straight line. Each type of hand motion demands a different manner of holding. When the straight line technique is used, the hammerstone is held by the thumb and the first three fingers with its base resting under the first or second knuckle. The handstone is then struck in much the same manner as a carpenter strikes a nail with a hammer. By using the forearm and keeping the wrist ~~ridged~~ rigid the impetus of the stone is converted into propulsive force. The motion is in a direct line with the follow through of the hammerstone. A [redacted] hammerstone with a curved surface is used in a manner which will force the center of the curve to strike the material being worked on. The straight line motion is used when accuracy is not required and to [redacted] reduce large masses of lithic material into a workable piece and generally to make thick flakes and blades. The straight line motion will not give the accurate results of the arc motion. When the straight line method is used, the hammerstone is struck back from the leading edge of the core. Flakes or blades that have been detached by the straight line percussion technique leave several marks of distinction at the proximal ends. One distinguishing mark is that the top of the flake or blade is thick with the material flaring on either side of the truncated cone of percussion. The cone part is well defined and there is usually a scar remnant of an eraillure flake present on the bulb of percussion. When the straight line blow contacts the edge of the core, both flake and platform will crush. These flakes show little or no refined platform preparation. Elongated hammerstones

Ce. 35.14.5.1-18

used for the straight line technique will only show use marks on either ends if they were used alternately. If the hammerstone is ball shaped, it may bear use scars over the entire surface.

The arc motion technique using the hammerstone is much more accurate for removing flakes and blades from cores, but is unsatisfactory for cleaving large masses of lithic materials. The arc motion uses the hammerstone in a different manner than the straight line method. It is held between the thumb and the first and second fingers. Both the forearm and the hand which holds the hammerstone is propelled in an arc. The hammerstone contacts the artifact or core on its prepared edge. Because of its curved surface and the way it is projected the hammerstone strikes only a glancing blow. This type of blow does not permit the artifact or the core to receive the full intensity and shock of the hammerstone. When using the hammerstone in this fashion the range of accuracy is greater because the curved surface of the hammerstone and the curved path of flight, the intensity of the force is increased as the hammerstone travels across the striking surface. The tolerance is proportional to both the curvature of the hammerstone and the arc of the blow. The arc technique permits the artifact to be moved into the path of flight of the hammerstone and preselected areas of impact to be struck more accurately then the straight line method. The shock on the artifact may be increased or lessened by the manner of holding the artifact and the hammerstone. By relaxing the hands or by making them more rigid

practice, intuition and feel permit the knapper to thrust the hammerstone into the artifact at the exact time of impact to detach a flake. This feel is attained only after considerable practice. The arc method permits the knapper to isolate platforms by preparing projections to receive the force of percussion increasing the accuracy. The shape of the flakes or blades will depend on contours of the surface prior to striking. The striking angle of the blow and the angle of the platform will determine the termination of the flake or blade. Rippling or shock waves will be governed in part by the material and the velocity of the blow, and thickness of the flake. The hard hammerstone also magnifies the shock waves to a greater degree than a soft one.

Flakes, artifacts and cores made by the hammerstone held free-hand are variable in form and size, and many alterations are caused by constant changes of conditions. However, various stages of artifact making may be identified by separating flakes of similar character and stressing the character of the proximal ends. Certain rhythms in the use of hammerstones will disclose traits, heretofore undetected.

11) Hammerstone with Direct Rest: The hammerstone issues free-hand but instead of holding the implement or the core in the left hand and striking with the right hand as described under hammerstone free-hand No. 10. The artifact or core is artificially supported. Support of the object being worked on can be accomplished in several ways. The simplest is to place the core or artifact on the ground with the

edge to be worked exposed so the flakes may be freely detached without being driven into the ground. In this case, the ground serves as the anvil. The rests or anvils may be of many substances depending upon how much resistance is required for a particular technique. The anvil material may be either hard or soft stone, antler, horn, bone or wood. Such a rest involves the use of force in a direction opposite that which the hammerstone directs the blow. Downward motion of the object being worked on is prevented and at the same time force is exerted from the rest or anvil into the artifact or core. The forces are directed in a manner to prevent their opposing each other, which would cause crushing. This technique diverts them so they by-pass each other causing a shearing between the anvil and the hammerstone. Blades detached from cores by the use of the rest are much flatter than those held in the hand or against the thigh because they are allowed to roll with the blow and as a result are projected. Assuming the artifact is a biface, the shock is concentrated between the two points of both the anvil and the hammerstone which dampens the vibration to the distal end of the artifact. Cores are resistant to shock because of their greater mass. The flakes and blades will terminate to a better edge without removing the opposite side of the artifact or the distal end of the core. The use of the anvil or rest will not show compression rings starting from the distal end of the flake, but only at the proximal end which receives the force from the hammerstone.

Materials used for the rest are selected with regard to the lithic material being worked. For example, obsidian because of its brittle nature will require that wood be used to prevent its fracture.

Quartzite or granulose lithic materials which require more force to cause their fracture require an anvil of dense hard material. The use of the anvil or the fixed rest adds one more complication to a simpler method of hand holding. To use the rest method efficiently requires considerably more skill and practice because you have another force to be directed and the slightest miscalculation of this additional force will result in failure. When the artifact or core is hand-held the use of the rest is an important aid to the knapper because it relieves the strain of the left hand. One is assuming that the majority of the knappers were right handed and used the hammerstone in the right hand and held the artifact or core in the left hand. It is converse but interesting to note that the left hand performs considerably more work than the right arm and hand. The left hand must both support the core and manipulate it at angles proper to remove flakes. The fingers of the left hands seek out the ridges and examine the underside of the object being worked on. This must be by feel alone for the underside is not visible to the knapper. So in order to retain a fixed position and keep the feel which would be lost if the artifact was visually examined after each blow the fingers are in almost continual motion. The left hand must counter the shock delivered by the

hammerstone which also creates undue strain on the left hand. Hand holding provides for considerably more maneuverability and ease of manipulation than when using the rest or anvil method. There are advantages and disadvantages to both methods and their use depends upon the desires of the worker and the tool form he is going to make. The size of the material being worked on is sometimes a deciding factor in which method will be used. When a small object is struck it will be projected with the force of the blow more readily than one of greater size. An example of the use of this technique is cleaving of small pebbles of agate, a variety of chalcedony. These pebbles are from one to two inches in diameter and have a semi-polished surface. They are most intractable and unyielding and have no projections or flat surfaces on which to impart the blow. Because of this it is impossible to repeatedly cause the pebbles to be cleaved by hand-held percussion technique and, therefore, the worker must resort to the anvil or rest. Such an industry has been reported by Dr. Fred Wendorf , Joel Shiner, occurring in Sudan, Wadi Halfa, (personal correspondence)

12) Hammerstone with rest and clamp: The use of the hammerstone with the aid of the rest and clamp is much the same as described in section No. 11, with addition of a holding aid. The holding device allows the worker considerably more freedom of movement then when the left hand has to be used to hold the material being worked on. The holding medium may be a second person or it may be held between the feet of the knapper. These two methods permit a certain amount of movement of the article

being worked on and restrict and limit the positions in which they may be struck. The aboriginal probably used numerous and varying devices for holding, but because of their perishable nature little or no evidence remains. There is, however, evidence of holding devices used for certain techniques which were produced by both downward and outward pressure and percussion. Examples are the Artic microblade industries, the Mexican polyhedral cores, the Hopewellian cores and many examples of percussion struck flat blades and flakes. These types of holding techniques are by far more common in core and blade making than when making bifacially flaked artifacts. Stops and pegs are useful in restricting the movement of the artifact in one direction only and do not fully immobilize the implement. The stops may be simply depressions made in a log while the pegs may be driven into a log with a slight depression between them to provide a clearance for flakes to be removed. This method is more useful for indirect than it is for direct percussion and may also be used for pressure. These experiments have made use of all varieties of clamps, vises and maans of holding. I have found that no mechanical vise is as satisfactory as one made from two strips of wood loosely bound by cordage at one end and sufficiently far back to allow the insertion of a core. The opposite ends of the wooden strips are then spread until the desired pressure is attained. The strips of wood may be of any length or section. Great amounts of clamping force may be gained by such levers. When such a holding method is dismantled it would be un-

recognizable as a functional tool, but materials other than wood may be used for making a similar device. When doing preforming work with massive material I commonly use a large flat stone placed on top of the clamp to further immobilize the object being worked on.

13) Hammerstone with rest bipolar: The bipolar technique is a term commonly used in anthropological literature and one that deserves mention. In my attempts to produce a flake or blade with a cone of force at both ends, I have conducted numerous experiments. My present feeling is that it is impossible to make such a flake. If Peking man was able to produce such a flake, he took his secret with him. Today I haven't been fortunate enough to see such flakes nor have I seen such flakes in the numerous collections I have examined. I fail to comprehend the laws of mechanics which would create such a flake. If a nodule of flint-like material is placed upon an anvil, and then struck in a manner to form a cone on both ends it would have to be because two forces are simultaneously in direct opposition to each other. Such a method creates two opposing cones which would shatter the material without removing aflake. The resulting debitage from such an action is generally a mess of splinters roughly triangulate in section having no definition of a bulbar scar. The bipolar technique is not to be confused with the anvil and rest technique, because each embodies a different set of mechanical problems.

A cobble like core could, however, bear scars on both ends of a cobble meeting on the same plane, but the core would bear the negative bulbar impression and not necessarily indicate that they were removed at the same time which is unlikely. Such a distinctive core would possibly be a technological trait of changing ends of the core as each flake was removed from the same face. The flakes removed xx from such a core would be truncated by either a hinge or step fracture and expanding as they reached the distal end. The flakes would also be unduly thick. The core face would be concave rather than convex. A slight variation of the bipolar technique was used both aboriginally and in the experiments to make right angled edges on blades and flakes. Such a method is used to bear a burin core or at least one type of a burin core prior to removing burin blades, and notching the edges of blades, also for severing and making microburins. Some styles of both flakes and blade knives are backed by the rough retouch done by placing the flake or blade on an anvil and then carefully striking the supporting edge with a small pebble or a small hammerstone. However, the blow is struck slightly less than vertical which is not truely bipolar and the forces are not directly in opposition with each other. Edges made by the use of this technique have certain distinctive characteristics which will be described in more detail under flake and blade knives.

14) Hafted hammer free-hand: The use of the hafted hammer held in one hand and the lithic material held in the other has advantages and disadvantages over

the unhafted hammer stone. The handle affixed to a hammerstone has the advantage of increasing the velocity of the blow and the velocity is increased in proportion ~~xxxxxxxxxx~~ to the length of the handle. The higher ~~velocity is~~ velocities gained by the use of the handle serve an important step in free-hand flaking of small artifacts that have insufficient weight or ~~enertia~~ inertia.

If the striking motion is slow the artifact will be projected with the blow of the hammerstone. High velocity blows from a hafted hammer will permit the knapper to remove thin, wide and feathered flakes from the artifact. The hafted hammer doesn't bruise the hand holding the hammer. The disadvantage of the hafted hammerstone is that the slightest miscalculation in judging the point of impact on the artifact are magnified in proportion to the length of the handle because of the error factor. In using a hafted hammerstone the knapper must seek handle holding positions which will better enable him to use the tool with accuracy. I find that by holding the artifact in the left hand and ~~by~~ placing the back of the hand against the inside of the knee helps to fix the position of the artifact. The right hand ~~wheels~~ wields the hafted hammer, but the right elbow is held close to the body. This limits the movement necessary to deliver the blow of the hammer. This method is done in a sitting position on a low seat or on the ground.

15) Hafted Hammer with Rest: The hafted hammer is used in much the same way as in No. 14 with the exception that the object being worked on is placed on a rest.

The rest or anvil will aid in dampening the shock to the artifact but because of the inaccuracy of this method it is necessary to isolate the platforms. Accuracy may be increased by constant practice which is true of most flintworking techniques. Brief experiments will resolve little. The use of the rest will relieve the fatigue caused by holding in the left hand and will also result in flatter flakes with feathered edges. This method is suitable for the removal from tabular core pieces of the distinctive side struck flakes. They are the flakes which expand rapidly as they reach the edge of the core removing the distal end of the core part bilaterally. The distal end of the flake is then bipointed and somewhat triangulate in longitudinal section. Blades may be also removed by the use of the hafted hammer with a rest. The cores are predesigned to limit the blade's expansion. The shape of the flake is controlled for the largest part by the core surface. The size and weight as well as the length of the handle must be adapted to its functional performance.

16) Billets or Rods Free-hand: The use of billets or rods of wood or antler, hafted or unhafted, offer many advantages over the use of the hammerstone for removing flakes from bifacial tools. This baton-like percussor is held in the right hand and the material being worked is held in the left hand. The billet is normally swung in an arc-like path of movement instead of in a straight line. Its velocity can be increased or decreased by grasping the baton further or nearer its working end.

The billet has been a standby and a favorite among many of those experimenting in flintworking techniques. There are several reasons why this implement has produced better results than the hammerstone. Its use does not require the accuracy which is necessary when using the hammerstone. Also the billet does not impart the shock of a hammerstone. It is easier to direct the path of flight and vary the velocity. The wooden billet permits a novice to attain fair results even from blows of limited accuracy because the wood, even hard wood, is relatively softer than the hammerstone and permits the flint to slightly penetrate the billet without creating the shock of the hammerstone. Because of the dampening effect poorly directed blows will not shatter the artifact. The novice can repeatedly strike the edge of the artifact without removing the desired flake. And, even though the worker may be unaware of it, small bits of flint are being removed from either side of a ridge or the high part of the underside of the artifact. Because of its greater thickness the ridge or high point has more resistance. Repeated blows of the billet will eventually free the part of the edge which bears the ridge scar left from a previously removed flake, making a platform and centering the ridge without being conciously designed by the wielder? of the baton.

The flakes removed by the wooden billet will naturally be thin and without a sharp definition of the cone. Or in other words, they will have a diffused bulb of percussion. The area contacted by the billet will be of the width of the proximal

end of the flake. The flakes are usually characterized by the presence of a slight lip on the ventral side. The lip is caused by the slight penetration of the edge of the flint into the billet. It is more pronounced when using a wooden billet than one made from antler. When the billet technique is used, the hardness of the wood will accentuate this diagnostic feature. The wooden billet is of little use for striking blades from a core. The worker must be much more accurate in striking when using the antler billet, due to its increased hardness. The thicker flakes may be removed with a single blow. In order to use the antler billet efficiently one must have some knowledge of the fracture of flint-like materials because one must pre-establish surfaces prior to removing a flake to get the desired dimension. Special attention must be given to the selection or preparation of the platform areas. The end of the billet which strikes the artifact must be slightly rounded so that the edge of the material will contact the curved part of the billet. As the billet becomes worn from use, it may be rotated to prevent its becoming flat and developing large facets. There seems to be a scarcity of aboriginal billets. Wood could not be expected to endure the ravages of time but those of antler or bone could be expected to endure. Many flakes occurred in aboriginal sites which indicate that they were removed by the use of the billet technique. One explanation may be that they were consumed through use. There is, however, an illustration of four of the typical antler billets pictured on page 193 (B.A.E. Bulletin 60). W. H. Holmes (date?)

The wear patterns indicate that both ends of the billets were used for thinning and forming the preform which was made by a hammerstone.

My experiment was an exact duplicate of this process, see illustration for characteristic flakes removed by the use of wood and antler billets. There is another distinctive use of antler sections which is quite different from the use of billets previously described. The former was the arc-like motion of the baton held in the hand in the same manner as one would hold a common carpenter hammer. This technique is to hold the billet vertically and project it in a striking line to the point of impact. The billet is held vertically in the right hand and then projected in the same manner as one would use a hammerstone in a straight line technique. This method of using the billet is useful for detaching blades from a core. The advantage of using the billet in this fashion is that it dampens the shock normally created when using the hammerstone. There is a diffused bulb without the sharp definition of the cone, general absence of eraillure flake scar and a wide lateral platform. The definition of the compression rings are about midway between those made by the use of a hard hammerstone and those removed by pressure. The antler because of the nature of the material tends to prevent shattering which is common to the hammerstone. When using the billet in this manner a shorter billet is desirable than that used in the arc method.

Note: This may be a repeat in the Polyhedral Core paper. Since this is an outline of the techniques I feel it should be included here.

I first became aware of this technique in the 1930's when assisting with the paleontological survey on the Walker Lake Region of western Nevada with the late Dr. Reuben A. Stirton. While camped at the ranch of a Nevada pioneer, he told of the Paiute Indians stealing the wooden spokes of the wagon and buggy wheels to use for making stone artifacts. This elderly man didn't know how or why, this is what the Indian told him. Before acquiring this bit of information, I had used only hammerstones for roughing out preforms. I then began to experiment by using the broken handle of a prospector pick and was soon able to see the advantages of this type of a percussor over the simple hammerstone.

The Australian primitives have also been observed using a piece of hard wood to tap the flint-like materials setting the ends of their throwing sticks. Such was a common retouching or sharpening method. Others that have made use of the billet or baton in their experiments have been A. Coutier?, Prof. A. S. Barnes, Andres Kreigh, L. S. B. Leakey, P. Lee, Jacques Tixier and Francois Bordes, who has gained great control and understanding of the use of the billet. The methods of billet use is not too difficult. There are two methods the arc like path of motion and the straight line motion. When the arc like motion is used the billet is held in the right hand in the manner similar to holding a club, with the forearm supplying the force and the wrist being held immobile. The blow is

projected in a follow through motion. The objective material is held in the left hand either protected or unprotected. The novice should use protection, but upon gaining any experience the bare fingers are most useful for a feeling and examining of the underside of the artifact. The objective piece held loosely on the ~~fffff~~ four fingers of the left hand with the thumb ~~heldxtight~~ just holding the artifact in position with very light pressure. The blows delivered from the baton are then directed into the main body of the tool under construction, such a blow being directed from the tip towards the base and those from the base towards the tip and those on the marginal edges towards the opposite edge. There are several variations in the methods of holding and striking. One is that the tip of the billet is used at right angles to the artifact. The other is that the edge of the billet is used and the holding position of the left hand changed accordingly. When the latter method is used the flakes are removed between the first and second fingers of the left hand and the objective piece is held parallel to the arc of the blow. A thick core tool may be made very thin by the use of these techniques. When the billet contacts the edge of the artifact, the flake is removed from the underside of the object. Then if the flake removed has the desired qualities, one can proceed to remove the balance of the flakes from the margin keeping the angle of the blow and the angle of the ~~projective~~ objective piece and the intensity of the blow constant. The artifact is turned after each blow, the feel and rhythm is lost. However, with practice

and skill the worker will find it desirable to alternate the removing of flakes from both sides from the same margin. Each artifact presents a new set of problems and each must be dealt with in a slightly different manner and modification of the techniques. For instance, it may be desirable to terminate a flake in the middle of an artifact either by a step or hinge fracture, then meet the flake by removing another flake on the opposite side. Very thin bifacial tools may be made by this type of thinning. The thickness of the flake will depend on the distance from the edge of the artifact and the length and width depends on the exterior surface and the intensity of the force of the blow. The amount of area contacted by the billet will also relate the width of the flake and the flakes termination is related to the angle in which the objective piece is held and the angle at which the blow is struck.

The types of materials of billets leaves characteristic platform attributes on the platform area of the flake. These characteristics may serve to identify the billet material depending on the hardness or softness of the material used. The softer the material the greater the penetration of the flint-like material into the billet. Wooden billets will vary in hardness depending on what wooden material was used. There are a few of the exotic hardwoods such as mountain mahogany, sapodilla tree and others that will compare in hardness with antler. The results of different materials with equal hardness will therefore be similar.

The geographical area will in part be a deciding factor on what materials were available from which to make a billet. Whether the materials be of hardwood, antler, horn, bone or even stone depends on what was available at the particular time. Another consideration is the genus of the antler-bearing animal supplying the billet material. Those derived from caribou, moose and elk are considerably larger and more massive than those from the deer, resulting in billet material of increased weight which would allow the knapper to remove larger flakes than if only deer antler was available. The use of the bone billet should be mentioned in these experiments. I found that the cannon bone of a horse is well adapted for the experiments because of its shape and weight. The bone billet is not long enduring because of the spongy nature at the ends making it unserviceable after making only one or two medium sized artifacts. The ends become unduly soft making it impossible to remove any large number of flakes. When the spongy part of the bone has been consumed the solid part is very brittle and lacks the strength because of the marrow cavity at the center of the bone. Fresh uncooked bone will withstand the impacts much better than the weathered or altered bone. Both individual and traditional techniques of using the billet will be revealed by examination of the platform area of the flakes. There will be a major and minor variation which will depend on the manner of holding the artifact, the hardness or softness of the billet and the character of the surface prior to receiving the force of the

blow. The salient bulb or one showing a conspicuous well defined cone part is not common on flakes detached by the use of the billet technique which is common from the application of the hammerstone. The presence of a slightly overhanging lip is usually found directly beneath the continuous oval curve of the platform. Such a curve on the platform is caused by the billets contact surface on the core as it pulls away the ~~xx~~ flake. Because of the nature of the billet material, the cone is caused to spread and is known as a diffused bulb. Most of the flake character is dependent on the preparation of the platform which will be detailed in another part of the ~~xfk~~ flake ~~xxxyx~~ analysis. Granular materials can also cause bulb diffusion. Since the billet is commonly used to finish the artifact other than pressure flaking, and was preformed by the use of the hammerstone, the dorsal surface of the first series of flakes will bear the scars of previous flakes removed in the stage prior to using the billet. The billet flakes are usually rapidly expanding with a feathered edge and an accentuated curve.