writer could equal in praise the opinion of this distinguished authority. The exact reference is here given:—

> It may be that the makers of Cashmere shawls, Dacca muslins, Aztec veils, and Peruvian robes inherited the long labours of a thousand generations; but so far as the spinners of what we call modern civilization are concerned the ideal has been realized, and belongs rather to the past than to the present or the immediate future. The perfect thread is not to seek; it has been made.[1]

[1] William S. Murphy, vol. 3, 83.

The modern method for determining the fineness or size of yarns, is to ascertain how many yards of any given kind are contained in a pound. The ordinary way is to weigh a certain unit of length which is known as a hank, and then determine how many hanks are contained in a pound. The number of hanks in a pound is the count of yarn. The number of yards in the yarn hank varies with the nature of the fiber. For example, the linen hank contains 320 yards; the worsted 560; and the cotton and silk, 840 yards. These arbitrary divisions date back to the days of hand spinning and lack scientific clarity inasmuch as they consider only two qualities — length and weight. The diameter of the yarns is not considered. Obviously, it was impossible to obtain such great lengths of Peruvian yarns as are necessary to make the modern weight tests. Shorter lengths would reduce accuracy. Therefore, the only way to determine size or count of the yarns was by comparison with modern yarns of known count and the approximate counts given therefore, apply solely to diameter. In the interest of clearness, a single standard was chosen, all yarns whether cotton, wool, or maguey were compared with modern cotton yarns, the hank containing 840 yards. Such a gauge is at best guesswork, but repeated comparisons under magnification and the consensus of opinion of many yarn experts, better qualified to judge than the writer, made these tests fairly accurate.

It will be recalled that three of the four great classes of fiber were spun. It will be shown later that almost every class of woven fabric had its representative in Peru. The difference of fiber spun and the varying weaving requirements of the yarns were carefully considered: strength, covering qualities, rigidity, evenness, elasticity, according to the ultimate purpose of the yarn, were fully allowed for by the spinner. In short, after a very careful search no incident of the improper use of yarns was discovered in the Museum's collection. To be fair, the spinning is not only in advance of the best machine spinning but apparently contains the application of certain principles that are unknown today. This applies more particularly to their finest work. The yarns in their commoner and coarser fabrics are not as even as our cheaper yarns today, but I hazard a guess, were much stronger in proportion to diameter.

Peruvian wool yarns are almost invariably two-ply. Of course, they were spun singly. In only one fabric — a light veil — were single-ply wool yarns woven. Owing to the superior dyeing qualities of wool, these yarns were generally used as the decorative element. All the finer tapestries and bobbin-weaves contain two-ply wool weft. Trifling exceptions to this are the occasional use of white cotton, where white is required, and human hair where black appears. The alpaca, llama, and human hair are occasionally employed as warps.

The best illustration of the knowledge of the craft to which these old spinners attained is to be found in their matchless tapestries. Here the weft must be exquisitely fine so as to allow for a great number to be inserted in an inch, and at the same time possess great covering quality so as to leave no bare spots on the warp. A certain degree of elasticity is requisite to allow for a very severe beating up in the weaving. But the acid test for the spinner is the tapestry warp. Here is required a yarn as nearly cylindrical and smooth as possible, very even in diameter and possessing great strength and rigidity, for the weft must meet with no roughness during the beating up. There must be no sagging in the warp, nor great difference due to inequality in the size of the warps in the repp effect that is characteristic of tapestry.

The finest Peruvian tapestry warps are of cotton. Three and four-ply cotton was used. But the three-ply has certain advantages of smoothness over the four. In some cases the yarn is formed from two slack twist yarns, twisted tightly with a third of tighter twist. An example of the finest cotton warp (B-1225) is on exhibition in the Museum collection. It forms the warp in the finest piece of tapestry the writer has ever seen; from a technical standpoint perhaps the finest ever woven. It is unique among Peruvian fabrics in having a true selvage in the modern sense, that is, a selvage running parallel to the warps. This was formed by inserting four seven-ply warp ends at the edge. Surely, this is an unusual thing for a primitive weaver to do.

The warp and weft of bobbin-weaves have about the same characteristics as in tapestry, but in double warp fabrics a new condition is faced; here, both warp and weft appear equally in design and therefore must have the same degree of twist, while in pile knot and in embroidery a much slacker twist is employed. A large number of light weight fabrics have a certain crêpe-like appearance due to the intentional insertion of a great degree of twist in the yarns that produced a very attractive crinkle in the fabric. Voile fabrics very open in appearance were made from yarns containing a truly amazing number of turns or twists per inch. These yarns do not crêpe, as above, but have bite enough to prevent the fabric from slipping. A yarn from the finest example of this class of weaving has been photographed by Mr. Lamb through a microscope and is the basis of a very remarkable calculation in his report. (Fig. 1.)

Ply yarns from singles of different colors, were twisted in what is known today as contrast twist. Tinsel yarns of silver have been spun in Peru by twisting a thin band, or ribbon, of silver about a finished yarn. It is a principle of doubling yarns, that the softer yarn will cover. In this case the silver ribbon was the softer and it seems certain that originally

the silver covered the entire yarn, but wear and the expansion of the yarn due to moisture has given it, at present, a banded appearance.

The maguey yarns are so rare that anything approaching a generalization on them would be very rash. Only two examples of this kind of fabric are in the Museum's otherwise ample collection. However, there is a large amount of twine spun from this kind of fiber and one interesting fragment of tapestry has maguey warps.[1] The great length and individual strength of this bast fiber made the very tight twist so remarkable in the cotton and wool yarns, undesirable in maguey. The evident knowledge of this fact coupled with the great excellence of the few samples examined lead to the conclusion that the weaving of this kind of fabric was much commoner than the paucity of the specimens might otherwise indicate.

Mr. M. C. Andrews of the Ardoyne Works, Belfast, Ireland, a prominent manufacturer of linens, examined a small sample of the two maguey fabrics and pronounced them excellent both in regard to fiber and yarn.

We will now consider the fineness of these yarns in connection with their diameters. In so doing it may be well to call attention to the fact, quite obvious to anyone having textile experience, that the count of yarn possible to be spun depends largely on the nature of the fiber used, and what in one grade of staple, might be excellent spinning, in a finer grade would be very ordinary, and vice versa. It is to be regretted, that so little information is obtainable as to the modern use of the great wool staples of Peru, llama, alpaca, and vicuña, but the general opinion is, that, along with South American sheep wools, they possess rather inferior spinning qualities. To the eye the soft lustrous vicuña appears to be a most beautiful staple, but under the microscope it shows much fewer scales than a corresponding grade of camel's wool, and on the friction producing quality of these depends the spinning qualities of wool.

The Peruvian cotton of today is perhaps a little better than the old grade, owing to the crossing in of the Barbardense, or Sea Island strain. But both are greatly inferior to the wonderful silky fiber of the modern Sea Island cotton. The marvelous Daccan muslins of ancient India, have always stood as the acme of ethereal lightness among woven fabrics. Here too, the fiber played a vital part, for it has been discovered that a certain stretch of rich valley in the Punjab produced, in ancient times, a cotton little if any inferior to the finest of our modern cottons. The spinners of Dacca strove for great lightness, which does not appear to be the case in ancient Peru. From the best evidence at the writer's command the finest Daccan yarn was about No. 500 or 500 by 840 yards per pound, or 420,000 yards.

[1] A number of handsome lace bags were knit from maguey thread.

In Manchester, England, a few pounds of No. 420 are spun today from cotton one third less in diameter than the Peruvian staple, at least twice as long and containing from one third to one half more of the indispensable convolutions per inch. From the Peruvian cotton the best modern spinning ranges from No. 50 to No. 70. The writer has examined ancient Peruvian single ply cotton yarns as fine as No. 250, many as fine as No. 200 and 150 and three and four-ply yarns from 120 to 130.

If some consideration must be allowed Peru in the comparison in regard to the cotton yarns because of fiber, no such leniency is necessary when we come to the consideration of wool or rather worsted yarns. For almost all Peruvian yarns from this fiber appear to have been combed. The finest modern worsted yarn at all common is about No. 120 in the worsted scale of 560 yards to the hank or approximately No. 80 in the cotton scale of 840 yards per hank. Perhaps some finer worsted yarns are made, but very few, and certainly none in this country. Now, while the nature of fiber, improved method of cleaning and combing, dampening, etc., are advantages in favor of the modern spinner, the ancient Peruvian craftsman, produced yarns of worsted about three times as fine. Many woven fabrics contain yarns as fine as 130 to 170 two-ply and one fragment of undyed yarn is between No. 180 and 200 two-ply in cotton count, or about 300 worsted count! While little remains of this spinning masterpiece, yet there is quite enough to prove it was not an accident. And the wonder how such yarns could be produced with their simple tools has never left the writer during the entire investigation.

The finest maguey yarns are about the same as a modern 36 two-ply cotton. Considering the fiber this is remarkably fine.

The ways in which yarns are put up are very important as indications of their use. The different forms in which yarn occurs in the Museum's collection and their different functions are as follows —

1. Balls about the size of an orange. These are very closely wound about some object, sometimes a corncob. The degree of twist in these yarns indicates that they are warps. Aside from a possible use as a reserve supply or a convenient form for storage, I can assign no use for them in weaving. It is generally supposed they were used as a form of currency.

2. Small skeins for dyeing. Sometimes these were loosely knotted to prevent tangles in the dye pot. Other small skeins of decorative weft, the unused fragments from woven figures, could be used in small tapestry and embroidery figures when only short lengths of yarn were required.

3. Weft yarns, wound on banded spindles, tri-part spindles, and bobbins, ready for weaving and a number of short pieces of cane, wrapped with a reserve supply of yarns for the spindles and bobbins.

4. Warp chains, consisting of a number of skeins of the same length and each as long as the fabric into which they were to be woven. This was an important discovery as indicating the method employed to avoid a fatal tangle in the warps when placing them on the loom. With the exception of certain narrow ribbons, the entire length of warp was stretched on the loom at one time and previous to the introduction of the warp beam, the use of a chain of skeins containing the same approximate number of threads, and exactly the same length was a most ingenious method of handling warps.

Fineness of diameter alone, while an indication, is by no means an infallible proof of the best spinning. Evenness in size and strength and a proper consideration for the intended purpose are much better guides. The degree to which these were carried in Peru beggars description. It is no exaggeration to refer to them as perfection. From a technical standpoint it may be said that the single yarns show a much higher degree of twist, and the ply yarns rather more turns per inch than our modern yarns. They are much more cylindrical in form, contain a larger amount of fiber in proportion to their diameter, and were much stronger.

Space does not permit of a more exact treatment of this interesting subject. Specimens of cotton, maguey, and wool, and human hair yarns have been prepared and are on exhibition in the Museum with specimens of the different types of woven fabrics. An examination of them will amply prove the accuracy of the above statements.

Another important subject for investigation is dyeing. The writer is not competent to go into the details of this problem, but submitted samples of these yarns to Mr. K. C. Lamb of the United States Conditioning and Testing Company, from whose report we quote as follows:—

> As far as can be determined, considering the great age of the samples and the chemical changes which may have taken place during this time, all the fabrics are dyed directly without the use of a mordant. It is possible that in some of the yellows and greens a vegetable mordant such as some tannic material has been used, but tests fail to confirm this.
>
> The blues are very fast and the best of all the colors examined. They are probably indigo shades oxidized on the fiber, this being the reason for their fastness. The browns are poor in fastness and cannot compare with the other colors.
>
> The tests were made for fastness to boiling water, boiling solution of neutral olive oil soap, acids (hydrochloric, acetic) and alkalis, (caustic soda, ammonia). The fact that the dyes have kept their brilliancy and body for three or four thousand years is a good proof of their fastness to air, light, dust, and general atmospheric conditions.

WEAVING AND WEAVING IMPLEMENTS.

What are commonly known as hand looms, really might better be called foot looms, since the feet are used to perform very important movements. Aside from the application of power they differ little from the automatic looms of the great mills of today, but the mechanical difference between them and the real hand looms of the Peruvians is immense. The nearest approach today are the Oriental rug and the high tapestry looms. In these all weaving operations are done by hand.

There are four points about weaving to be considered: first, the drawing in, or securing the warps in the loom in an untangled condition, at the proper distance apart, and at the correct degree of tension. Second, the shed, or separation of the warps for the insertion of weft. Third, the insertion or picking of the weft through the sheds. Fourth, the beating up the weft so as to form a compact fabric.

The Peruvian loom consisted of two sticks, one at the top and one at the bottom. In certain tapestry looms, when it was desirable to allow the warps little play, they were fastened directly to the loom bars. (Fig. 13.) But in most cases the warps were strung over strings of soft yarn, and these yarns attached, by a second string to the bars. (Fig. 14.) Assuming that the warp chain described under yarns was the form warps generally took before weaving, this was the method: a skein, as long as the desired web, was slipped on the loom string; the warps were separated into small equal groups, and the binding string, secured these important separations and fastened the whole to the loom bars at top and bottom, thus performing the divisional function of the modern reed. The importance of this separation into groups lay in the fact that this enabled the weaver more readily to manipulate the desired warp groups. At the top of almost every web, that is at right angles to the warps, runs a selvage which binds the warps into the unit groups convenient for weaving. The ordinary selvage runs at right angles to weft and parallel to warps and is generally absent in primitive textiles. However, it occasionally appears in the fabrics under discussion. The object served by attaching warps to the loom string instead of the bar, was, that the former had greater elasticity, and took off the warps a great part of the strain, incidental to weaving. Tension was obtained by tying the loom bars at the proper distance apart. Certain stakes, with carved heads, found in the graves may have been used for this purpose. One bar may have been secured to the weaver and the other to stakes. The

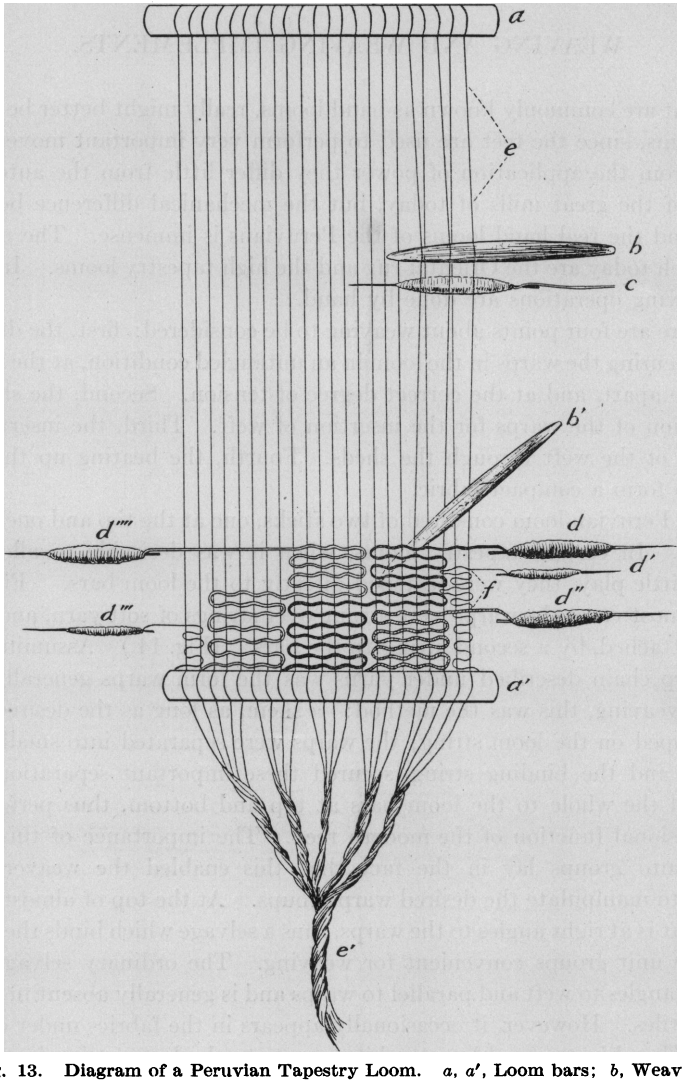

Fig. 13. Diagram of a Peruvian Tapestry Loom. *a*, *a'*, Loom bars; *b*, Weave dagger forming short shed; *b'*, Weave dagger beating up pick of weft just delivered by bobbin (*d*); *c*, Bobbin of weft being drawn through shed formed by (*b*); *d*, *d'*, *d''*, *d'''*, *d''''*, Bobbins containing the different colors of yarn required in fabric; *e'*, Warp twisted from small groups to avoid tangles; *f*, Yarn from bobbin (*d'*) closing up slit in weaving; *e*, Shed formed by weave dagger (*b*).

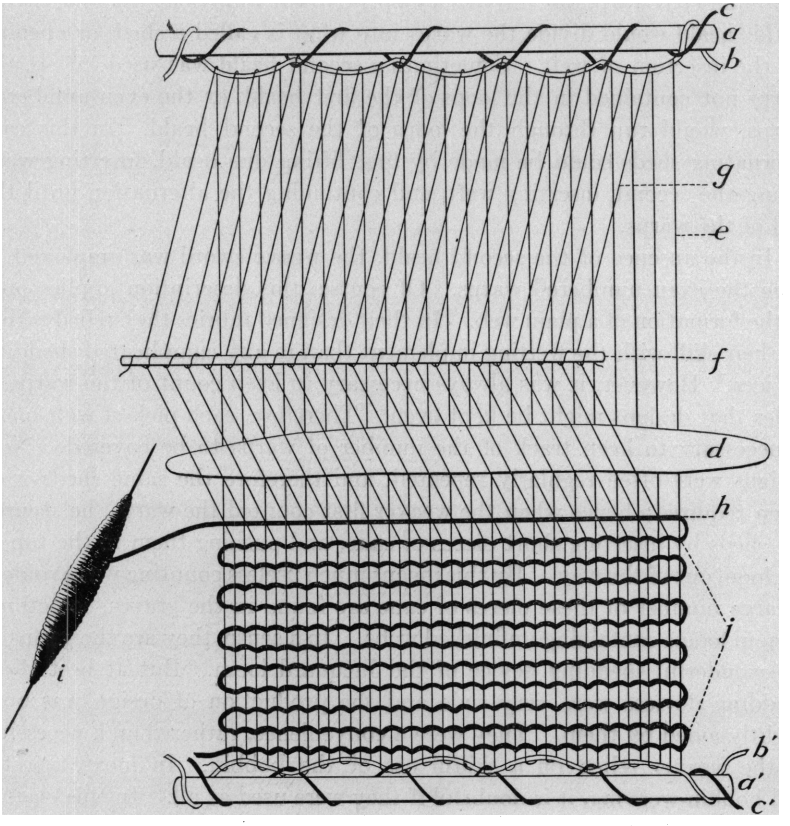

Fig. 14. The Common Type of Peruvian Loom. *a*, *a'*, Loom bars; *b*, *b'*, Loom strings; *c*, *c'*, Binding strings; *d*, Weave sword beating up weft; *e*, Warps not attached to heald rod (*f*), hence not lifted; *f*, Heald rod lifted to form shed; *g*, Warps attached to heald rod (*f*) and raised to form shed; *h*, Weft just delivered by spindle; *i*, Spindle after inserting pick of weft (*h*); *j*, Fell of cloth (already woven portion of web).

upright looms were secured to the boughs of trees at the top, perhaps, and to stakes at the bottom.

The one pure shedding device was the heald rod. (Fig. 14f.) This was a straight stiff stick to which was secured a yarn containing many equidistant loops. This was arranged on the loom so that every other, or odd numbered warp, ran through a loop. Now it is obvious that the lifting of this heald would divide the warps into what is called a shed, or opening for the insertion of weft. Sometimes a second heald was used; if so, the warps not contained in the loops of the first heald, or the even numbered warps, would run through the loops of the second heald. In this case alternating sheds could be made by first lifting one heald, inserting weft, lifting the second, inserting weft, and continuing the alternation until the end of the warps.

In the absence of the second heald, the weave sword was employed to raise the even numbered warps. Of course, this description applies only to the formation of a plain web. In their designed fabrics they relied rather on their skill with the wefting implement than in any complicated shedding devices. However, it was always necessary to keep count of the warps in order that designs might be kept even. Therefore, each pick of weft made it necessary to keep track of the number of warps to be covered. Now designs were often regularly repeated, and therefore the same sheds were often required; hence when the weaver first counted the warps, he secured the sheds by inserting short pieces of cane, and pushing them to the top of the loom out of the way. By this means much useless counting was avoided. A large number of these pieces of cane are found in the graves, sometimes even in looms containing unfinished webs. In a sense, they are the germs of the wonderful shedding device of the Jacquard loom. But at best these shedding devices were very rude and the production of design was only slightly aided by them. They were a convenience, rather than a necessity, as the weaver relied on a skilful use of the bobbin. In most tapestry and bobbin-weaving, it is doubtful if they were used at all. In this class of work the insertion of the weft is more nearly described as darning than weaving.

The implements for inserting weft were, the tri-part and banded spindle, and the bobbin. The two former have been described in the chapter on spinning. (Fig. 11.) The bobbin was a slender polished piece of palm wood about six inches in length and pointed only at one end. The other end was slightly grooved near the unpointed end. This groove appears to have been burned in, not cut. The object of this burning was to avoid rough edges that might cut the delicate yarns which were continually being fastened in it. (Fig. 15 a–c.)

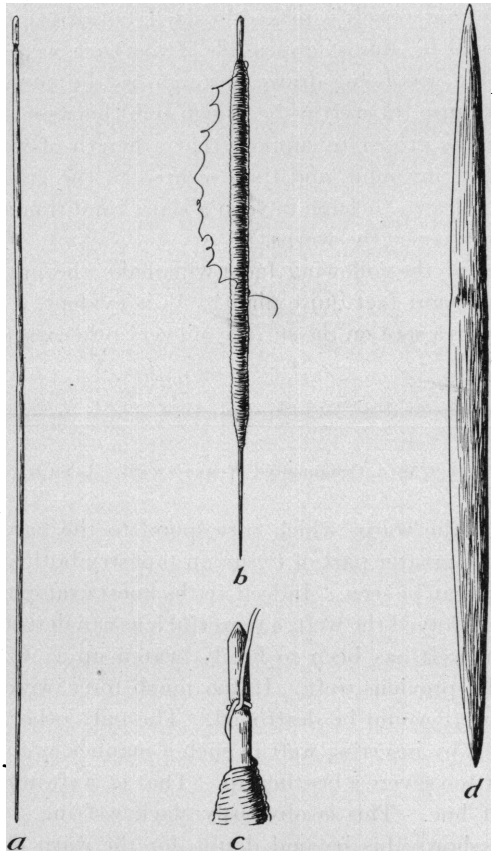

Fig. 15. Weaving Implements. *a*, Empty bobbin showing groove at blunt end; *b*, Full bobbin with weft unwound ready for inserting; *c*, Detail of blunt head of bobbin showing probable method of securing weft before picking; *d*, Weave dagger.

As has been observed, the shedding devices do not appear to have been used in weaving figured tapestry. Weft was laced through only such warps as the figures required, and did not make the complete traverse of the warps as in true weaving. The weaver counted the requisite number of warps and separated them with a finger and then drew the weft through. One cardinal feature of this class of fabric must be borne in mind. I refer to the fact that tapestry weft is picked-in slack, not drawn tight as in other styles. This would be almost impossible if the yarn were allowed to unwind as the bobbin was being drawn through, as the necessary tension to effect this would cause the weft to be drawn tight between the warps. For this reason, it seems proper to suppose that a length of weft sufficient for the figure was first unwound, and then secured to the grooved end of the bobbin and lastly drawn through in such a slack condition as to permit the beating up to fully cover the warps.

Consideration of the following facts will make the importance of this apparently insignificant fact quite plain. As is evident, a pick of weft as first inserted, covers a spot on the surface of every other warp. On the back

Fig. 16 (B-8758). Ornamented Weave Sword. Length, 57 cm.

it covers spots on the warps which correspond to the bare spaces on the surface; but in the greater part of Peruvian tapestry both sides are exactly alike and no warps can be seen. Indeed, in the finest examples, except where wear has obviously frayed the weft, a powerful lens can detect none. Therefore each pick of weft has been so firmly beaten up as to cover the bare spaces left by the previous weft. If too much force were applied in the beating up, the weft would be destroyed. The only other method of accomplishing this is by inserting weft in such a manner as to allow covering the warp without too severe a beating up. That is, weft must be beaten up out of a straight line. This is obviously slack wefting. The weft itself when pulled out shows this beyond doubt, for the warp dents in it are so deep as to bury half the circumference of the warp.

The bobbin (Fig. 15 a, b) was certainly the implement employed in weaving the finest examples of what has been termed bobbin-weaving, in which design is created by weft crossing prearranged groups of warps. The same consideration of slack wefting occurs in this style of weaving. I am inclined to believe that the warps in tapestry and in bobbin-weaving were under a higher degree of tension than in the other styles of weaving. To this conclusion, the absence of the loom string in some of the Peruvian

belt looms points. If, as supposed, the shedding was by hand, then the advantage of a wefting implement less in circumference than the large spindle-bobbins will be quite plain. However, in the unfigured tapestry, great continuous lengths of weft of one color have been employed, and therefore the most plausible explanation of the bobbin is that it was the most convenient form to hold the short lengths of yarn required for the figured webs.

In all other styles of weaving the banded spindle and the tri-part spindles were used as weft containers. The way in which the cops are formed leads to the conclusion that weft was allowed to unwind as the wefting implement was being drawn through the shed. The characteristics of these tools have been explained under the head of spinning. The greater length of the tri-part spindle made it more convenient for use on the wider looms. It must be borne in mind that the spindles were passed through the sheds from hand to hand, not thrown.

The operation of beating up the weft was accomplished in two ways and by two distinct implements. The first and common method, was to insert the weave sword, or batten in a shed after the pick of weft had been inserted and to drive it into the crossed warps by a series of sharp blows. (Fig. 14 d.) In such places as it might catch, it was forced home with some pointed piece of wood or bone, perhaps the tip of the spindle. This is the method employed by most users of this kind of loom today. But when textiles reached a certain degree of fineness such a crude method no longer sufficed. In Asia a comb is used, the teeth of which penetrate between the warps at right angles to the weft, not as the batten through the shed, parallel to the weft. Many combs resembling weaving implements are found in Peru, but the weight of archaeological evidence against their use as other than hair ornaments is so complete as to make it next to impossible to ascribe to them any textile function. There is, however, a narrow, thin, edged wooden implement which could have been pushed between each pair of warps to beat up weft on the same principle as the comb. This is found in almost every basket containing fine fabrics and I have called it a weave dagger (Fig. 15 d).

Two types of loom are shown in the illustrations (Fig. 13, 14), both are diagrams of looms in the Museum. For clearness, only one heald rod is shown lifting warps. Many Peruvian looms had two and I am inclined to believe that in double cloth weaving four must have been employed. The narrow loom without loom string was employed where great tension was desired, and where the small number of warps made the careful division into unit groups less necessary. But how little the loom influenced the nature of fabric produced may be judged from the fact that many fabrics contain three distinct classes of decoration. The change from one type to the other was apparently under easy control of the weaver.

FABRICS.

Cloth is the interlacing of two sets of yarns. It had its origin, no doubt, in basket-making. A portion of a wicker bag in the Museum ornamented with colored wool yarns, may be an example of how basket-making gradually merges into weaving. There is reason to believe that some of the oldest fabrics were rather for decorative than protective purposes. However this may be, it is certain that in primitive weaving the decorative motive appears early, and, with the gradually acquired knowledge of the craft, many ingenious methods of varying the monotony of plain fabrics were discovered. It may be said that there is no process of decoration known to modern textile science but had its origin in some hand craftsman's brain. The philology of such words as shawl, carpet, chintz, calico, gauze, bandanna, and satin, and the plan of the eighteenth century loom, plainly show the Asiatic origin of our textile industries. Roughly speaking, we have but applied steam, water, and electric power to ideas advanced to unsurpassed perfection on the Indus and the Ganges when our forefathers were still satisfied with the pelts of animals and the coarsest of linen and wool fabrics for protection against the cold. No doubt India borrowed something from China, Persia from both, and trade for centuries with Egypt must have resulted in the interchange of ideas as well as commodities. And yet, with the exception of roller and block printing, at least some form of all the combined processes of these great textile masters of antiquity are found in the sand-filled graves of ancient Peru. Some forms are more highly developed than others, and perhaps the different degrees of excellence may be a key to the priority of the different processes. However, the Peruvians were capable of producing many of the same figures in all the distinct techniques and some of their fabrics have never been equaled. I am aware that this is a rather startling announcement, but the proof lies in plain sight in the cases of the Museum; and furthermore, certain skilful expedients of the weaver's craft were unknown outside of Peru, and certain of the finer fabrics, the writer believes after careful search and through inquiry, have never been equaled from a technical point of view.

By far the finest examples of the textiles of Peru and certainly the most widely known of all the fabrics from this interesting country, are the tapestries. What little reference is contained in modern technical writings on primitive Peruvian weaving is to them exclusively. Their marvelous dyeing, the most delicate shades of which have defied an antiquity that makes

the oldest European tapestry seem as a thing of yesterday, and their interesting design treatment will not be here discussed. Suffice it to say, that geometrical and conventional figures appear and their puma, jaguar, fish, bird, and human forms underwent marvelous changes, partially dictated by a savage sense of art and also by the obvious limitations of weaving as an artistic expression. As to their colors, the range of shade is very remarkable, and certainly no better dyeing has ever been done, but this article deals with technical features only.

Tapestry has been aptly described as embroidery on bare warps. Each color only covers such warps as are required in the figure. Weft completely covers warps. Warps are occasionally treated in groups of two or more, but whatever the unit, the weft crosses over or under not more than one unit at a time. Where two colors meet on opposite warps it is obvious that a slit must occur. These slits are joined in the following manner: —

The weft of one color, locks with the weft of the other as shown in the illustration (Fig. 17). A sharp unbroken color contrast is the result. This is weft locking. Another method of overcoming this difficulty is to allow a single bare warp to come between the colors. This warp is then wrapped with a black weft. This black weft at the desired spot takes a turn around the nearest warp in one color, around the single warp and then around the nearest warp in the adjoining figure. Thus, besides a contrasting black line between the colors, a slight dash of black enters each figure. The result is very artistic. This method of closing the slits is called warp locking. (Fig. 18.)

The slits were done away with, in a third class, by the manner in which the weft was inserted. In almost every known form of weaving the crossing of warp and weft is at right angles. Only in the Coptic tapestries and those of Peru is there ever any deviation from this rule. The ancient Peruvian weavers evidently had wonderful control of the bobbins, since weft was picked at every angle; sometimes almost parallel with warps. In this way the openings between figures were closed, and in some cases by surrounding a figure with a binding weft a raised effect was produced. For want of a better name this class of tapestry is called eccentric weft (Fig. 19).

Another form of warp lock appears in a narrow border of a contrasting color on a tapestry ribbon. The weft from the border, for two picks, is laced with the nearest warp as shown in Fig. 20.

The fourth class of tapestry appears as the border to a plain woven fabric. It appears to be sewed on, but in reality the warps run down from the fabric into the border. For artistic effect the border is made heavier. This is accomplished by combining a number of the warps, generally three, into one warp for the tapestry. To prevent slipping, the outside single

warps of each group of three have been crossed. The illustration shows this more plainly than can any description (Fig. 21). Sometimes four warps were thus combined for warp in the border but were not crossed.

A distinguished expert on Oriental carpets, Mr. John Kimberly Mumford, is authority for the statement that no Kelims were ever woven as fine as some of these Peruvian tapestries; and, of course, no European

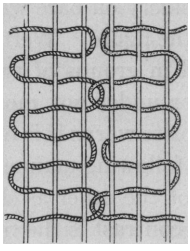

Fig. 17.

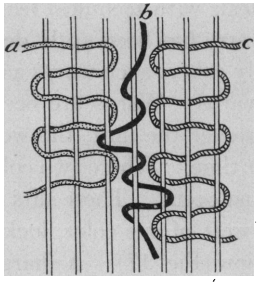

Fig. 18.

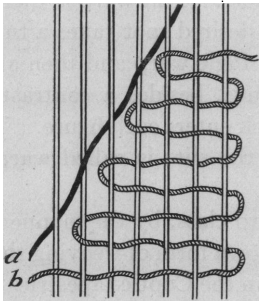

Fig. 19.

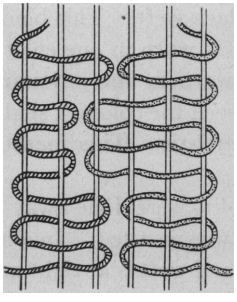

Fig. 20.

Fig. 17. Weft Lock.

Fig. 18. Method of closing Slits by employing an intervening Warp covered with black Weft between the two Colors. *a*, Weft of first color; *b*, Black weft covering intervening warp; *c*, Weft of second color. The black weft takes a turn around the nearest warp in the figure covered by *a*, around intervening warp, and around nearest warp in the figure covered by weft *c*.

Fig. 19. Detail of Eccentric Weft. *a*, Weft outlining figure; *b*, Ordinary weft inserted at right angles to warp.

Fig. 20. Method used to close Slits when weaving colored Border to narrow Tapestry Ribbons.

tapestry compares in fineness with Oriental craftsmanship. It must be understood that this comparison is entirely apart from design and deals only with the dyes, the yarn structure, and the number of warps and weft to the square inch. Gobelins seldom contain more than twenty warps per inch. The number of weft is not stated, and the writer has never been

able to use a high power counting glass on these works of art. The finest Peruvian tapestry analyzed gave the following amazing result: warp three-ply, 150 cotton warps, forty-two per inch; weft two-ply No. 250 vicuña, 260 to 280 picks per inch. The sample referred to is B–1225. So close was

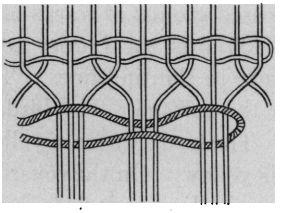

Fig. 21.

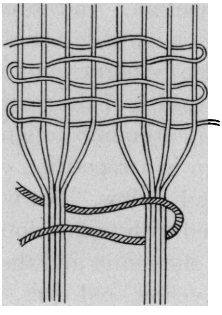

Fig. 22.

Fig. 21. Skilful Method of combining three Warps of a Plain Fabric into one of a Tapestry Border.

Fig. 22. Method of forming Tapestry Borders by combining four Warps from a Plain Fabric to form one Tapestry Warp. There is no crossing of warps as in Fig. 21.

the texture of this unrivaled web that the most powerful counting glass could not make a certain test. It was necessary to pick the weft off the warps with a needle under a powerful dissecting microscope. Several perfect specimens in the Museum appear to be as fine, one at least, finer, but they are in too perfect a state of preservation to be subjected to such a severe analysis.

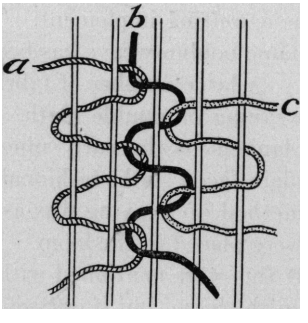

Fig. 23. Method by which each Pick of Weft is locked into the next Pick.

Few of the comparatively coarser Peruvian tapestries are as coarse as Gobelins. Ply yarns carefully spun for this kind of weaving, appear universally. The great abundance of tapestry webs and the very advanced state to which the art was carried, places it easily at the head of Peruvian textiles. True woven designs in which figures were formed by the manner in which the weft crossed prearranged groups of warps were carried to a high degree of perfection. Considering the primitive methods employed in shedding, it is remarkable that such designs could be worked out. This is conclusive evidence, if any were needed, of their ability to carry each detail of a complicated design in their minds, for here the appearance

and disappearance of each weft across the entire warps had to be considered.

One type of bobbin-weaving requires so careful a consideration of weft appearance and disappearance and the ability to carry a preconceived arrangement of color and design of such remarkable complexity as to deserve especial mention. In this class of weaving both sides are finished, the color appearing on one side as designs, on the other as background and vice versa. It must also be borne in mind that unlike tapestry each pick of weft covered the entire width of the warps and also crossed groups of warps of different numbers in forming designs. Sample B–5917 is the border to a tunic. The design is a repetition of the bird figure in slanting lines. The colors are red and yellow. No warps show on the surface. The birds and the lines are red with yellow dots on one side. The bird's eyes are yellow with a red dot in the center and the background is yellow. On the reverse side the birds are yellow, red eyes, yellow dot-lines, yellow, red, dots, background red with yellow dots. In other words, the weaver had to arrange the insertion of each pick of weft so as to form designs on one side and background on the other. It is virtually a double set of weft on single warps. The very finest example of this nature appears in a stripe in B–1225. It must be understood that every appearance and disappearance of weft on face and reverse had to be arranged for beforehand in order to produce design by this method. It falls in the same class as Jacquard weaving. In Peruvian craftsmanship this class of fabric differed from other woven design in that weft was beaten up in the same manner as in tapestry, and owing to the frequent change of colors, the bobbin instead of the spindle-bobbin was used as a wefting implement. To distinguish it from other woven designs the name bobbin-weave has been applied.

A large number of fabrics have been made by what is styled two-beam weaving or double cloth. Modern examples are the old blue and white blankets of the early nineteenth century and certain fancy blacked and plain-faced cloths fashionable in overcoats within the last generation. The method of weaving was as follows:— Two sets of warps of different colors were placed in the loom. Each warp was picked with the same color weft. If this were continued without variation two separate cloths would be left on the loom, but if one set of warps for a certain space be raised above the other and picked with the same color weft, and the other set lowered and picked with its weft, the result would be crosses that lock the fabrics together. To this class belongs a large number of cocoa leaf bags and the figured portions of the little charm bags buried with the mummies. The singular feature of this textile is that the design will be one color on the face and another on the back. At the edge of the figures the lock takes place.

In unfigured spaces the two fabrics can be separated. The finest example of double cloth weaving examined appeared in a bag and is numbered B–4660 in the Museum catalogue. The colors are brown and white, combined in a well-balanced design consisting of small geometrical figures. Each of the combined fabrics contains 48 warps and 48 weft per square inch or 96 by 96 in both. It is interesting to note that all Peruvian double cloths are square in count, that is the number of warp and weft yarns are equal. Other specimens examined were 22 by 22, 36 by 36, and the above 48 by 48. The yarns are cotton, white, and dyed brown, two-ply, perhaps about No. 40–48 warp and 48 weft per square inch in each of the cloths.

Peruvian embroideries also show a remarkable degree of skill. However full the design may be, it seldom shows on the back of the fabric. Most fabrics embroidered on were of cotton and had either a double warp or weft, sometimes both double and untwisted. How carefully the stitches were counted is evident in that class in which the needle has picked up the ground threads in such a manner as to create designs on the embroidery itself. For a clearer comprehension of the style I have named this double design embroidery.

Now of all weaving tricks tubular weaving seems the most unlikely for the primitive craftsman to stumble upon. Today the most common example of this class is the pillow slip. Yet in the Peruvian collection we find a narrow tubular ribbon in which the warps of great variety of color produce design. In order to make the texture solid, the colors on one side have been drawn through to make designs on the other. This is an application of the principle of double cloth weaving. Tubes without this crossing of wefts appear as borders to certain tunics. They are generally filled in some manner.

Crocheting was another method of decoration in Peru. This was done with great skill. In some cases three stripes of crochet were joined together in such a manner as to form single designs. The parts of the figure appear in each strip and are correlated only when combined. Besides this, designs were crocheted and attached with their own yarn as ornaments to a basic fabric. Certain very rare rugs known as Cordovas have the same style of decoration.

Certain very interesting lace bags were made from a bast fiber. The micrographs of this fiber resemble hemp, perhaps maguey or cactus. No people, without borrowing ideas, are supposed to have made use of more than two of the world's four great textile fibers and yet the ancient Peruvians, were able to use three with great facility. Most of their cordage was of this fiber and nets were also made from it.

Net-making naturally suggests the weaving of lace and sure enough at

least two examples of this dainty material are found besides the bags noted above. Several examples of tied dyeing are in the collection. The Indian name for this is bandhana from which the cheap gaudy handkerchief takes its name. It has heretofore, always been considered a purely Asiatic craft.

A very curious and at times confusing characteristic of Peruvian webs was the ease with which they passed in the same web from one style of technique to another. Plain weave, tapestry, and embroidery often appear in the same fragment. Apparently it was as easy to produce design by one method as another. This is good evidence, of how small was the influence of the style of loom, the sudden and amazing transpositions giving the artists an opportunity for proper expression and freedom to demonstrate their peculiar skill. From the size of the web it seems certain that most of the fabrics in the collection were intended for bodily ornament, some few may have been hangings, but it is extremely doubtful if any were used as floor decorations in the sense that rugs now are.

Some mention must be made of the rough but useful sleeping mats. These were made with tight twisted two-ply warps and very heavy two-ply slubbed cotton weft. The extreme dryness of the climate made cotton a better fiber for this purpose than wool. Very skilfully made tassels also appear as a border to woven fabrics and sometimes a series of large ones were formed into what appears to be a girdle.

The pile knot appears in certain ornamental cordage. The knots have been laced with one thread and then caught in a core composed of three threads. A few small fragments of belts, with a design similar in surface appearance to Oriental rugs, is one of the most remarkable exhibits in the Museum's collection. This method of producing designs has always been considered as Asiatic in origin, and the discovery of undoubted specimens of a pile knot fabric in ancient Peru is most astonishing. The knot is rather simple and the number per inch about twenty. In one example five colors have been used.

Brocade weaving appears in some simple designs. This method of decoration is by the inserting of yarn of greater diameter and softer twist than the weft of the cloth and appears on the surface only where the design calls for it. Its soft character allows the weft of the fabric to be beaten up and buried under it. An example of this style of weaving appears in a partially completed condition, on one of the looms in the Museum exhibit.

A large class of Peruvian cloths come under the head of crêpes and voiles. That is, pleasing crinkled effects have been produced by the use of super-tight or crêpe twist in the yarns. This allowed for very open fabrics and the friction-producing twist prevented slipping. In some instances a

reverse twist weft was used with great effect. One piece containing heavy tapestry stripes of varying width, combined with crêpe stripes would furnish a possible design for use today.

One Peruvian method of producing design is most interesting in its technique. In appearance it closely resembles those fabrics in which the plain weft has been either omitted or cut out and a figure of different color darned in. Certain Chinese tapestries have been made in this way, but the technique of the old Peruvians is very much neater and resulted in a firmer texture. The specimen examined is a white cotton crêpe with brown figures. In the figures the weft is brown and although the weft in the basic fabric is white, there is no trace of it in the figures which are composed of brown weft and white warp. The white was inserted to the edge of the figure, then turned back, the brown weft crosses the figure, loops into the white and turns back. Certainly this is evidence of a great degree of patience and desire for perfection almost incomprehensible. To the writer's knowledge no such technique has ever before appeared in any textile.

In most Peruvian weaving the peculiar slack weft characteristic of tapestry appears. This allows for the partial or complete covering of warps. This fact, taken in conjunction with the unrivaled fineness of their best tapestries, leads the writer to suggest that this form of woven design was the oldest in Peru and, judging by analogy, in the world. It may be said in this connection that the earliest form of Oriental rug was the unpiled Sehna Kelim.

Space does not permit the complete analysis of every fabric examined and properly such a list should appear in a catalogue. To the writer's knowledge no such opportunity for the study of the uninterrupted textile development of a people, free from outside influence has ever been presented and he feels that this paper is but an introduction to more exhaustive research.

There is in the Museum a beautiful veil of gossamer lightness which contains heavy medallions of embroidery. No illustration can do justice to this exquisite piece. How a fabric of such lightness could have stood the insertion of such heavy figures is a mystery. The background is a kind of open voile, the yarn is brown cotton about No. 250 or finer and of most amazing twist. The embroidery is two-ply dyed cotton No. 80 perhaps; except the yellow which is two-ply vicuña. No pulling is evident in the stitches.

What may be called the common textiles of Peru, resemble our lighter ducks. The yarns were two-ply cotton, warp much the tighter twist. In this class belongs an interesting cotton homespun. The yarns are contrast twist, brown and white cotton combined. Often these ducks bore painted

designs. Another method of decoration was using stripes of colored warps or wefts or combinations of both in patterns strongly suggestive of modern ginghams. Some of these ducks are remarkably fine and resemble tapestry in appearance, except that it is the warps which greatly predominate in number.

That class of fabrics known as gauze, familiar to us in certain curtains, is well represented in the Peruvian techniques. The peculiarity of this fabric is that pairs of warps are twisted together and the crosses made permanent by the insertion of a pick of weft. It has always been considered that this weaving trick originated in India, but the old weavers of Pachacamac used it with great freedom producing many fancy designs with great ease. The designs were formed by skilfully combining or separating the groups into which the warps were twisted.

The bast fiber used in the twines is rather coarse, showing rough heckling resulting in fibers very uneven in diameter. The lace bags of bast fiber are made of much finer fiber as the nature of the yarn clearly indicates, but by far the greatest skill in handling this staple is in certain linen like fabrics resembling the older mummy cloths of Egypt. Here the fiber shows unquestionable evidence of a high degree of preparation. The extreme fineness and the amazing regularity of diameter lead to the assumption that some form of heckling must have been employed. From certain facts to be noted, it is the opinion of the writer, that the rarity of this kind of fabric in Peru, in a woven condition, was because this class of yarn, made under the most ideal conditions did not lend itself readily to the exquisitely even textiles of Peruvian weavers, rather than to any lack of knowledge of its spinning qualities. Lastly, linen is best adapted to a moist hot climate, whereas the dryness of Peru is proverbial. Of course, Egypt was naturally the same, but the yearly inundation of the Nile caused what may be styled an artificial dampness. The two Peruvian examples examined indicate a much more extensive use and greater knowledge of this class of staple than the small number of examples in the Museum's otherwise wonderful collection seems to indicate. The fiber is very fine, so fine indeed, as to strongly suggest true flax. The yarns are well spun and very even. The finest fabric contains 80 two-ply warps about as fine as No. 32 two-ply cotton, 60 weft about as fine as No. 36 cotton two-ply. The maguey fiber of today is made into some rough native cloths, but in our mills it is considered too coarse for anything but rough bagging and harvester twine.

DESIGN TECHNIQUE AND WEAVING TRICKS.

The figures best known to the student of Peruvian art, are the human figure, the cat, the fish, and the bird, and the conventional representations of the same. This chapter does not deal with the consideration of design that was obviously intended to convey some concrete idea, however vague, but rather with forms of textile decoration that spring almost spontaneously from the mechanical combination of warp and weft in a fabric. It is not amiss, however, to draw attention to the fact that so far was weaving skill advanced that these designs could be produced with equal facility by at least four principal mechanical methods of weaving, such as tapestry, bobbin or true fancy weaving, embroidery, and double cloth. Even in lace, pile knot, and gauze fabric the same figures may be said to find a place.

Let us first consider the weft as a decorative yarn. Its purpose in tapestry is quite obvious. Here it is the sole decorative element. Embroidery may be classed as a kind of weft decorated fabric. What I have styled bobbin-weaving, is another class, almost as important as tapestry, in which weft is the sole apparent ornamental element. Here the warps are covered as in tapestry, but owing to prearranged appearance or disappearance of weft over or under unequal groups of warps, the latter may be said to have a secondary decorative function. Stripes made by the insertion of colored weft appear both in certain tapestries and plain webs.

A very interesting group of textiles is ornamented with warp stripes. So cleverly have some been woven as to leave not a trace of weft. At first sight they appear to be true tapestry, and the tendency to mistake warp for weft is very natural, but fabrics woven by passing a bobbin of weft from hand to hand, with very few exceptions, rarely exceed twenty-seven inches in width. If we erroneously assume the warps of these fabrics to be wefts, we must then assume that they wove fabrics six feet four inches wide and twenty-two to twenty-seven inches long. From this absurd supposition, we are saved however, by finding the characteristic loom strings at the ends of the long yarns, thus establishing them as warps beyond question. The stripes were caused by drawing in the warp in groups of colored yarn, such as the width of the stripes required. In this class of design the warps outnumbered the weft generally more than two to one. Perhaps, the warp predominance may not have as great a weft in tapestry, but I assume only for the reason that these fabrics though fine, were not carried to the exquisite degree of excellence achieved in the former. The finest example was B–5449 in which the warps were 104 per inch and the weft 34.

Combinations of warp and weft stripings produced patterns, many of which appear today in our ginghams. A very interesting comparative exhibition of these designs might be made from the Museum collection. Shadow stripes were produced by the occasional introduction, generally near the edge, of light colored yarns in the darker stripes, either warp or weft. Fancy and broken stripes were produced by warps being unpicked for a certain number of passages of the bobbin, or by the weft jumping certain groups of warp ends.

What is known as gauze is a fabric in which two warps are twisted around each other and the cross locked by the introduction of a pick of weft. If this order were maintained throughout an entire fabric, it resulted in what may be styled a plain gauze. But occasionally they left warps untwisted for a short distance, and by inserting weft in the ordinary way produced weft stripes or by allowing certain warps to remain untwisted through the length of the web produced warp stripes. Sometimes, designs were made by the order in which the gauze twist was used in the warps as in B–4070. In certain plain weaves, an occasional use of the gauze technique produced simple cross-like figures. By the use of gauze warps in plain fabrics, warp stripes were formed.

Besides greater evenness in strength, ply yarns have a value in art. The light refraction from them is softer than from the singles and they give a much more pleasing effect when employed in weft. In warps their roundness produces very handsome repp effects. . At times two picks of weft were run between each shed in the warps. Again, two warps were used as a unit. There are fabrics that contain double warp and weft. This technique varies the monotony of plain cloth and involved little, if any, additional labor. Its purpose was purely artistic. Most fabrics highly embroidered were thus woven.

The knotting on of feathers, sewing on of metal ornaments, the use of tassels and fringes also come under the head of mechanical design. Aside from the actual mummy wrappings, few fabrics, even the coarsest but have some decoration. The use of even the most complicated methods ran through the entire gamut from exquisite tapestries to the coarsest ponchos.

In Egyptian weaving it is very common to find borders sewed on the garments. The Peruvians generally scorned such makeshifts. Almost never was this done. If a border to a fabric was desired it was woven on in the most careful manner. In the same piece they changed from plain warp stripes to double cloth with a tapestry border or stripes of bobbin weaving with narrow tapestry border, or embroidered plain cloth with tapestry edge. In fact, almost every fabric showed their wonderful mastery of the loom.

To classify the mechanical designs, the following generalities may be useful:— In tapestry, bobbin-weave, and to a lesser degree brocade and embroidery, weft is the sole decorative yarn. Here weft greatly outnumbers warp. The coarser bobbin-weaves contain about 24 warps per inch and 72 weft; the finest tapestry 44 warps to 280 weft. Warp stripes, as the name indicates, contain about three times as many warp as weft. The finest example contains 104 warp and 36 weft. In the plaids, warp and weft appear nearly equally in design, varying somewhat with the weaver's idea of beauty. In the double cloths warp and weft appear equally in design and here the counts are exactly square as given above.

The necessity for covering so large a field within the limits of this article leaves little space for the technical discussion of special fabrics. In a second paper the writer hopes to give complete analyses for a large number of the characteristic weaves and diagrams of the distinct technical methods. Yet I have selected four examples, not more interesting than many others, but sufficiently unique, to show the craftsmanship of the whole.

B–5449 is a warp striped poncho. The point of technical interest in this piece is that warps have been drawn in the loom in a slack condition so as to completely cover up the weft. The effect is aided no doubt by the crêpe twist spun in the yarn; but even so, the weaver must have aided by slacking off the warps to an almost incredible degree when the number of 104 per inch is considered. The fabric is absolutely even, no puckering or pulling is evident, and the differentiation of the stripes is sharp and clear. It seems a simple point, but ask any hand loom weaver and you will hear a different story.

B–764 is a fragment of an embroidered cotton duck bag. The figures are the conventional bird in a diamond. Warp and weft of the basic cloth run double, but untwisted, two weft to a shed, two warp to a dent. The embroidery yarn has been locked under every pick of weft, except where it appears to form a pattern. Yet, so nicely has its size, the count of the fabric, and the twist and size of yarns been considered that it is scarcely perceptible except in the clearly outlined design. The pattern appears on the back as though embossed but no trace of the colored yarn can be seen. The slight raising of the weft in a repp by the embroidered yarn gives a very artistic effect.

B–993 is a plain cotton fabric with a slight crêpe effect containing cat figures and a conventional diagonal stripe. The design is brown. The fabric is white. In the figures white warps and brown weft appear. The white weft of the basic fabric comes right up to the edge of the figure and is then looped into the brown weft of the figure. Similar figures are woven in certain Chinese tapestries but here the weft of the fabric has been cut out

and the decorative weft inserted. The Peruvian method is much more skilful and shows the great pride they took in even the simpler textiles.

40.1–1152 (Nasca). This is a very interesting narrow tapestry web. The warps are single-ply, very fine, perhaps No. 100, white cotton, and are treated in units of two. The evident intention was to produce a tapestry without the characteristic repp effect. The design consists of three small squares of scroll-like figures. Each square contains two colors, outlined with fine black lines. Where the two colors come together there is always a line of black between for contrast and as each colored weft comes to the black, they are looped into each other. That is, each color locks into a loop in the black weft. There are 72 picks of weft per inch, and in each inch there is an average of eight such locks, making the astonishing total of 576 places where wefts loop into each other in a square inch.

Under the head of fabrics the construction of the very fine tapestries has been considered. This and the later examples have been chosen as typical rather than extraordinary. The effort has been to give a fairly comprehensive picture of their technique, not an account of some particularly fine specimen. Pile knot, gauze, tubular weaves, and lace were somewhat more rudimentary and yet show remarkable skill and their development may rather indicate preference in textiles than any lack of skill. Of the remarkable range and combination of yarn I have already spoken, but I repeat that this vital part of the art was developed to as high a standard as anywhere in the world. In fact, they were complete masters of their tools. If no other knowledge of textiles existed (aside from the application of purely mechanical invention) except such as owed their earliest origin to Peru, there is no great class of fabrics but of which we would have some knowledge today. Apart from all known outside influences, depending entirely upon their own resources, they produced practically every kind of textile decoration and technique known. Our debt to Asia for textile knowledge is too obvious to be disputed, the very philology of our industry forbids, but it is wonderful to consider that each problem had been worked out and buried under the sands of Pachacamac centuries before the first white man set foot on the shores of Peru. It must ever be a regret to everyone who looks upon certain textiles as a high form of art that a race of such consummate craftsmen should have left no heritage of skill to their descendants.

GLOSSARY OF TEXTILE TERMS.

Warp: The threads which run lengthwise in the fabric. They are the ones first placed in the loom.

Weft: The yarn laced into the warp by the spindle or bobbin.

Shed: The space formed by separating the warps so as to insert weft in desired order.

Heald rod: A stick around which a string is looped in such a manner as to attach it loosely to every other warp. Lifting this stick is one method for forming a shed.

Bobbin: A slender stick of wood pointed at one end, containing weft yarn and used as a wefting implement in figured tapestry and bobbin-weaving.

Banded and tri-part spindles: Used in spinning, and as wefting implements in fabrics other than figured tapestry and bobbin-weaving.

Weave dagger: Thin, edged piece of polished wood used for beating up in bobbin and tapestry weaving; also to form short sheds.

Weave sword: Large, heavy piece of polished wood, drawn to a double edge. Used to beat up weft in weaves other than tapestry and bobbin-weave. Also used to form alternating sheds in looms containing single heald rod.

Beating up: Act of forcing last length of weft delivered by spindle or bobbin into cross of warps, and up against portion of fabric already woven. This portion is referred to as fell of cloth; that is, that part of a partially woven fabric already finished.

Pick, weft yarn: to pick, to insert weft.

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(*Continued from 2d p. of cover.*)

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