TECHNOLOGICAL TRAITS

The aspects of typology based on technological traits, form, function, materials, tradition, and distribution in time and space are many and varied. Certain typology models based on technology, form and function may be unique in that they will include only one of these characteristics; or they may be stereo-types including all three of these attributes. Due to the blending of the many subtle features and characteristics of the specimen, it is difficult to establish hard and fast typology rules to include the numerous cultural traits of a specific type. This paper will be concerned with the technological traits of the aboriginials' stone tools and their relationship to typology and is intended to assist in separating flakes and blades for the purpose of relating them to cores and techniques by an interpretation of their mode of manufacture. For purposes of analyzing assemblages, all flakes and blades will be called "flakes" although existing literature does use the term splinters, chips, spalls, blades, lamellar flakes, lamellars, bladelets, prismatic blades, flakes and blades.

Experiments carried out over the past years have afforded a basis for some conclusive evidence regarding the mode of manufacture. Hopefully, these experiments will shed some light on the aboriginal lithic industries and will point out the magnitude of debitage flake study and their relationship to techniques. Results of experiments with various techniques will be cited to project the need for additional research on types not yet fully understood. Those not fully understood will be hypothecated on the basis of conclusions drawn from the experiment, and possible techniques will be postulated. Experiments have confirmed the theory that before final judgement or analysis of technique can be made, the stoneworker must replicate both core, flakes, and blades in all aspects and characteristics. Further, unless a replica of the original can be duplicated by the same technique - not one, but many times - one can go far afield with theory alone. In toolmaking, there are definite laws of mechanical and physical properties of materials and applied force which remain constant. Therefore, if the experimental results are the same as those of the aboriginal, then we may conclude that the techniques used were much the same. The holding method may vary the direction of flake removal and cause a variation in flakes and flake scars, but the actual mechanical principals of platform preparation and applied force remain constant.

My attempts to replicate flakes and cores have revealed a neglected concept in the study of prehistoric man, i.e., that the lithic materials of his tools, the muscular motor habits of the toolmaker, technological traits, human behavior patterns, evolution and phylogeny, conscious planning, traditional development, outright invention, pride of workmanship, and the need for superior tools provides an insight into the lives and economy of the prehistoric people who skillfully fabricated stone tools so necessary for their existence. My attempts to replicate the tools of this very complex industry have increased my respect for prehistoric man's knowledge of lithic materials and its source and his mastery of fashioning stone into a formidable weapon or a useful tool. His stone implements exhibit unbelievable control of muscular coordination; an ability to visualize the artifact within an irregular block of stone; he understood how to overcome the mechanical and physical problems necessary to produce a useful end product, and he had a consistent and precise ability to calculate angles for projecting forces of variable intensities.

Typology based on technological traits will have a greater consistency of habits and rhythms of flake removal whether it be an individual blade, flake, or a complex artifact. Technology also demonstrates not one but many traits whether the analysis be of a simple flake, blade or even the more complex phases of toolmaking. Debitage can indicate definite technological traits and techniques that may be useful in distinguishing at least one phase of a cultural complex. Assiduous examination of both the flakes and their scars will readily reveal the technological traits and techniques which associate themselves with tradition, environment, and distribution in time and space; and may reveal these traits developing into more refined techniques in different geographical regions and periods of time. There appears to be both singular and parallel technological trait phylogony based - in part- on environment, and showing a need for a definite tool to perform a certain function. An infinite variety of core, flake and blade forms must be considered to separate the techniques used over a span of both time and space. It is the writer's feeling that flake study will resolve definite types of flakes pertinent to only diverse groups of people in various periods of time and geographical areas.

Typological manifestations pertaining to techniques and technological traits should consider the adaptation of material varieties to both techniques and function for certain materials have a direct bearing on the manufacture technique and the proposed function of this material. Since the aboriginals' material preferences encompassed both technology and function, this could well be a diagnostic trait. For example: many times, and for technological and functional purposes, he preferred and chose granular and coarse textured rocks when obsidian or a vitreous stone was readily available.

Sorting artifacts into form categories is useful for rapidly classifying certain artifact types such as projectile points and their related forms, but it cannot be used alone as a basis for typology. Artifacts - other than unifacial and bifacial implements - are too variable to have form alone considered. Measurements and shape can and do vary with the individual problems of function. It may be necessary to modify the implement, during manufacture, because of imperfections in the material or a miscalculation by the worker.

The functional category of typology should be related to both form and technology. Functional analysis of tools, except hafted artifacts, will probably always be a matter of conjecture, but flakes removed by use will indicate the manner in which the tool was held and in which direction it was drug or propelled.

The form of the tool must conform to the specific function for which it was designed. Many unmodified blades and flakes were used freshly struck from the core and are a definite tool type, such as a backed knife. These tool types require special techniques of detachment and only through examination of the use flakes can their function be determined.

It would be difficult for any one person to conduct experiments on all core and flake types or to understand fully all their permutations of the features that go into the making of cores and their flakes and blades. We can broaden our knowledge and resolve certain types by a careful study and analysis of flakes, blades, and the debitage resulting from their manufacture. Flake analysis is basic to a concept of technological studies and is an important factor of flake, blade, and artifact analysis. This text will attempt the analysis of flakes and cores by outlining the variables in stoneworking, and explain how they are overcome and controlled by different techniques. Consideration of the debitage flakes found at the occupation site and subsequently relating this waste material to stages of flaking techniques required to produce the desired size and type of flake, blade, or artifact, is almost a necessity for it will give a true picture of the various technological stages of manufacture. Admittedly, debitage flakes are not as glamorous as the stone tools or cores, but they can be just as interesting and can furnish information not found on the core and the artifact. These usually only show the last stage of the several steps of manufacture, whereas, the waste flakes can give clues to the primary, secondary or intermediate steps of fabrication. Proper flake analysis should show the development of techniques traditional with each generation and any parallelisms in development; as well as other techniques which are highly specialized for particular functions.

As more flake assemblages are analyzed in different geographical regions and related to different periods of time, the need for such a study will become apparent.

Flake tool industries are represented by residue and debitage of the various stages of development of the artifact from the initial break of the raw material to the completed implement. The quality and size of the flaking residue will normally be proportionate to the distance of the workshop or campsite from the source of raw material; but an occupation site located near a large quarry is more likely to have flakes representing all phases of their particular techniques of manufacture. Should the archaeological site be of some distance from the source of raw material then several stages of manufacturing are apt to be absent. This is due to roughing out, blanking, and preforming of the artifact at the quarry. In this case, the flakes representing these phases of tool manufacture will occur in the proximity of the material source. Unifacially and bifacially worked preforms found at the quarry are generally made by the core technique using direct percussion.

By comparison of their diagnostic attributes, flakes are determined to be similar, and then one may select one or two as being representative of form and technique. Studying flakes and ultimately relating them to various tool types will indicate the cultural technological traits in modes of manufacture and will greatly assist in obtaining a sharper definition of a complex in a cultural area. The debitage flakes from the making of just a single artifact may number several hundred, whereas, the artifact is often considered individually without placing too much emphasis on the surface flake scars. When these surface scars are evaluated, they usually cover only the last stage of fabrication. The debitage flakes which occur in conjunction with this would give us the true picture of the many stages of manufacture. The flake is far more useful in determining the technique than the flake scar as the platform and part of the original lateral edge of the artifact was removed with the flake. Sometimes a remnant of the platform may remain on the artifact but it in no way represents the contact surface of the flintknapping tool. Although the flakes removed from the artifact can be uniform, they may leave scars on the surface that are multi-directional. Uniformly flaked artifacts bear scars that appear to duplicate artifact types but, in reality, there is no exact facsimile. There are duplicates in technological traits but there is no exact duplicate artifact. Life fingerprints, each is distinct and a mould of one artifact would not fit the mould of another. The elements involved in manufacture are not that stereotyped and the human margin of variation is too great. Analysis of flakes will show a greater consistency of form and attributes as it is only necessary to consider one unit rather than the composite units that compose an artifact. It will be much easier for a student to separate flakes into different technological categories than to type artifacts if he considers the surface character of the artifact together with the form. Projectile point forms are probably the most consistent of the flaked artifact types, but they too vary with the whim and needs of the maker. While their dimensions are variable, their mode of manufacturing is generally constant. An outstanding and well-known example of the variation in form but consistency of technique is the points found at the Bison Kill site excavated by Dr. Joe Ben Wheat (Olson-Chubbuck). This site yielded a large population of unbroken and mint-condition projectile points and was devoid of the discards and debitage usually found in zones of occupation. The flaking technique of these points was consistent and uniform, with only slight variations - yet they vary in size and form. Unfortunately, we do not have enough occurrences of these finds for they are a fine example of what actually went to the field and they furnish much knowledge regarding technology and typology. Because of their unique mode of manufacture and because they are in mint condition, a thorough analysis of this collection should resolve the consistency of flaking techniques and the variation of form and size.

Because of the nature of the material being worked and the human element of change and error involved, there are many characteristic variables and, therefore, stereotype of flakes and artifacts cannot be expected but we can look for consistency. Consistent differences (reflecting minor and major changes in techniques of flake and blade removal can be noted when the flakes are separated into the stages of their taxonomy. Each stage will readily demonstrate the rhythm attained by the worker and then there will be a greater consistency of flake types. Categories, similarities, and like attributes will show the development of patterns which will denote the phases and stages of the part they played in the development of artifact types which will greatly assist in the interpretation of the cultural traits. Because of these slight variations and variables, the flakes should not be appraised individually but rather by the manifestations of their traits and techniques.

I recently had an opportunity to study collections at Idaho State University, Washington State University, University of Washington, University of British Columbia, University of Arizona, University of Colorado, National Museum at Victoria, Canada, Museum of Man at San Diego, California, Southwest Expedition Field School at Vernon, Arizona, Denver Museum of Natural History site at Kersey, Colorado, and the information gleaned from these collections has been most rewarding and emphasized the need for debitage analysis for numerous technological traits and techniques were represented. My personal rapid method of surveying flake assemblases was: (1) Separate the flake parts into categories of abberant, ill-formed, and broken material which would serve no functional purpose and not of the proper size for modification or artifact manufacture. Then isolate the unbroken flakes which are useable or may even show signs of function. (2)

Flakes are then arranged in rows with the platforms on the proximal end facing the sorter for these ends provide the bulk of the information pertaining to technology. (3) Then the mid-sections and the distal end of the flakes are arranged in a like manner. (4) The proximal ends (those bearing the platform of applied force) are then regrouped by segregating those with like platform characteristics. These characteristics are further explained in this text.

Percussion flake assemblages fall into two classes - the debitage flakes from artifact manufacture and flakes and blades made either to be used freshly struck or to be modified into tool types characteristic to blades and flakes. It is not the intention of the writer to infer that there is a major cultural difference between debitage flake assemblages derived from artifacts percussioned by the core method and those derived from the modification of large flakes or blades. Both techniques can be used by a single group of people and it is only important to be able to recognize these techniques when they make their appearance. However, the core method is a wasteful technique and discards a greater amount of debitage than does the modification of a flake or blade. The use of the core as a source of blades or flakes is an indication of man's first economy for it provides quantities of useable flakes either modified or unmodified, whereas the artifact made by the core method provides only a single tool and much waste material.

There are numerous types of flake specializations. Many now existing in collections have no terminology, yet they could have considerable diagnostic value in the interpretation of technological traits. At present, the only separation of flakes seems to be bladelike forms, yet there are numerous technological techniques and flake specializations used to remove blades from cores. The term "blades" encompasses a vast array of flakes with parallel sides with "their length being two times their width" (Francois Bordes, Les Eyzies Lithic Technology Conference, November, 1964). Individual analysis of such assemblages will readily demonstrate that they fall into two technological patterns which are distinctive to that group alone - the mode of manufacture and the refinement of production. One cannot separate flakes and blades according to whether their manufacture was by pressure or percussion but must evaluate the techniques and even then there will be a blending of form when shape alone is used to separate flakes and blades. Size should also be considered as both percussion and pressure flakes range from the dimunitive to the more massive and it is not enough to assume that because a flake or blade is massive that it was produced by percussion. Consider the prismatic blades from Meso-America which may be as much as an inch wide and eight inches long and yet are made by pressure. These blades have a consistency in form with two or more scars running the longitudinal axis on the dorsal side, the result of previous blade removal. They are complete tools within themselves, or they can be altered into geometrics, microburins and other forms characteristic to blades. Their preparation and pressure removal represent a variety of technological traits (See Polyhedral Core paper)

Old World blade forms are much the same in shape as the prismatic blades but undoubtedly various forms of percussion techniques - such as indirect percussion - were predominant in their making. Normally, blades are considered to be the result of a refined technique and of a definite form, however, some classify long narrow flakes with parallel and sub-parallel sides to be blades. There are specialized flakes removed by simple direct percussion that could technologically be blades but they lack the refinement of form which is the result of exacting core preparation and method of removal. So there can be no sharp lines of demarkation between the blade industry and indiscriminate blade making. The main differences are technological ones. Future study will, no doubt, indicate certain parallelisms and traditional traits in flake stone technology .

The very presence of cores in tool typology is mute evidence of the importance of flake scar study. They are not considered a tool, (unless they show functional scars), but they are of prime importance in typology for the express purpose of studying the scars and technological features to resolve the tool types of their flakes and blades. Debitage flakes can be equally important.

In the Americas, where we have a great absence of cores, it is not only recommended but almost imperative that we resolve the core techniques by analyzing and mentally if not actually reconstructing the cores from the flakes and blades if we are to ultimately postulate the type of core with which they are compatible. Conceivably, a shortage of raw material forced the ancient stoneworker to reduce his core to a minute, unrecognizable or insignificant size and it is possible that this same lack of stone prompted the modification of these exhausted cores into tools such as wedges, scrapers, and other cutting implements. No doubt pebble tool industries developed because materials larger than pebbles were not available. Even though we rightfully regard cores as basic in the study of the toolmaking industry, they represent only the residue of discard debitage to the prehistoric stoneworker. He was not concerned with their weight, beauty, or form, and he made no real attempt to keep them uniform other then that required to successfully remove a flake or blade of the desired width, thickness and length. To the stoneworker, the core was the nuclei, the waste product, and he had no thought for their regularity or uniformity. His efforts and aims were on the detaching of flakes and blades. But since his needed blade type required certain consistencies in flintknapping techniques, he ultimately produced a uniform core type. In other words, the design of the blade or the flake, which was pertinent to different cultures, geographical areas and economies determined the type and design of the core. This, of course, is what makes core study so import and contemporaneous with the movement and age of man. It also points out the need for careful study of the debitage flakes and for core reconstruction when none of the cores are found at the site.

Cores may be derived from large tabular or primary flakes, sections or parts of nodular forms, or simply from parts of cobbles derived from alluvium. Populations of cores are usually limited to areas abundant in lithic materials for when materials had to be transported a great distance to the occupation zone, the core was normally consumed by flake and blade removal until there generally remained only a bare and unrecognizable remnant of the original piece of material. In this case, we must attempt to resolve the core type by relating the flakes. Flakes and bladeshave certain identifying characteristics such as the platform angles, curvature of the flake, depth of bulb of force, termination of the flake, etc. which make it possible to reconstruct the core to which they are pertinent. A previous study of aboriginal cores and flakes will help one to resolve core types from the flakes alone. Because the core was designed to produce flakes and blades and is, therefore, consumed in the process, the study of cores and their stages of development is usually difficult. Unless the aboriginal worker was interrupted and his unfinished work abandoned, or the core was ruined during manufacture, or unless he discarded the core because the removed blades were too small to suit his purpose, it is unlikely that the evolution of the core would remain. Therefore, at best, one must generally base his conclusions on the exhausted or malformed cores and flakes.

It is rare, indeed, to find a great population of cores such as Francois Bordes found this year at Corbian (about 1000) of the Upper Perigordean (Personal communication, November 6, 1966). On the other hand, most literature shows great populations of flakes or blades with small proportions of cores (J. Radley and P. Mellers, 1964 Proceedings of the Prehistoric Society. A Mesolithic Structure at Deepcar, Yorkshire, England. (23,000 flakes and 17 cores were found)

The people who adapted the core and blade traditions most certainly recovered all flakes and blades which conform to their needs and, therefore, those found usually are aberrant, malformed or those which broke as they were removed from the core. Such populations of useable flakes, other than trimming, retouch and modification debitage, cannot be expected - other than an accidental occurrence - for the flakes were removed from the core for a functional purpose. It is from a reconstruction of these waste flakes and blade assemblages that the end product can be evaluated.

Before the experimenter starts to remove a flake from a core, he must understand that detachment is not accomplished by indiscriminant random blows, but is the result of a preconceived design of the flakes. Most literature which described the manufacture of stone tools speaks of the "impulvise blow". The student of Physics will immediately identify this word "Impulsive" with that of motions which take place quite suddenly; or, forces acting which are rapidly changing in magnitude and direction. However, this word also convey the interpretation of psychological use - a desire to act resulting from instantaneous judgments as to how to meet an emergency, and a lack of deliberation. For this reason, I think the term "impulsive blow" show be dropped from the literature when referring to stone tool manufacture. THE PAST ARTISANS IN NO WAY STRUCK IMPULSIVE BLOWS, AND ONLY AFTER CAREFUL PREPARATION OF

SURFACES AND ANGLES, WAS THE BLOW DELIVERED WITH CONTROLLED, CALCULATED AND METICULOUS PRECISION. The worker must have control of muscular motor habits and must deliver the pressure or percussion force with extreme accuracy. Any carelessness or miscalculations in detachment will result in a hinge or step fracture causing the artifact to be malformed or useless. The superb examples of aboriginal work reveal not a bag of tricks but an intensive knowledge of materials that lend themselves to stone toolmaking and a splendid display of mental and muscular coordination.

A flake and blade (specialized flake) industry represents specially formed flakes removed from cores - the flakes being used freshly struck or modified into artifacts. Blade making techniques are various and involve different types of core preparation from the simplest to the more refined. Blades can be used without modification or retouched by pressure flaking. Large flakes and blades are sometimes preformed by percussion into knives, projectile points, etc. When smaller flakes are to be modified into a projectile point, the flake is straightened by removing the bulb of applied force on the ventral side of the flake and by trimming the distal end of the flake on the ventral side until the longitudinal axis of the flake is straight. This is usually done by the pressure technique. Most pressure flakes are crushed during their removal and, therefore, will pass through the sifting screen at a dig. Cores which result from flake and blade making are sometimes utilized as core tools or can be reduced to useable flakes. Therefore, discarded well-defined cores cannot be expected unless there is an abundance of raw materials near at hand. An exception to this is the microblade cores of the Arctic. Some well-defined cores are found there for the worker removes microblades until they were so small there were practically no room to seat his tool and, therefore, he discarded his core. So, sometimes the very technique can determine whether or not cores were left at a site.

Flakes and blades are removed from a mass of material (core) by applying force at varying degrees of intensity and velocity at a specific angle on a definite and predetermined surface area. The surface receiving the applied force is known as a platform and its design has a direct bearing on the type of flake or blade removed from the core. The raw material sometimes determines the technique of flake and blade removal, for the stone must respond to the application of force to detach, in any direction, portions of the material. This quality in material is known as isotropism. Flaking must include control of the width, length, and thickness of the flake; and the applied force must follow the desired direction of the worker.

The simplest core form is a piece of material bearing a flake scar. This embryonic stage of core development could go unrecognized but, nevertheless, it was able to provide substance for useable flakes. Most cores have more than one flake scar which are usually characterized by a negative bulb of force at the apex. The removed flake retains the platform and the bulb of force but the scar left on the core indicates the order of flake removal. When a cobble is severed by force delivered by a hammerstone, the portion bearing the bulb of force will be the flake part and the half bearing the negative bulbar scar will be the core. There is one exception to this rule and this is the absence of a bulb on either part of a severed cobble. This is accomplished by a special technique which results in the splitting of the cone of force. When the cone is split, both halves will have duplicate features. This special technique occurs rarely and is usually associated with pebble and cobble industries and core rejuvenation. Normally, the flake will be smaller than the core for the core must be heavier and more massive in order to provide sufficient inertia to remove the smaller flake.

Since both artifacts and cores bear flake scars, it is sometimes difficult to determine whether it is a core or a tool. For example: A chopping tool is the core remnant and, under certain conditions, could be mistaken for a core or vice versa. A case in point is the so called cores from the Shoop site. These were identified by John Whitoff as exhausted cores and, in fact, could be confused as such. But, at the Les Eyzes conference, November, 1964, it was termed by both European and American archaeologists that they were "Piece Esquiellles". They are, in fact, a core tool but not an exhausted core. The normal conception of the core is a mass of material used for making blades and flakes and the the residue or remnant of this mass is the core. A notched projectile point couldn't look less like a core, yet a core it is. Exhausted cores, or cores which had the flaking operation either suspended or discontinued, were sometimes converted into hammerstones or used as functional tools such as pulping planes. Cores defined as having been used as a tool should be appraised very carefully before they are typed. The leading edges should be examined for wear patterns and functional scars for sometimes a similar surface is produced by the toolmaker when preparing platforms for subsequent flake removal. Grinding and removing the overhang left by the last series of flake removal are technological traits used in certain techniques and could be mistaken for functional scars or abrasions.

Core forms are endless, yet they play an important part as a diagnostic trait and they demonstrate many technological differences. When they are worked down to a small unfamiliar form, many are difficult to recognize as cores. Some sites are distinctive because there is a complete absence of cores, yet the flake discards indicate detachment from a core. Generally, this denotes a shortage of material and the worker's need to reduce the core to the last useable piece of material. In this case, flakes and blades will have to be evaluated and the core reconstructed from the diagnostic features which the flakes and blades reveal.

Since all man's acts are by nature inquisitive with a natural and inborn urge or motivation, a relationship between the lithic techniques of primitive man and my experiments will have certain parallelisms. The methods I use and his techniques may not be concurrent but their counterparts may have a certain amount of similarity. Before I made my first eolith, I tried to remove useable flakes from a core by striking a piece of flint-like material with a small cobble. I used direct free-hand percussion which resulted in battering and bruising and ultimate shattering of the piece of flint. My core was not even recognizable and the flakes lacked style and uniformity. However, several flakes in this shattered mass had sharp cutting edges and could have served as tool but they would not be recognized as such by an archaeologist. I continued using this method over a considerable period of time and occasionally would remove a few good flakes. By studying the conditions which accomplished this removal - such as the correct amount of force, the vector of striking angle, the character of the point of impact and the surface of the stone on the dorsal side of the flake - I could determine the conditions which produced a replica flake. But these conditions must be firmly resolved in the mind of the stoneworker before he becomes a good eolith maker. These first futile stoneworking attempts did, however, produce flakes and cores even though any refinement was sorely lacking. Since these first efforts some forty years ago to successfully remove a flake from a core, certain conclusions have been reached regarding the mechanical laws pertinent to isotropic materials and relating them to core types. When working isotropic material, its inherent nature causes definite patterns in flakes and cores. Upon appraisal, these characteristics may be related to various techniques and these techniques correspond to certain people in time and space.

To coherently explain cores and flakes one must understand what is happening when force is directed against a mass of flint-like material. Impulsively striking a stone mass will result in a shattering of the piece, but when force is properly applied against a flint-like mass, the objective piece will fracture. However, to successfully remove surplus material from an artifact, or to detach a flake or blade from a core, the worker must control the direction and amount of force. He must be able to terminate the force at a predetermined point and remove flakes of the desired shape and thickness. This is the basis for the many and diverse stoneworking techniques. To make cores, blades or tools, the worker must dominate the stone by being aware of and controlling its elastic limit and providing for future and subsequent flake detachments to be in accord. Allowing a flake to step or hinge fracture will ruin the core or artifact. But sometimes, in spite of the best of coordination, a failure will result from a slight miscalculation, an undetected flaw in the material, a crushed platform, the slightest angle change of either the artifactor the flaking implement and from the improper dampening of force. It is doubtful if there are any perfect for the human margin of error prohibits fabrication of a perfect example of the more complex artifacts. Even the classic examples of

Danish and Egyptian work reveal slight miscalculations of the worker. This statement will probably meet with disagreement, however, minute examination of specimens will reveal minor flake scar distortions, or insignificant step-fractures. The making of flint tools is not the manifestation of a long line of ancestors, but is the result of each new generation trying to improve the product or to make it fit his particular need. In a short time with an experienced teacher, an apt and interested student can learn the basic techniques.

Following is a list of points to be followed in flake analysis: CORES

1. Material identification
2. Texture of material
3. Material altered by thermal treatment
4. Relation of material to flakes
5. The amount of applied force
6. The kinds of applied force
7. Methods of applying force

PERCUSSION (List of flintknapping techniques)

8. Throwing on anvil

9. Striking on anvil

10. Hammerstone (free hand)

11. Hammerstone (with rest)

12. Hammerstone (with rest and clamp)

13. Hammerstone (with rest, bipolar)

14. Hafted hammers (free hand)

15. Hafted hammer (with rest)

16. Billets or rods (freehand)

17. Billets (with punch)

18. Billets (with punch and rest)

19. Billets (with punch, rest, and clamp)

20. Hammerstone with punch (free hand)

21. Hammerstone with punch and rest

22. Hammerstone with punch, rest, and clamp

23. Indirect (hammer) free hand

24. Indirect (hammer and rest)

25. Indirect with fixed punch

26. Pressure (free hand) Unhafted

27. Pressure (free hand) hafted

28. Pressure (with rest)

29. Pressure (finger held, reverse)

30. Pressure with rest and clamp

31. Pressure with short crutch

32. Pressure with long crutch

33. Pressure (notched tool)

34. Pressure Lever and fulcrum

35. Pressure with fixed punch

36. Pressure on anvil

37. Egyptian creating flake character Implement used to detach the flake

38. Size and weight of flake

39. Primary flakes (cortex) Secondary flakes

40. Flakes with pronounced undulations or waves

41. Flakes with little or no waves

42. The angle of the platform in relation to the longitudinal median axis

43. The width of the platform surface

44. The thickness of the platform surface, or the distance from the dorsal edge to the ventral edge of the platform surface.

45. Types of platform preparation

46. The use of the natural surface or the platform

47. The platform with prepared facets

48. The isolation of the platform

49. The grinding of the platform

50. The polishing of the platform

51. The absence of platforms on complete flakes

52. The platforms crushed upon removal from the core

53. The orientation of the platform with the longitudinal axis

54. The depth of the bulb of force

55. The presence of the lip on the ventral side of the platform

56. The absence of the lip on the ventral side of the platform

57. The presence of the overhang left by the bulbar scar of previous flake

58. The absence of the bulbar overhang showing special platform preparation

59. The flake with disfused bulb of force

60. The flake bearing sharp definition of truncated cone part

61. The flake having no cone definition

62. The flake bearing the negative bulb on dorsal side and positive bulb on the ventral side (chapau Gendarme)

63. The presence of the eraillure scar on the bulbar part of flake

64. The absence of the eraillure flake scar on the bulb

65. The presence of radiating fissures on the bulb of force.

66. The absence of fissures on the bulb of force.

67. The nature and occurrance of fissures on the lateral margins of the flake.

68. The terminations of the lateral margins of the flake.

69. The length of the flake

70. The width of the flake

71. The thickness of the flake

72. The uniformity of the three dimensions, length, width, and thickness.

73. The expansion and contraction of the flake from point of applied force to termination.

74. The character and direction of the flake scars on the dorsal side of the flake.

75. The curve or straightness of the flake

76. The flake termination by feathering.

77. The flake termination removing a greater mass at the distal end of the flake, rapidly expanding as it leaves the core.

78. The flake truncation by flexing.

79. The flake truncation by snapping.

80. The flake truncation by hinge fracture.

81. The flake truncation by step fracture.

82. The flake truncation by notching or special severing.

83. The intentional modification of flakes.

84. The flakes bearing functional flake scars on lateral edges.

85. The flakes bearing dulled or abraided lateral edges.

86. The flakes that show the rhythms and consistency of patterns in techniques

87. Directions of flakes to show technological patterns

88. Typology based on technology

(1) Material Identification:

A basic step in the appraisal of flake assemblages is an evaluation of the lithic material. Postulate how far the material is from its original source. What are its diagnostic qualities? How does it compare to materials from other well-known sources? How many varieties are represented in the occupation site? Sometimes the material source may be identified by the outside surfaces found on the dorsal side of the primary flakes. This natural surface may denote bruising, abrading and cratering which is typical of alluvium. Natural surface can give a clue to whether the material was quarried or it may show natural breaks of ledges, lodes, fault zones, bearing the mold markings of the vesicular cavity. Organic replacements will indicate that the material formed in sedimentary deposits. Concretions of flint will indicate the whereabouts of limestone and dolomite. These are but a few of the clues found on flakes which may indicate material occurrence and may aid in locating the source. Detailed studies of material which was used in the lithic industries holds much information regarding the movements of man through time and space for generally material bears impurities which are characteristic to that material alone. (See materials paper) Even though cultural tool forms are not in evidence, this type of study could ultimately aid in resolving man transporting materials and the route of travel from their original source to their final destination.

(2) Texture of Material:

The texture of material is an important consideration in determining the quality of the modes of manufacturing. The quality of the artifacts and the manufacturing technique cannot exceed the quality of the material regardless of the knapper's skill. Lithic materials range from the glassy to the granulose, and the more granular varieties can result in inferior types of flakes and artifacts. Techniques must be adapted to materials. Fine definition of flake attributes are usually erased in the coarse-grained rocks because the platforms crush more easily and the flakes or blades will collapse before they terminate at the distal end of the core. Flakes of coarse material haven't the resistance to end shock and the worker must apply a greater amount of force to accomplish detachment. To successfully fracture coarse-grained material, it is necessary to use a hard hammerstone and direct percussion in order to concentrate the kinetic energy to a confined area. The more vitreous material increases the worker's ability to control the flakes and the cutting edge of such flakes will be much sharper. A decreased amount of force is required to remove a flake of equal area on fine-grained material for vitreous material has elastic qualities which is not present in the granulose rocks and this allows the flakes to bend without breaking. This does not imply that coarse-grained materials are not important to the economy of many ethnic groups for they did play an important part. Sometimes they were even preferred to the more vitreous rocks because the flakes struck from coarse-textured rocks were more useful for certain functional needs. Such flakes serve admirably for sawing and carving, and for forming materials of wood bone, antler, shell and soft stone.

Tool types for sawing can be fashioned more rapidly from coarse-grained material than from a vitreous stone because they give an edge that can be used freshly struck whereas the vitreous rock must be serrated to do similar work. A simple field test should be the actual flaking of questionable material before any final decisions are made regarding the workability of a particular mineral.

(3) Material altered by thermal treatment:

Certain siliceous materials will respond to an artificial vitrification by the application of heat. The change occurs upon the temperature being slowly raised to around four or five hundred and then slowly cooled. (Correction to Crabtree and Butler, Tebiwa, Vol 7, 1964). The material will stand considerably higher degrees of heat but the change actually starts taking place at the above noted temperatures. Different materials require different temperatures to effect the alteration and only experimenting will define the temperature and time needed to effect the change. All materials do not respond to the heat treatment. Successful alteration of materials is an exacting practice requiring a thorough knowledge of the material being altered. (Crabtree and Butler, Tebiwa, Vol. 7, 1964) In order to determine if the material has been altered, one must look for a few identifying clues before making final judgement. For example: after heating, the original surface of the material remains unchanged and removal of a test flake will reveal a lustrous texture. To be positive of the thermal change, a flake of suspected material must be found which bears a flake scar on the dorsal side which still retains a little of the original textured material prior to heating. If the material has been altered, the ventral side of the removed flake will have a distinctive lustrous character pertinent to thermal treatment which is not present on the original surface. But should a flake be detached from a treated core containing no original surface, it will be lustrous on both the dorsal and ventral surfaces. Few materials have natural vitreous luster, therefore, the flake will be suspect but not reliable and no definite conclusions can be made on the alteration. Occasionally, abandoned heat-treated flakes are found which retain their original texture but examination may reveal small flake scars on the margins which show the change of luster. These small flake scars may be the result of the aboriginal testing the material to see if the heat application was successful. A simple field test is removal of a small flake and subsequently examining the scar to determine the difference in texture. If the material is heated over a long period of time, the trace minerals will be subject to oxidation causing yellows to become red and various other color changes, depending on what mineral impurities were present in the treated material. Flakes which are overheated result in crazing, potlidding, and occasionally complete disintegration. These are relatively infrequent considering the exacting control necessary to perform this alteration.

(4) Relation of Material to Flakes:

The character of the flake has a direct relationship to the quality of material. Unlike the granular rocks, glassy rocks have attributes and characteristics which leave well-defined flake scars and this will greatly assist in flake analysis. The worker must conform both the tool and the technique to the material. A case in point is the relationship of applied force to materials. Removing flakes from tough, granular, tenacious material requires a greater amount of applied force than do the vitreous materials, therefore, the platform, or impact area, must conform with the velocity of force. As a rule, platforms on the proximal ends of flakes of tenacious material will be larger when simple direct percussion is applied with a hard hammerstone. Coarse-textured materials do not require the careful platform preparation which is necessary when working vitreous stone for the freeing, or isolation, of the platform in granular stone would reduce the amount of material which would receive the force and, therefore, the chance of platform collapse would increase.

Regardless of the worker's skill, the granular-textured material will not effect the refined artifact which can be made from vitreous material. But, conversely, the lack of skill can reduce high quality material to an inferior artifact.

(5) Amount of Applied Force:

The amount of applied force may be hypothecated by measuring the area on the ventral side of the flake, or on the flake scar, itself. The amount of force required to accomplish fracture is contingent on the type of material being worked. But, regardless of the quality of material used, the amount of force must be conditioned to deliver the force to a predetermined area at the proper intensity and velocity. Because the amount of necessary force to sever or detach portions of material varies contingent on material and flake dimension, the ratio of force must be precisely calculated to fit the need. Analysis of artifacts will show that the last repetitious series of flakes either from an artifact or a core were detached in a constant pattern and the applied force delivered in a uniform manner. Such a series of blades or flakes demonstrates the control and concentration of the mind directing the muscles to respond uniformly. Control of the applied force on ideal materials is one of the basic principles of flintknapping.

(6) Kinds of Applied Force:

Types and variable velocities of applied force (Pressure, Percussion, indirect percussion, etc.) are the key to the development of independent techniques. The need and desire to make flakes of certain dimensions and form require applying force in different methods and at varying velocities whether by pressure or percussion. Force is transmitted to the material by incorporating several techniques such as percussion and pressure tool types, varying velocities of force, dampening of force, angles at which force is applied and the method of material support. All have a direct bearing on the detached flake. Certain combinations of methods will make similar flakes but variation in techniques will make minor but consistent differences in the resulting flakes. These differences will be useful in separating pertinent cultural traits.

(7) Methods of Applying Force:

Methods of applying force fall into three major types:

1. Percussion
2. Indirect Percussion
3. Pressure
4. Pressure with the aid of percussion.

Still another, but untried, method is the Egyptian technique of pressing the percussor on the edge of the artifact and then striking both percussor and artifact against a wooden anvil. This, purpotedly, drove the retouch flake toward the anvil, thereby removing the retouch flake by bi-directional forces, a variation of the bipolar technique.

Methods of applying force are numerous and variable and the use of these methods results in a variety of flake forms and scars. There may be parallelisms of techniques which appear to duplicate and converge, yet minor and major features will be represented on the flake to a greater extent than on the flake scar. This is due to methods, materials, types of force, and the implements used to transmit the force. Force ranges from a very sharp impact to gradually applied pressure. Pressure requires greater energy than percussion for a blow delivered by percussion is increased by the instantenous conversion of potential energy to kinetic energy. Aboriginal man instinctively took advantage of this feature and concentrated stress and strain on the raw material by over-extending the elastic limits of the stone to the point of fracture. Experiments have shown that the amount of required force varies with each technique. A large hammer impelled at a decreased velocity can deliver the same amount of energy as a small hammerstone moving at high velocity. Using a large hammerstone at a lessened velocity decreases the shock and will prevent the shattering of the lithic material. Therefore, the use of a large hammerstone at slow velocities is only suitable for the more massive types of flake and blade removal. Decreasing the velocity of the large hammerstone uses potential energy as a means of slowly applying force, or if you want to be very technical it is a rapid application of pressure. However, it has the disadvantage of overcoming the inertia of the object being struck and propelling the objective piece. By changing the percussor from stone to a softer material such as antler, bone, wood, and soft stone, Potential energy can be used instead of Kinetic energy. The softer the percussor material, the greater must be the velocity of the blow. Flakes and flake scars made by the use of Kinetic and Potential energy bear diagnostic features pertinent to each which will be described under individual techniques.

(8) Throwing On An Anvil:

The initial toolmaker derived his flakes by percussion detachment. There are many percussion methods and techniques which produces flakes. The simplest - and probably the initial - method was by throwing a piece of flint-like material against a larger rock until it shattered and pieces were dislodged and then recovering the pieces which had a sharp cutting edge. But flakes produced in this manner will be irregular in form and will show evidence of shattering and it is inconceivable that any degree of control could be gained with this method. It does not allow selection of impact surface and the angles on the surface of the core cannot be predetermined. Further, the amount of force required to propel the core could not be related to the size of the detached flake, nor could contact be made with the anvil with any duplication or regularity. When this technique is used, both cores and flakes will contain strains and weaknesses which would render the largest portion of the material useless.

However, this method has recently been observed among the Australian aborigines by Dr. Norman Tindale. (South Australian Museum Vol. 15, No. L, October, 1965) This cultural trait is characteristic to the Nakako and the Ngadadjara as well as the Pitjandjara of the Great Western desert. At the same time, Donald F. Thompson writes of his experience among the Bindibu and of their skillfully removing flakes from large blocks of material with smaller one of the same stone - striking the flakes off, shaping these with the larger blocks either to a rough point or a sharp cutting edge. Such refinement has to be the result of long experience and a knowledge of the stone's behavior. He stated: "We watched men carefully examine and balance each block and with a few dexterous blows convert them into what was obviously sharp effective cutting tools". (Proceedings of the Prehistoric Society, 1964) According to Tindale, these are examples of embryonic and refined techniques being used at the same period of time and not separated by a great deal of geography.

Cores resulting from casting material lack regular form and have a battered and bruised surface and do not bear the flake scars which result when detachment is by applying force at a preconceived and planned point of impact. Also, flakes detached in this manner will have no consistency of form whereas Thompson's Bindibu people have cores and flakes which show the selection of platforms and flakes removed in a regular manner plus the evidence of percussion tools.

(9) Striking on An Anvil:

Using the anvil as a percussor is just the reverse of the normal procedure of using a stone to strike the material to be worked. This technique involves holding the material to be worked in both hands and then striking it on a large stone which is partially immobilized by being buried in the soil - or at least secured in a manner to prevent its movement when struck by the core. This technique uses the maximum concentration of kinetic energy. Due to the mass and stability of the anvil and the velocity of the object being propelled, the energy and force is condensed into the material being worked. Because the core is not projected by the force - which is the case when the core is struck by another object - there is a greater concentration of forces. Force applied to isotropic material in this manner causes a distinctive break which is definitive by a lack of any bulbs of force. The bulb of force is part of a cone, usually well-defined by the radiation of the force. But this technique causes the cone to be sheared and bisected which is distinguished by the expanding circles of force making waves at the point of impact. These waves are much closer together than when the flake is removed with a hand-held hammerstone. I experimented with this technique by immobilizing a large cobble which had a natural ridge on the exposed surface. This ridge was used as the contact area for the isotrophic cobble to be cleaved. The cobble to be bisected was held in both hands and struck vertically on the anvil, which was a partly-buried tough, granulose, waterworn cobble. The flint-like material was cleaved in two equal pieces, each part having a flat surface at the point of fracture and each piece was well suited for a core. This technique was well understood in Mexico and probably used to make the thin, flat, regular, uniform thickness, flakes which were used to make graduated radii of obsidian for neck ornaments. The surfaces of these ornaments bear the same type of rippling or force circles.

But this technique requires considerable skill to deliver an accurate blow of the correct intensity and simultaneously calculate the correct striking angle. Angles may vary, depending on the desire of the worker and the proposed implement. Because the force is concentrated in such a restricted area, this technique is unsatisfactory for removing blades.

There are indications that a similar striking method was used to make Levallois Flakes, for the Levallois core is held in the hands and struck against an anvil stone. However, only the striking is similar, for a platform is prepared on the Levallois core and then the core is struck against the anvil but at a different angle to cause the platform on the core to contact the anvil. Levallois was not attempting to cleve the core, but only to remove one or possibly two specialized flakes. The platform on the Levallois core is established by preparing a ridge directly above the spot where the flake will be removed as the impact area. This provides for greater accuracy. Ridge is established by removing two or more flakes horizontal to the longitudinal axis at the top of the core which will produce a ridge from the dorsal side of the core to the ventral side. The ridge is isolated so it will contact the anvil when the core is struck and increase the accuracy of the blow. In order to make a Levallois flake, the cone of force must be isolated. The angle of the cone is calculated and the core struck against the anvil in such a manner that the cone will make the negative scar on the core. If the core is struck against the anvil in the proper manner, this technique will concentrate the force to such a degree that the Levallois flake will not flex and will be flat. This experiment requires proper preparation of the core and platform and practice and skill to regulate the intensity and velocity of the force. It also requires an abundance of material and it is wasteful when only one or two useable flakes are desired.

A small anvil is useful when making certain types of burin-like implements from flakes and blades. Two experiments in replicating this burin-type form are: Select the proper blade or flake with an existing flat on the lateral margin and, if none is available, a flake can be made flat by marginal retouch. The flattened edge will serve as the platform to be impacted on the edge of the anvil. The angle at which the edge of the flake is struck will determine the angle of the useable edge and will produce a simple burin. The flake can then be struck against the anvil a second time to make an angle burin but the striking angle of the flake must be changed to use the flat surface of the previously struck flake to serve as a striking platform. The removal of this second flake should leave a chisel edge on the burin. The angle of the chisel edge is contingent on the striking angle of the flake. Another method of producing a simple burin is to place the flat edge of the flake on the anvil and strike the flake with a small hammerstone to remove the second flake. However, this method usually dulls the tip of the burin. This burin technique is fast, but lacks control. Another method is to remove the burin spalls by the use of an antler, or suitable, pressure tool which will be described in detail under pressure techniques, but a quick explanation is to hold the objective piece in the left hand which is rested against the left knee, prepare a platform and remove the burin flake by pressure.

The anvil is also used to make simple chopper forms from cobbles, for the anvil concentrates the amount of force on the cobble and greatly assists in the fracture. It is difficult to remove flakes or cleve a spheroid cobble with a hammerstone but the anvil stone allows the worker to concentrate the force in a predetermined area and produce a fracture that will cleave the cobble or remove a flake. Once a flake has been removed or an angle created, then a hammerstone can be used efficiently. Evidence of this anvil technique was noted on material collected by Dr. Charles Borden, University of British Columbia. Material collected from the high terraces above the Fraser River exhibited both flakes and cores made with great skill with the aid of the anvil. Some of the large primary flakes show superb control of this technique. It is unfortunate that the very useful anvil is difficult to recognize as a tool. This may be because it can be of any hard, durable stone of assorted shapes and sizes and only close examination of its surface would distinguish it from another similar stone.

While experimenting in replicating knives, or sawing devices, with the distinctive cortex backing, I made use of the anvil to remove flakes from one end of a quartzite cobble. Backed knives made of coarse granular material should possibly be called saws, because they are excellent for shaping and forming objects of antler, bone, wood, and soft stone, yet they are almost worthless for skinning or dressing game. The original texture of the aboriginal backed-saw indicated that its origin was a waterworn quartzite cobble. My first attempts to replicate backed-saws was with a hammerstone and simple direct percussion. I shattered three hammerstones without severing or removing a flake from the quartzite cobble, so I resorted to striking the cobble on an anvil. By using the anvil, a series of flakes were removed from the cobble, which bore a strong resemblance to the backed saw-like implement. After these backed blades were removed from the cobble, the cobble core replicated the common chopper. It might be well to note that unless there is a sign of use on the chopper, it could very well be the core. By using this same technique on vitreous material, the backed flakes are duplicate but are suitable for a different function, such as skinning and other cutting purposes.

Another use for the anvil stone is for turning the edges of a bifacial flake stone artifact prior to thinning, either by direct percussion or pressure.

The anvil serves a dual purpose for turning the edges of an artifact. After the edge of the artifact is turned, I abrade the edges by rubbing them on the surface of the anvil in order to make them more resistant to crushing. This marks the anvil with incised parallel markings rather than bruising which is characteristic of the normal anvil function. The anvil is also often used as a rest for other stoneworking techniques.

(10) Hammerstone, Free-hand

The hammerstone has, no doubt, endured as a flintknapping tool for the longest span of time in the history of man's development. It is a tool which persisted through time and space until the advent of metal. Its only modification is usually the result of use alone. A hammerstone is selected, to suit the technique for which is will be used. Some techniques demand that the hammerstone be of hard, tough material, while other require a soft stone. Weight and form of the hammerstone are variable and must conform to the technique. The hammerstone is used to cause the fracture of material in a predetermined manner. With the exception of pressure flaking, it is used for all phases of stone implement-making from the quarrying to the finished form. Two types of hand motion are used to project the hammerstone to the objective piece. One method is to propel the hammerstone in an arc pattern and the second striking pattern is in a straight line and each method demands a different manner of holding.

Straight Line Method:

Straight line means a direct blow with the line of propelled force being straight with no deviation of the path of flint. The hammerstone is weilded by propelling the arm forward in a thrusting movement to contact the objective piece away from the leading edge. By using the forearm and keeping the wrist rigid, the impetus of the hammerstone is converted to propulsive force. The hammerstone can be round or oviate and is held by the thumb and the first three fingers with its base resting under the first or second knuckle.

The straight line motion is used when accuracy is not required and usually only to reduce larges masses of lithic material into workable pieces; or when the worker desires thick flakes and blades.

The hammerstone contacts the core back from the leading edge, for if the edge is struck with this motion, both platform and flake will crush. Flakes or blades that have been detached by the straight line percussion technique have distinctive marks at the proximal ends such as - the top of the flake or blade is thick with material flaring on either side of the truncated cone of percussion; the cone part is well-defined and there is usually and eraillure flake scar present on the bulb of percussion. Flakes removed in the straight line method show little or no refined platform preparation.

If it is necessary to use a hammerstone with a curved surface, then the contact surface of the percussor must be the center of this curve which will bear the functional scars. If an elongated hammerstone is used and its ends alternated, then use marks will show on either end. But if the hammerstone is ball-shaped, it may bear use scars over the entire surface.

Arc Method:

For this method, the hammerstone must be round and be held between the thumb and the first and second fingers; and both the forearm and the hand are propelled in an arc motion. The arc method is quite different than the straight line method for it strikes a glancing blow rather than a direct hit. This is due to the curve on the rounded hammerstone and because the path of flint is curved. The blow must be calculated, for the hammerstone must contact the artifact, or core, on its prepared edge. This type of blow prow prohibits the artifact, or core, from receiving the full intensity and shock of the hammerstone. The arc motion gives a greater range of accuracy and because of the curved, or rounded, surface of the hammerstone and the curved path of flight, the intensity of the force is increased as the hammerstone contacts and moves across the striking surface. Tolerance is proportionate to both the amount of curvature of the hammerstone and the magnitude of the arc propulsion. The arc technique permits the artifact to be moved into the path of flight of the hammerstone and, therefore, accurate contact on the designated point of impact. Shock to the artifact may be increased or lessened by the hammer of holding both the artifact and the hammerstone, i.e. by relaxing the hands or by making them more rigid. Practice intuition and "feel" permit the knapper to literally thrust the hammerstone into the artifact at the exact time of impact to detach a flake. This intuition and "feel" are attained only after considerable practice.

The arc method is much more accurate for removing flakes and blades from cores but is unsatisfactory for cleaving large masses of lithic material. The accuracy of the arc method can be controlled and, therefore, the worker can prepare platforms by isolating projections of stone to receive the percussion force. The shape of the flakes or blades will depend on the contours of the surface prior to striking. Both 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 and thickness of the flake. A hard hammerstone also magnifies the shock waves to a greater degree than a soft one.

Flakes, artifacts, and cores made by percussion with the hammerstone free hand-held are variable in form and size. These deviations are the result of 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 the hammerstone will disclose definite traits, patterns, and techniques.

(11) Hammerstone with Direct Rest:

The hammerstone is propelled in the same manner as described under No. 10, Hammerstone, Free Hand, but the objective piece (artifact or core) is artificially supported. Support can be accomplished in several ways (the ground, against the thigh, on wooden blocks or logs, or an anvil stone) but the simplest is placing the core, or artifact, on the ground with the contact edge exposed so the flakes may be freely detached without being driven into the ground. In this case, the ground serves as an anvil. Rests, or anvils, may be of many substances such as hard or soft stone, antler, bone, horn, or wood, depending on how much resistance is required for a particular technique. Materials for the rest are selected with regard to the lithic material being worked. For example: obsidian, because of its brittle nature, will require a wood anvil to prevent its unpredictible fracture. Quartzite, or granulose lithic materials which require more force for fracture, demand an anvil of dense, hard material such as an anvil stone, etc.

This method creats bi-directional forces, for the anvil will project force simultaneously when the hammerstone contacts the objective piece. The purpose of the anvil is twofold; it prevents any downward movement of the objective piece and, at the same time, transmits force into the core or artifact. The striking pattern must allow the flake to detach without being obstructed by the support, otherwise there would be opposing forces between the anvil and the hammerstone and consequently only a crushing of the flake or blade. Properly executed, this technique diverts these forces from their path of contact and causes a shearing between the anvil and the hammerstone. Blades detached by this method are flatter than those made by the freehand technique because the lack of support in freehand holding allows movement of the core. Also flakes detached by this method will be devoid of compression rings radiating from their distal end but these rings will be present on the proximal end which receives the force from the hammerstone.

If the artifact is a biface, it is rested vertically on one lateral margin upon the anvil, with striking on the opposite margin. This confines the shock between the anvil and the hammerstone which dampens the vibration to the distal ends of the artifact and flakes can be terminated and detached at the desired point without carrying across the width of the artifact and removing the opposite edge. Cores because of their greater mass are more resistant to shock and the flakes and blades will terminate to a feather edge without removing the distal end of the core.

Using the anvil, or fixed rest, method efficiently requires considerable more skill and practice than the simple hand-holding method because two forces are created and, therefore, any miscalculation or neglect of this additional force will produce 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 on the left hand (assuming the majority of knappers were right handed and weilded with the right hand and held with the left). Conversely, the lefthand performs considerable more work than does the right arm and hand for it must both support the core and properly manipulate its angles to successfully remove flakes. Also, the fingers of the left hand seek out the ridges and examine the underside of the object being worked and this must be by feel alone for the underside of the artifact is not visible to the worker. To retain this feel, the artifact must be kept in a fixed position and, therefore, the fingers are in almost continual motion. The left hand receives further strain for it must counter the shock delivered by the hammerstone. Hand-holding provides for considerable more maneuverability and ease of manipulation than does the rest, but it is less accurate. There are advantages and disadvantages to both methods and their application depends on the desires of the worker and the tool form he needs. The size of the objective piece is sometimes the deciding factor for when a small object is struck it will be projected with the force of the blow more readily than one of greater size. When a small agate pebble, devoid of a flat surface or projection, is cleaved, it is more intractable and unyielding and because of the lack of flat striking area, it is impossible to repeatedly cleave these pebbles by the hand-held technique. Therefore, the worker must resort to the anvil or rest technique. This type of industry has been reported in the Wadi Halfa Sudan area by Wendorf and Shiner. (Personal Communication)

(12) Hammerstone With Rest and Clamp

The use of the hammerstone with rest and clamp is much the same as described in No. 11 but with the additional aid of a holding devise. The clamp frees the left hand of its holding function and allows the worker considerable more freedom of movement. The holding medium may be either the feet and heels of the worker or a second person may assist in the holding. Feet and heel holding has been noted recently by Norman Tindale (Stone Implement Making among the Nakako, Ngadadjara and Pitjandjara of the Great Western Desert. From records of the South Australian Museum, Vol. 15, No. 1, October 6, 1965). Also this method of holding was noted by Donald F. Thompson (pp 400-422 Proceedings of the Prehistoric Society for 1964, Vol. XXX)

When the feet are used as the holding medium, a certain amount of movement is still present and the striking area of the stone is restricted and limited because the worker must remain in a stationery, seated position and he cannot manipulate the working piece to allow for selection of platform surface. When a second person is used, there is still a small amount of movement of the objective piece, but it does allow for greater platform selection and maneuverability of the worker and the artifact. However, further experiments with this method will be tried when I have a second person to assist who is familiar with this technique.

The aboriginal probably used numerous and varied holding devises but because of their perishable nature, little or no evidence remains. Some blades and unifacial and bifacial artifacts indicate that they were made by a combination of percussion and downward and outward pressure. This technique produces a tool which is flat on the ventral surface end termination of the flakes is a feathering out without adhering to the core or artifact. Also, the undulations on the blade and core lack definition. Examples are the Arctic Micro-blade industries, the Mexican Polyhedral cores, Hopwellian cores and many examples of percussion struck flat blades and flakes. These types of holding techniques are more commonly used in core and blade making than on bifacially flaked artifacts.

Stops and pegs are useful in restricting the movement of the artifact but they do not fully immobilize it and restrict movement in one direction only. The stops may be simply a depression in a log. The pegs may be driven into a log but providing a slight depression between them to allow clearance for the flakes being removed. This method is more useful for indirect than for direct percussion and it may also be used for pressure.

These experiments have made use of all varieties of clamps, vises, and holding devises. They have proven that no mechanical vise is as satisfactory as the primitive method of loosely binding two strips of wood with cordage at one end and inserting a mass of rock between the slats at the other end to provide leverage. The binding must be far enough back from the working end to allow for insertion of the core. The opposite ends of the wooden strips are then spread by moving the lever rock forward until sufficient pressure is attained to immobilize the core. The strips of wood may be of any section or length. This type of lever provides the maximum in clamping immobility. Besides being perishable, a vise of this type would be quite unrecognizable as a functional tool when it was dismantled. However, materials other than wood may be used to make a similar devise. When doing preforming work with massive material, I commonly add a large flat stone to the top of the clamp to provide greater weight and further immobilize the object.

13. Hammerstone (With Rest Bi-polar)

This technique is not to be confused with the anvil and rest method for each embodies a different set of mechanical problems.

The bi-polar technique is useful for certain phases of stoneworking, such as cleaving a cobble and ____, but it will not produce a flake or blade with a bulb of force on the ventral side at each end. I have examined many collections but I have never seen a flake or blade with this technological trait and I fail to comprehend the laws of mechanics or force which could produce such an implement. If a nodule of flintlike material is placed on an anvil and then struck in a manner to detach a flake bearing a cone at both ends, the two simultaneous forces (from the percussor and the anvil) would be in direct opposition. Two opposing forces could create two opposing cones and their attempt to expand would exceed the elastic limits of the material and, therefore, the mass would shatter without detaching a flake or blade. The opposing forces and the opposing cones would restrict the normal expansion of the cone; the two forces would compress and, therefore, the mass would shatter. The resulting debitage would be a mass of splinters roughly triangulate in section and having no definition of a bulbar scar. However, a cobble-like core could bear bulbar scars on both ends with the distal end of the flake scars having a common termination point on the same plane. However, this does not necessarily indicate that the flakes were removed simultaneously, but rather that they were detached by rotating the striking ends of the core. A core with this distinctive technological trait would show that the flakes were truncated by either a hinge or step fracture and expanded as they reached the point of termination. Also, the flakes from such a core would be unduly thick and the core face would be concave rather than convex.

Using a hammerstone with rest or anvil to support the objective piece is a technique involving the principals of force, motion, and the elasticity of solids. Absolute bi-polarity of forces applied to isotropic and homogeneous material is not useful for making flaked stone artifacts with any degree of control. To observe the behavior of forces in direct opposition, a simple experiment can be conducted.

Place a pebble of flint-like material in a machinist's vise and then subject the pebble to the forces of the tightened jaws of the vise until rupture occurs. The force exerted from each jaw of the vise will cause a cone of force to form at both poles of the pebble and as the pressure is increased, the elastic limits of the material will be exceeded and the piece will shatter. (For laboratory purposes, a glass marble can be substituted) When this experiment is altered to include percussion instead of pressure and an anvil is used instead of a vise, the results will be duplicate.

Therefore, the bi-polar technique must be changed to prohibit the opposition of forces and provide for the by-pass of the two movements. This causes a shearing and then the objective piece and cones of force will be severed. The fracture and cone-severing which occur from the by-pass of forces does not produce a bulb of force because the plane of fracture does not involve using the angle of the cone for detachment. Force is directed slightly less then vertical to prevent their opposition. When the angle of the cone is used, the force must be directed at an angle which corresponds with that of the cone.

When cleaving the mass by the bi-polar technique, it is difficult to distinguish between the core and the flake as there is no bulb of percussion on either. The fracture surface is quite flat and the concentric rings of force are diminished and very closely spaced. When shearing occurs, the Apex of the compression rings is from only one pole and which pole will be determined by the dominant force and the contact points of the anvil or the percussor. Because of the irregularity and, therefore, difference in distribution of the mass, the end, or pole, with the greater mass will have greater resistance.to the force and permit the fracture to start at the end with the least resistance. If the vertical axis between the anvil and the point of the hammerstone impact are tilted more then a few degrees, the bulb of force will be more conspicuous and will increase in prominence as the deviation from vertical is increased.

My experiments with bi-polar flaking have shown that this technique is unsatisfactory for detaching blades or flakes the entire vertical length of the core. Attempts have been made to fabricate flakes and blades with a bulb of force on the ventral side at both the proximal and distal ends but have resulted in failure when using the bi-polar technique. Flakes and blades can, however, be produced with bulbs of force on opposite ends but the positive bulb of force will be on only the proximal end on the ventral side and the negative bulb of force will be at the distal end on the dorsal side.

Both the aboriginals and the writer have used a slight variation of the bi-polar technique to make right angle edges on blades and flakes to prepare a core prior to removing burin blades for notching blade edges, and for making and severing microburins. Several styles of flake and blade knives are backed by an abrupt retouch which is accomplished by placing the flake or blade on an anvil and then carefully striking the supported edge with a small pebble. (Small hammerstone) However, the blow is struck slightly less than vertical, which is not truly bi-polar, for the forces are not directly in opposition. Edges made by this technique have certain distinctive characteristics which will be described in more detail under flake and blade knives.

14. Hafted Hammers (Freehand)

Using the hafted hammer freehand has advantages and disadvantages over the unhafted hammerstone. The affixed handle increases the velocity of the blow which will be in proportion to the length of the handle. The increased velocities gained by the handle are very important in freehand flaking of small artifacts which have insufficient weight or inertia. If the striking motion is slow, the artifact will be projected with the blow of the hammerstone. High velocity blows from the hafted hammer will permit the knapper to remove thin, wide flakes from the artifact and to feather them out at point of termination. Also the hafted hammer does not bruise the striking hand as readily as an unhafted hammerstone.

The disadvantage of the hafted hammerstone is that the slightest miscalculations in judging the point of impact on the artifact are magnified in proportion to the length of the handle. Because of this factor, the knapper must seek handle-holding positions which will better enable him to use the tool with accuracy. I find that by placing the back of the left hand, which is holding the artifact against the inside of the knee aids in fixing the position of the artifact. The right hand then weilds 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 except the object being worked is placed on a rest. The rest or anvil will aid in dampening the shock of the blow to the artifact but, because of the inaccuracy of this method, it is necessary to isolate the platforms.

Striking accuracy may be increased by constant practice which is true of most flint-working techniques. Using the rest will relieve the fatigue of the left hand and the flakes will be flatter and have feathered edges. This method is suitable for removing the distinctive side-struck flakes from tabular core pieces. Side-struck flakes expand rapidly as they near termination and bi-laterally remove the distal end of the core. Therefore, the distal end of the flake is bi-pointed and somewhat triangulate in longitudinal section.

The hafted hammer and rest may also be used to remove blades. Cores are designed with one or more ridges to limit the blades' expansion, for the shape of the flake or blade is largely controlled 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)

Using billets, rods of wood or antler - either hafted or unhafted - for removing flakes from bifacial tools offers many advantages over the hammerstone percussor. This baton-like percussor is held in the right hand and is normally swung in an arc-like path of movement rather than a straight line to contact the objective piece in the left hand. The width of the proximal end of the flake will be the area contacted by the billet.

Velocity of the blow can be increased by grasping the baton at the far end and decreased by holding near the striking end. For several reasons, this implement can produce better results than the hammerstone. It permits a greater margin of error and miscalculation than the hammerstone will tolerate. Also, the billet imparts less shock to the artifact and it is easier to direct the path of flight and to vary the velocity of the blow. A novice can attain fair results with the billet even though the blows are not exact because the flint will slightly penetrate the wood billet and dampen the shock. Because of this dampening effect, poorly directed blows will not shatter the artifact and the novice can repeatedly strike the edge of the artifact without removing the desired flake. However, even though he is unaware of it, small bits of flint are being removed from the underside of the artifact on either side of the ridge (high part). This ridge, or high part, has more resistance because of its greater thickness. Repeated blows of the billet will eventually free the part of the edge which bears the ridge left from a previously removed flake - thereby making a platform and centering the ridge. Flakes removed by the wooden billet will naturally be thin, have a diffused bulb of percussion, a slight lip on the ventral side and will lack the sharp definition of the cone. The slight lip on the ventral side of the flake is due to the slight penetration of the edge of the flint into the billet and is more pronounced when using a wood billet then one made from antler. When the billet technique is used, the hardness of the wood will accentuate this diagnostic feature.

I first became aware of the wooden billet technique in the 1930's when assisting with a paleontological survey in the Walker Lake Region in Western Nevada with the Late Dr. Reuben A. Stirton. While camped on the ranch of a

Nevada pioneer, he told of the Piute Indians stealing the wooden spokes of the wagon and buggy wheels to use for making stone artifacts. This elderly man did not know how or why they used the wood but the Indians had told him of the wooden billet. Up until this time, I had used only the hammerstone for roughing out and preforming. But I tried using the broken handle of a prospector pick and was soon able to define the advantage of this type of percussor over the simple hammerstone. The Australian primitives also used a piece of hard wood to tap the flint-like material set in the ends of their throwing sticks - such was a common retouching or sharpening method. Others who have used the billet or baton in their experiments have been M. Leon Coutier, Professor A. S. Barnes, Andres Kreigh, L. S. B. Leakey, Jacques Tixier and Francois Bordes, who has attained perhaps the greatest control and understanding of the use of the billet.

The wooden billet is of little use for striking blades from a core and the antler billet is preferred. The striking end of the angler billet must be slightly rounded and the percussion blow must allow the curved part to contact the edge of the stone. As the billet becomes worn from use, it may be rotated to prevent its becoming flat and developing large facets.

By using this harder billet, thicker flakes may be removed with a single blow, however, because of this increased hardness, the antler billet requires that the worker be much more accurate in striking. To use the billet efficiently, one must first understand the fracture of flint-like materials. To get the desired flake dimensions, the worker must pre-establish surfaces prior to removing a flake and special attention must be given to the selection and preparation of the platform area.

Many flakes found in aboriginal sites indicate that they were removed by the billet technique but there seems to be a scarcity of aboriginal billets. Wood could not be expected to endure the ravages of time but there should be evidence of the antler billet unless it was consumed through use. On page 193 of B.A.E. Bulletin #60, W. H. Holmes, there is an illustration of four typical antler billets. The wear pattern on these four billets indicates that both ends were used for thinning and forming the artifact which was originally preformed with a hammerstone. In my experiments, I have used both ends of the antler billet and have a wear pattern duplicate to those illustrated. See Figure ____________ for characteristic flakes removed by the use of the wood and antler billets.

There are two striking patterns when using the antler billet - the arc-like motion and the straight-line movement - and the choice depends on the length of the antler - whether it is a full section or a part section.

When just the section of antler is used, the straight line method is employed and the billet is held vertically and projected in a straight line to the point of impact much the same as one would use a hammerstone in the straight line technique. This tool and technique is useful for detaching blades from a core for it dampens the shock normally created when using the hammerstone. Blades removed by the antler section in the straight line method will have a diffused bulb without the definition of the cone; a general absence of an eraillure flake scar; and a wide lateral platform. The definition of the compression rings will be less than those left from the hammerstone and more than those resulting from pressure. The antler section does not work well for the arc method.

When a longer piece of antler is used in an arc-like motion, the billet is grasped in the right hand as one would hold a club; the wrist is held immobile and the forearm supplies the force. The objective piece is held loosely on the four fingers of the left hand with the thumb exerting a slight pressure to hold the artifact in position. The blow is projected in a follow-through motion to the main body of the objective material. The novice should protect the left hand with a glove or pad until he has become experienced and adept with this technique. After this, the protection can be deleted for the bare fingers have the advantage of inspecting by "feel" the underside of the artifact.

When making a biface, the blow is directed from the tip toward the base and then the piece is rotated and the blow delivered from the base toward the tip. When this has produced a shape suitable for flaking, the artifact is turned so the striking area will be the edge and the blow is delivered from one marginal edge toward the opposite lateral margin.

There are several variations in methods of holding and striking. One is to strike with the tip of the billet and at right angles to the artifact. Another is to strike with the edge of the billet and change the holding position of the left hand to line up the marginal edge for proper contact. When the latter method is used, the objective piece is held parallel to the arc of the blow and the flakes are detached from the underside of the artifact between the first and second fingers of the left hand. This technique is also useful for thinning down a thick core tool. If flakes removed by this technique have the desired qualities, one can then remove additional flakes from the same margin. For the novice it is recommended to keep the angle of the blow, the angle of the objective piece and the intensity of the blow constant. After the experimenter has practiced and attained much skill, he will find it desirable to alternate flake removal from both sides from the same margin.

Each artifact presents a new set of problems and they must be dealt with in slightly different manners and modification of the techniques. For instance if the artifact is not sufficiently thin, it may be desirable to terminate a flake in the middle of the artifact by either a step or hinge fracture and then remove a flake from the opposite edge to meet the flake termination of the step or hinge fracture. Very thin bifacial tools may be made by this type of thinning. The thickness, length, and width of the flake will depend on how near or far from the marginal edge of the artifact the blow is hit. The length and width of the flake depends on the exterior surface of the artifact and the force intensity of the blow.

Flake termination is dependant on both the angle of holding the objective piece and the angle of striking. Different types of billet materials leave characteristic attributes on the platform area of the flake. The hardness or softness of the billet will leave characteristics which may help to identify the billet material.

The softer the material, the greater the penetration of the flintlike material into the billet. Wooden billets will vary in hardness, depending on the type of wood used. Some of the exotic hard woods such as Mountain Mahogany, Sapodilla, and others will compare in hardness with the antler. The results of different materials with equal hardness will, therefore, be similar. The geographical area will be, in part, a deciding factor of materials used for billets for whether the materials be of hard woods, antler, horn, bone, or even stone, depends on the availability of material at the time of manufacture. Another consideration is the Genus of the antler bearing animals supplying the billet material. Those derived from the Caribou, Moose and Elk are considerably larger, heavier and more massive than the deer antler which allows the knapper to remove larger flakes.

The bone billet should also be mentioned in these experiments. I found that the cannon bone of the horse, because of its shape and weight, is well adapted for a billet. But the bone billet will not survive making more than one or two medium sized artifacts because of the spongy nature of the ends. When these ends become unduly soft, it is impossible to remove any large number of flakes and when the spongy part is consumed, the remainder is very brittle and lacks strength due to the narrow cavity in the center. Fresh uncooked bone will withstand impacts much better then weathered or altered bone.

Both individual and traditional techniques of using the billet will be determined by an examination of the platform area of the flakes. Major and minor variations 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, i.e. one showing a conspicuous, well-defined cone part, is uncommon on flakes detached by the billet technique but is characteristic to the hammerstone. The softer billet leaves a slight overhanging lip directly beneath the platform. This curve on the platform part is the result of the billent contacting and penetrating the platform surface and pulling away the flake. Because the billet is soft and yielding, the cone is spread leaving a diffused bulb. Much of the flake character depends on the preparation of the Platform. (See platforms)

Granular materials can also cause bulb diffusion. Since the billet is commonly used in the intermediate steps between hammerstone preforming and the final pressure flaking, the dorsal surface of the flakes will bear scars of the previous preforming. Billet flakes are usually rapidly expanding with feathered edges and an accentuated curve.

(17) Billets (With Punch)

This technique uses the billet to transmit force to an intermediate tool which will be called a punch. Using the punch as an intermediate tool not only permits the knapper to make knives, spears, and assorted unifacial and bifacial implements; but it is also useful for detaching blades from cores.

The punch is usually an uncurved antler tine or a rodlike piece of bone or a suitable antler part. By using an antler billet rather than a small stone, I found I could strike with increased velocity and greater accuracy. The proximal end of the intermediate tool which is to receive the blow from the billet is made flat and the distal end which is placed on the objective piece is slightly accuminated. Generally, the billet is of hard wood, antler, or bone. Its dimensions will depend on the type of work to be performed. A long billet will increase the velocity of the blow as opposed to a short one. The diameter and weight will determine the amount of force - the longer the diameter, the more force at even a reduced velocity.

The billet and punch technique permits the worker to accurately select the impact area which is not possible when using just the billet without the punch. This technique has been described by B.B. Redding in the American Naturalist, 13, No. 11 (1879) "Holding the piece of obsidian in the hollow of the left hand, he placed between the first and second fingers of the same hand, a split piece of deer horn, the straight edge of the split deer horn resting against about one-fourth of an inch of the edge of the obsidian; then with a small stone he, with his right hand, struck the other end of the split deer horn a sharp blow". But this method leaves much to be desired for the first and second fingers cannot apply sufficient pressure to provide good contact between the tip of the punch and the edge of the artifact. This method is unduly cumbersome and it is hard to simultaneously manipulate both the angles of the punch and the artifact in the left hand and, at the same time, strike the punch with the right arm. It is difficult to hold an object larger than an arrowpoint and also the punch in the same hand. However, by slightly changing the style of holding, I found the method has some merit. By placing the artifact between either the knees or the heels, the punch may then be used with accuracy and satisfactory flakes can be detached. But for satisfactory results, the blow must be delivered with considerable velocity to prevent the artifact moving with the blow.

A variation of this technique requires two persons to do the work. One person holds either the punch or artifact and the second person delivers the blow.

George Catlin describes this technique in "Last Rambles Amongst the Indians of the Rocky Mountains and the Andes" (New York D. Appleton and Co., 1867. "The master workman, seated on the ground, lays one of these flakes on the palm of his left hand, holding it firmly down with two or more fingers of the same hand and with his right hand, between the thumb and two forefingers, places his chisel (or punch) on the point that is to be broken off and a co-operator (a striker) sitting in front of him, with a mallet of very hard wood, strikes the chisel (or punch) on the upper end, flaking the flint off on the underside, below each projecting point that is struck". This indicates very close observation by Catlin, even defining the use of projections as platforms for seating the tip of the punch. This method is useful for thinning and finishing artifacts which have been previously preformed by direct percussion. The length and width of flakes is governed by the exterior surface of the artifact, the angle of the punch and the intensity of the blow. The size of the platform must be the same size as the contact point of the punch; and the cone part (bulb of percussion) will be salient with good definition. This two man technique allows the striker freedom of working manipulation but for success the workers must coordinate their actions and synchronize punch placement with the blow. When the punch process has sufficiently thinned and formed the artifact to the stage where further work with this method would break the artifact - then a pressure technique is used to remove any irregularities and ridges left by the accentuated bulbs of percussion; straighten and sharpen the edges and make the artifact more uniform.

Flakes or blades detached by the punch will vary according to the type of artifact the worker needs. The character of the platform, the bulb of percussion, the dimension and termination of the flakes or blades will depend on the workers individual and traditional traits and implement being formed. However, there will be a certain consistency and uniformity of flakes removed by this method; their major and minor deviations being a reflection of the particular type of manufacture.

To relate this technique to the flake or blade, one must examine the platform for pertinent characteristic features such as special platform preparation - grinding, isolation, angle, limited area and the distance of the platform from the leading edge of the artifact or core. Flakes will reveal that the punch was placed with precision, care, and accuracy on an established platform which is not the case when direct free hand percussion is the technique.

(18) Billets with punch and Rest:

Using the billets with punch and rest is much the same as No. 17. Flakes or blades made by this technique will have a slightly less accentuated curve and some may be almost flat with little or no curve at their distal end. The anvil provides inertia and affords a means of immobilizing the working material which decreases the amount of force necessary to detach a flake or blade. The impact of the billet also causes the rest, or anvil, to exert force in an opposite direction, resulting in a shearing action of the material. This produces a flatter flake or blade and terminates them at a point just beyond the edge of the anvil which avoids compression of the material by the anvil and the force of the blow.

(19) Billets with punch, Rest and Clamp

This technique eliminates the need of a second person for holding. There is a variety of ways to secure the core or artifact - the simplest being for the worker to assume a sitting position and use his heel to hold the objective piece. According to Dr. J. Desmond Clark, this method has been recently used by the Africans to make gun flints. (Personal communication) Dr. Clark has conducted numerous experiments on the function of Paleolithic implements (Page 120, Early Man: Life Nature Library by F. Clark Howell)

Both the writer and Dr. Francois Bordes have conducted experiments with this punch, rest, and clamp technique and found we had much greater control of flake removal than when we used simple direct percussion. However, the feet allow the objective piece to move slightly and, therefore, it is difficult to exert downward pressure and still hold the objective piece firmly on the anvil. The slightest movement of the objective piece will cause the flake or blade to be malformed. Much preferred is a holding devise made from two lashed poles and a fulcrum which permits a minimum amount of movement and allows the worker to accurately remove blades and flakes. The clamp allows the worker to accurately place the tip of the intermediate tool, or punch, on a pre-selected platform area and both the vertical angle and the angle of fracture can be calculated. Then the velocity of the hammerstone or billet, which is relative to its weight, is calculated to comply with the size of the desired flake and the angle of the plane of fracture and the texture of the material.

The form of the flake or blade is controlled by its dorsal surface. Should the face of the core be flat, the blow will create an expanding flake, but if the core has a prepared longitudinal crest or ridge on the face, it will form a narrow flake or blade.

The billet with punch rest and clamp technique is used for making blades and for the refined percussion flaking of artifacts following direct percussion preforming and prior to final pressure retouch.

Characteristics of this technique can be found on the proximal or platform end of flakes and blades. The size of the platform area is governed by the size of the tip of the punch or by a special preparation which isolates the area contacted by the punch, which can then be smaller than the punch. The platform can be the natural cortex, an unmodified plane of fracture or a part that is concave as the result of removal of one or more flakes; or a crest left from the removal of a flake on either side of the crest; or it can be ground or polished. Should the platform be convex, it usually indicates that the platform was either isolated, ground or polished. The angle of the platform is variable depending on how the core was formed and is a significant factor in determining core types yet should be constant if a single technique was used. If the top fo the core is prepared at a right angle to the long axis - then the platform of the flake or blade will have a corresponding angle. If less than a right angle, the platform will correspond to this angle. The angle of the platform on the flake is at right angles or less than a right angle to the longitudinal axis of the core. The apex of the angle begins at the dorsal side of the flake or blade and will never slant toward the dorsal side but rather toward the ventral side.

In general, flakes and blades made by the billet, punch and clamp technique are uniform; generally have small platforms; a salient bulb of percussion, and a general absence of eraillure flake scars - features not characteristic to an assemblage made by direct percussion. Because of the use of the clamp, flakes and blades will be flatter; they can be controlled and, therefore, terminated by feathering at their distal end. Because of the decreased shock when using a billet, the ventral surface of the blade or flake is generally smooth and without well-defined pressure rings. Because of the use of the clamp, the flakes and blades will be flatter and they can be controlled and, therefore, terminated by feathering at their distal end. Because of the decreased shock when using a billet, the ventral surface of the blade or flake is generally smooth and without well defined pressure rings.

(20) Hammerstone with punch (free hand)

This technique has been described under No. 17 except that in this case and as Redding described a hammerstone was used instead of the billet. I found that the billet was considerably more useful than the hammerstone, but with practice one may become proficient in using the hammerstone. The disadvantage in using the hammerstone is that it is difficult to project the hammerstone with sufficient velocity and proper follow through without causing aberrate fractures. Also the left hand is directly in line with the blow causing the knapper to flinch. The shape of the hammerstone is usually ovoid and not flat and causes the force to be deflected unless the blow is very accurate. The objective piece is usually too light to have sufficient inertia to prevent its moving with the force imparted. The flakes have salient bulbs of percussion and exaggerated compression rings and often terminate as step or hinge fractures. Should there be a choice the billet is preferred over the hammerstone.

(21) Hammerstone with Punch and Rest

Much the same as described under No. 18 except that a hammerstone is used instead of the billet. The hammerstone causes the punch to become softened from its mushrooming from repeated blows. The hammerstone imparts more shock than does the billet causing the flake or blade to have more pronounced compression rings than when using a billet. In order to perform this technique a second person is needed, yet by holding the objective piece between the knees or by resting it on the ground or a suitable support, a well padded knee or the foot may be used to hold the core for blade making. Using this technique for making bifacial tools a second person is needed for holding. The flakes or blades will be quite flat because of the support, the more resistant the rest or anvil the flatter the flake. The velocity and weight of the hammerstone must conform to the work being accomplished.

(22) <u>Hammerstone with punch rest and clamp</u>

The clamp or holding devise permits the objective piece to remain stationary while giving the knapper more manuverability. The clamp is generally used for blade making, and is too cumbersome to use for removing flakes from bifacial artifacts. The blade types will be similar to those using method 21 but having more uniformity.

(23) <u>Indirect, hammer freehand</u>

This technique requires the use of an anvil of either stone, antler, or bone. The objective piece is placed on the anvil held in the hand and then the artifact is struck by a percussor. Such a technique makes it difficult to determine the exact plane of fracture and usually causes the working edge of the artifact to be crushed or bruised. It is not a good sharpening technique but is useful to turn the edge or to cause a bevel to be formed to be used for a platform. Blades may be backed or severed for micro blades and the making of geometrics. Burin core preforms can be made by first snapping a thick flake or blade then turn the flake vertical and resting the 90 degree break on a flat part of the anvil then striking it with a percussor and a long narrow flake will be removed on the upper margin, the flake or blade can then be inverted, the process repeated to remove the snapped part. The correct angle of the core faces is determined by the knapper, the angles depend on the angle in which the flake or blade is held on the anvil. Burin blades may then be removed by pressure and the core left with a sharp edge. The first burin blade removed by indirect percussion is usually triangulate in section while the following blades will be either rectangular or rhomboidal in section and the width of the burin core. The bulb of force will be diffuse because of the wide contact between the edge of the core and the anvil. Concentric rings of force will be more pronounced when percussion is used than pressure. The intensity of the blow determines the termination of the burin blade. If the force of the blow is dissipated before the blade reaches the distal end of the core a step fracture will be caused to form at the distal end of the burin blade and if additional blades are removed each will be slightly shorter than the one that caused the first step fracture. If the force is not dissipated the blade will be removed the full length of the core and remove its distal portion.

The term indirect at present blankets two sets of techniques, the first is the various uses of an intermediate tool to transmit force from the percussor to the objective piece and the other encompasses the group of techniques that the force is delivered directly to the objective piece being obstructed by an anvil, causing a flake to be dislodged, by the inertia of the anvil.

(24) Indirect with hammer and rest

This method of flake removal is much the same as described under No. 23 except that an anvil or suitable rest is used in a fixed position, and not hand held. The anvil can be keeled, pointed, flat edged, or simply ovoid, depending on what function or technique is to be performed. This technique permits the knapper considerably more lasitude in the work to be performed because the larger the anvil the greater the inertia and therefore gives a greater range of size of flakes that may be removed. The flakes may be removed more uniformily from the objective piece. The hammerstone or percussor must be of a softer nature than a polished hard stone hammer or the objective piece will be either bruised or shattered. Discoidal anvils may be used for notching large bifaces to facilitate hafting. The bulbs of force are absent when the cone of force has been split, yet the flake and flake scar has close well defined compression rings radiating from the point of contact. There are several ways of using indirect percussion and the flakes and flake scars will have similar characteristics pertinent to each method used. For an example, the backing of a knife by the burin technique cannot be compared to removing the cortex from a nodule. There is a need for additional experiments in using the indirect percussion technique because the objective piece may be placed with greater accuracy than by using direct free hand percussion, also the technique of splitting the cone should be further investigated.

(25) Indirect with a Fixed Punch

This method of flaking is done by securing a punch-like object made of antler, bone, horn or stone in a log or some other object with enough weight to cause inertia. The objective piece is then positioned on the pointed end of the punch at a pre-selected spot or platform and the core or artifact struck with a percussor that will not cause fracture or bruising. Such a technique permits accurate placement of the object being worked on, but because of change of form of the core due to position changes of the area that is to receive the force of the percussor is constantly changing. My experiments have not permitted me to remove blades from a core with the accuracy of hand holding the punch and then directing the blow at the correct angles. The fixed punch technique can be used to notch large thick bifaces if much care is exercised. Upon striking the artifact the intensity of the blow must be directed with considerable control or the artifact will be broken. It is possible to make one style of a burin or burin core by placing one angle of a truncated flake or blade on a fixed projection and then striking the flake or blade. Such a method requires considerable practice in calculating both the angle of the blow and the angle to hold the objective piece. Experiments using the fixed punch technique in making either uniface or bifacial artifacts has resulted in only thick, steep angled implements because the artifact must be held at such an angle that a blow may be delivered to its face that only short flakes may be removed. A long narrow artifact is easily broken. Using this technique because it is due to striking the artifact without being able to dampen the shock. The flakes that are removed by the fixed punch have salient bulbs, are rapidly expanding, usually feathered at the distal end and short because the force cannot be directed across the face of the artifact.

(26) Pressure, Freehand, Unhafted pressure tool

Freehand pressure flaking is accomplished by placing the objective piece in the unsupported left hand protected by some yielding material such as leather, grass, or cordage and then pressing off flakes from the margins of the preformed artifact or flake by the use of a pressure tool held in the right hand. The pressure tool is without a handle and is commonly of antler or bone, used as is or may be served to protect the hand. The objective piece is held in the left hand with the side to be flaked towards the palm. The flakes will be removed from the underside and their detaching cannot be observed by the knapper as only the leading edge is exposed. The objective piece is held by the fingers with the thumb extended. The fingers are pressed on the top of the objective piece with just sufficient pressure to immobilze the artifact to be. Any excessive pressure will cause the objective piece to be fractured when the pressure is applied at its edge. The objective piece is held in the palm in such a manner that the proposed flake will be directly over the concavity formed between the heel of the thumb and the plam approximately in line with the center of the wrist and between the second and third fingers when they are securing the lithic material. The angle in which the objective piece is held depends on the preference of the knapper and what problem of flaking is to be accomplished. The methods of holding the objective piece and the pressure tool are many and varied as was the skill in applying the pressure. The pressure tool is held in such a manner that it will rest just slightly forward of the first knuckle and as close to the tip of the pressure tool to afford greater leverage. The wrist is held rigid with the pressure being applied form the right shoulder through the arm. The muscles of the back are used in conjunction with the shoulder as the knapper leans in to the work being performed as each flake is being detached from the objective piece. Such movement makes it necessary for the knapper to be seated rather than standing. The previously described method of pressure flaking is used in stages to remove irregularities and to develop a more regular form in order to remove flakes with regularity. The knapper cannot duplicate a series of flake scars or remove flakes that are uniform from a surface that is irregular. This method of stone working by the simple application of pressure has been widely observed and accounted for by explorers and historians and a few archaeologists. Multimillions of tools have been made by using freehand pressure flaking in most parts of the world occupied by man. The freehand pressure technique is used on blades or flakes and pre forms made by the percussion technique. This method was probably first used to resharpen a dulled edge and to modify a flake or blade to suit some functional objective piece that would facilitate holding or hafting. A blade, flake, uniface or biface may be sharpened to the same degree of sharpness as originally removed from a core by removing a series of pressure flakes from its margin. The technique of sharpening involves more than just pressing a series of flakes from the edge of the objective piece. The tip of the pressure tool is placed on the prepared edge at either one end or the other and the first flake removed by pressing inward and downward. The bulb of pressure will be removed with the flake leaving an edge that is uncrushed, then the tip of the pressure tool is placed directly over the ridge caused by the removal of the first flake and pressure applied in the same fashion as the first. The spacing is such that the bulbar part of the flake removed will intersect the bulbar scar left form the previously removed flake. This process is continued until the desired part has been sharpened. The edge will be as sharp as a newly removed flake if the worker had sufficient skill to avoid crushing the edge. The edges sharpened in this manner will naturally be slightly more irregular than the edge of a freshly removed flake or blade, the irregularities do not deter the cutting qualities. If the artifact is flaked unifacially, the flaked surface will have a series of small channels, their spacing will correspond with the interval in which the pressure tool was placed on the edge of the objective piece. Both flake and flake scar will bear compression rings radiating from the point in which the pressure was applied. The flake scars are usually slightly oblique being directed from right to left by a right handed person holding the objective piece in the palm of the left hand. Should the person be left handed then the flake scars will be directed in the opposite direction. The flake scars can also be collatoral and at right angles to the leading edge. The way the objective piece is held, the way the edge is prepared and the skill in which the pressure is applied will reveal numerous technological traits. It is unfortunate that flakes removed by this method are usually broken because of the close contact with the protective pad held in the left hand. The flakes are removed from the under surface of the artifact pressing towards the palm of the left hand and in so doing are usually crushed or broken with only the proximal end of the flake remaining intact. Upon recovering such flake parts, the platform portion may be examined and the edge of the artifact reconstituted to show the edge preparation, the angle of the edge and the angle the pressure was applied. Complete unbroken flakes will show the curvature of the artifact by examining the arc of the ventral surface.

The distal ends of the flakes are also diagnostic and can reveal how the pressure was applied. Should the flake feather at its distal end and at its termination be come increasingly thinner and be sharp with no truncation will show that the flake was removed by more downward pressure than inward and it was snapped quickly and without follow through of the pressure. Such a flake is never made when one making a wide thin artifact. Should the flake terminate in a hinge or step fracture, it could be a mistake on the knappers part or done on purpose to stop the flake midway on the face of the artifact and then meet the flakes termination by removing another flake from the opposite side to intersect the hinge or step which will cause the artifact to be thinned. Single flakes may be aberations of the normal so flake populations and assemblages of workshop debris is necessary before worthwhile appraisals may be made. Each artifact with multiple flake scars must be appraised individually to show the sequence that the flakes were removed and the character of the flake scars. Having both artifact and accompanying flakes allows the appraiser to then associate and evaluate the various stages of manufacturing. Observations of aboriginal work, particularly projectile point industries show that certain cultural groups are distinctive because of the random nature of their flaking, being concerned mainly with function and little thought of regularity or artistry.

(27) Pressure, (free hand) hafted

The application of pressure free hand with a hafted pressure tool is much the same as described under No. 26, except that the pressure tool is more sophisticated and somewhat refined. There are many ways and ramifications of making a composite pressure tool. See paper on tool types. Generally implying that a pressure bit is inserted into a handle whose length will conform with the technique for which it will be used. The hafted pressure tools may be separated into two classes the short and the long. The short being made just to fit the hand and more comfortable to use and permit new bits to be inserted into the handle as they become worn without replacing the whole tool and instead of continual resharpening new bits may be inserted. The long tool is used in a slightly manner than the short one, the method of holding differs and greater pressure may be exerted because of the increased leverage. The long handled pressure tool is grasped near the bit in the right hand with the handle parallel with the inside of the forearm. The elbow holds the long handle of the pressure tool against the body. The tool held in this manner permits the worker to exert considerably more pressure on the objective piece by using the arm without tiring the wrist. Flakes of greater dimension may be removed by the long handled tool than with the short one. It is somewhat easier to keep the tip of the pressure tool in line with the ridge on the artifact, making the flaking more uniform. The tip of the pressure tools on both short and long styles will effect the character of the proximal end of the flake as well as the flake scar. The tip with a flat surface will contact a larger portion of the edge of the objective piece than will one with a sharper point. Such a contact causes the bulb of pressure to be more diffused or salient. The width of the flake or flake scar doesn't depend entirely on the width of the tip of the pressure tool but on the interval in which the tool was placed on the margin of the objective piece. Closely spaced flakes may be detached with a fairly blunt pressure tool. The amount of pressure required to remove a flake is proportional to the width and not the length. The exterior surface, or the dorsal side of the flake to be will control its relative length. The thickness of the flake is regulated by the distance from the leading edge into the body of the artifact the tip of the pressure tool is placed. This distance from the edge is also a factor in controlling the width of the flake. The nearer the edge of the objective piece that the tip of the pressure is placed without the edge crushing the less pressure is required. Additional purchase may also be gained by the use of the thighs. The back of the left hand is placed on the inside of the left thigh while the back of the right hand is placed on the inside of the right thigh, then by simultaneously pressing the thighs together and coordinated with pressure from the forearm and shoulder. As this pressure is applied the left hand is moved in such a way that as the inward pressure is applied by the pressure tool, the left hand is moved to control the downward pressure, thus permitting a flake to be detached first at the platform and then guided across the face of the artifact by the motion of the hand holding the objective piece. The long handle pressure tool is commonly used for medium to large projectile points and bifacially flaked knives which will be described in detail under point types. The character of the flakes using the short or long handled tools will depend upon the nature of the work being done. Their form and characteristics should be quite uniform and show consistent patterns if the implements being manufactured are the same. However, because the objective piece is held in the hand and the hand is rotated as the flakes are removed the flakes will be curved on the ventral side and the artifact will be convex on its flaked surface. The platforms of the flakes removed by the use of the pressure technique will denote the manner in which it was held, by relating the flake to the artifact and replacing them in the left hand with the flake between the artifact and the palm the angle of the platform will correspond with the lateral margin of the artifact, Should the transverse angle be at right angles to the longitudinal axis of the flake, then the flake would be a collateral flake if the sides of the artifacts edges were parallel. Should the angle of the platform be either to the right or left, then the flaking would be diagonal or oblique. The extent of course would correspond with the angle of declination from vertical.

The size of the pressure flake, generally width and thickness, will have certain limits depending on whether a short or long pressure hand tool was used and the strength of the knapper. There is naturally a limitation of the size of flakes that may be removed by the hand held pressure technique and the nature of the material being worked on.

(28) PRESSURE, Hand held with rest.

The hand held pressure with rest is much the same as in No. 26 and 27, except that the objective piece is supported on something besides the hand. A rest or semi-rigid support is used. Such a support will cause a difference in both flake and flake scar. The flakes will be flatter on the ventral side than those that have allowed the objective piece to move when the pressure is applied. The flakes will feather at the distal end of the flake. Bifacial tools made by the use of this technique will have a spine or ridge running longitudinally down the median line of both faces of the artifact. The cross section will romboid or diamond shaped. A preform cannot be thinned by using this technique. Examples of flaking of this character is to be found on some varieties of Eden points, usually those that are flaked collaterally, also some drills show the use of the rest. The flake scars usually terminate before or midway across the face of the implement. One of the methods used in flaking experiments is to use very thick stiff leather as a pad for the left hand with another piece folded and placed on top of the other and placed in such a manner that it will parallel the proposed flake. The folded strip of leather provides clearance for the flake to be removed from the artifact. I also used for experimental purposes a rubber heel with a groove cut into it for clearance. The rubber heel is preferred because the folded leather has to be adjusted after each flake is removed. Pressure is applied differently than when thinning or flaking from one margin to the other. The point of the pressure tool is seated on the marginal edge and the pressure is applied more downward than inward and gradually increased until the flake is removed. The flake comes off with a sharp snap and a different sound than without the support. The gradual application of pressure is important because as the pressure builds up to the point of fracture the flake will part from the parent mass in a straight line without curving and will terminate with a sharp edge at the tip. A flake removed in this manner literally explodes because of the elastic qualities of the material. Care must be used in seating the tip of the pressure tool to prevent the edge from being crushed. The seating of the tip may be done by removing minute flakes from the margin edge as each flake is removed or the entire perimeter or lateral edges may be slightly beveled by a wiping action to turn the edge. Too, the edge can be slightly polished by the use of an abrasive stone to be made stronger.

The hand is stabilized by resting the back of the left hand on the thigh and not permitted to move or the flake will not terminate with a feathered tip; and the flake will curve and cause the artifact to be biconvex in cross section. The way the hand is supported and the artifact is held will influence the flake character. In order to further immobilize the artifact it may be rested directly on a grooved stone, log or any similar medium. Experiments have shown that the fingers or the thumb must be given exercise and time to develop as each new position requires a new set of muscles to hold the objective piece while being worked on by the right hand holding the pressure tool. A novice knapper will find discomfort in a short time of working at any position and will find it most difficult to change techniques and develop new muscles and callouses. Experiments in replicating techniques will soon convince one that after one has become proficient using one method there is no reason to make the change if the artifact serves a functional purpose. Archaeology has shown that some technological traits have endured traditionally for long periods of time and methods pasted from father to son if their economy remained constant. Each artifact generally encompasses several technological traits rendered during its various stages of making.

(29) PRESSURE, reverse, finger held

A method of flaking that is reversed from the normal of pressing towards the body, using this technique the pressure is away from the body. Such a way of applying pressure causes the flake scars to resemble those made by a left handed person. The reverse flaking technique has been noted numerous artifact assemblages occurring in both the new and old world. Lithic Technology conference, Les Eyzies, France. At this time it is difficult to be sure if the maker was using the reverse technique or was simply left handed. When the majority of the artifacts bearing flake scars directed away from the worker, one could then conclude that the reverse technique was used, as it would be unlikely that left handedness would be so prevalent.

It was noted by H. Holmes Ellis (personal communication, 1940) that the occurrence of the beveling and the direction of flaking indicated left handedness rather than a change of technique. However, in the valley of Mexico and the State of Colima a high percentage of the pressure work does indicate that the reverse technique was used. The use of this technique was first resolved and developed and brought to my attention by Gene Titmus, an accomplished flint knapper, who developed this technique independently and without my assistance. The Titmus technique has also brought to my attention the importance of the individual developments of ethnic groups methods of flaking stone and each identifiable through characteristic flakes and flake scars. By the comparison of the results of our experiments and each attempting to use each others methods, we find much difficulty to make the change. Finding the others technique to be awkward because of different muscles that needed developing in order to hold the objective piece. In both cases the platforms had to be prepared in reverse. Both Titmus and I have now been able after many, many hours of practice to replicate the others technique but not with the accuracy of our original method. These experiments have shown that once you are accustomed to a particular method it is unlikely you will change techniques if the end results will accomplish the same functional results.

It would seem plausible that aboriginal workmen once developing a technique would be unlikely to change.

The reverse technique is done with the worker in a sitting position with the thighs spread so that the back of the left hand is placed on the inside of the left thigh and towards the body and away from the knee. The left hand supports the objective piece by resting it on the third joint of the forefinger and the palm of the hand. The first and second fingers are spread in such a manner that the flake to be detached will have space between the fingers. The thumb holds the objective piece in place. The hand is protected by a folded cloth or soft leather pad and is sometimes wrapped around the first finger with the balance of the protective material on the palm and covering the other three fingers. This technique is commonly used for retouching projectile points, and sharpening bifacial artifacts. First the base of the artifact is placed in the palm of the left hand with first finger extended and pointing towards the right thigh. The other three fingers are slightly curved under the pad to assist in the support of the preform. The distal end of the artifact is pointed towards the body with the lateral margin to be flaked towards the first finger. A small platform must then be prepared on the lateral margin or the leading edge to seat the tip of the pressure tool. The platform is prepared the same distance from the base as will be the width of the first flake. The platform preparation is done by removing minute flakes pressing from the under side of the artifact towards the thumb in a direction opposite that of the proposed flake. By removing these tiny flakes a small notch is made. The edge of the notch towards the base will have an abrupt angle for seating the tip of the pressure tool. The first flake will have to be removed with care or the base of the artifact will be partially removed with the flake. The pressure tool is held in the right hand with the pressure tip as close to the first knuckle to increase the leverage. A short hafted pressure tool is used because the pressure is directed outward and away from the body. A long pressure tool is cumbersome and gives the knapper no advantage of leverage. Experimenting and practice will determine the distance from the edge to place the tip of the pressure tool, the farther the tip is placed into the body of the objective piece the thicker will be the flake. The pressure tool is held at an angle to the lateral margin and in line with the proposed flake to be removed. The angle in which the pressure tool is held will determine the obliqueness of the flake scar on the artifact. The pressure tool is pressed directly in line with the proposed flake, then downward pressure is exerted towards the first knuckle of the left hand. The inward pressure must be adequate before the downward pressure is applied slowly and gradually increased until the flake parts from the artifact. After the first flake is removed from the base of the objective piece the scar is examined to see if a suitable ridge is left to guide the next flake. If the angle in which the downward pressure is not vertical with the longitudinal axis or the lateral margin, the ridge will be eliminated and will permit the second flake to spread. If the first flake is successful and a ridge or crest is left, then by the use of the pressure tool the edge is trimmed by pressing downward on the margin until the scar left by the bulb of pressure is straightened and is in line with the ridge. Another notch is then made in the same manner as the preparation for the first platform in removing the first flake. The inward pressure must now be in line with the ridge and be applied first before the downward pressure is put upon. Each successive flake is then removed in the same way until one reaches the tip of the artifact. Both the downward and outward pressures must be adjusted as the flakes diminish in size. The slightest miscalculation in applying both pressures, platform preparation and postion of the tool on the platform will cause a step fracture. Should a step fracture occur, then the next flake will also step fracture at the same point as the previous step fracture. This is due to the increased mass left by the step fracture and the next flake hasn't enough strength to by pass the increased resistance. Any interruption of the flaking pattern such as step fractures imperfections in the materials will defeat the knapper attempting parallel flaking, and all conditions must be ideal.

Occasionally one can recover from a step fracture by removing a flake from the opposite margin and on the same side to intersect the flake scar with the hinge fracture. Should the first series of flakes be successful then the objective piece is turned over and the next series started at the base on the opposite side. After this side is flaked the lateral margins must then be reworked to make their edges regular again before the next two series of flakes may be removed. The knapper now starts at the tip or the distal end of the artifact and removes the flakes towards the base. The first flakes must be removed from the fragile tip with great care and direct the pressures downward more than outward or the tip of the artifact will be severed. After enough flakes have been removed from the distal end of the artifact to a position on the edge then one will direct the flakes in line with those previously removed from the opposite margin. The flakes removed from an objective piece to parallel flake the surface of an artifact are in reality diminutive blades. Blades larger than those made by parallel flaking an artifact involves the same principles and a similarity of techniques. An association of blade making and parallel flaking is not unreasonable and any evidence of aboriginal similarities would remain to be seen; some evidence of a relationship in the Denbigh complex, Lena River in Siberia, polyhedral cores and parallel flaking in Meso

America and possibly some early man sites in North America.

(30) <u>PRESSURE with rest and clamp</u>

Pressure with the aid of a rest and clamp is a method used in experiments replicating various burin types and micro cores, associated with several of the Arctic cultures. The pressure, too, is long enough to be grasped by both the right and left hands, or at least eight inches long. The clamp is made from two pieces of wood or bone loosely tied to allow the objective piece to be inserted between them and the lashings serve as a fulcrum when the opposite ends of the wooden or bone staves are spread. After the objective piece is made secure in the scissor-like clamp, the objective piece is rested on a stone or bone anvil with the objective piece extending beyond the anvil to permit the blade to clear the anvil. The knees are then placed on the holding devise to secure both clamp and the objective piece, which in this case is either a core or a flake intended to be a burin core. A platform is prepared on either the core or the flake to prevent the pressure tool from slipping as the outward pressure is applied. The tip of the pressure tool is then placed directly over a ridge previously prepared to guide the blade, and in from the leading edge far enough to avoid its crushing and at such a distance that will control the thickness of the blade. This depends on the requisites of the maker. The right arm and shoulder then applies the downward pressure and the left hand pulls slowly outward until the blade is removed from the core. Should the knapper desire a burin blade with a hinge fracture at its distal end then the downward pressure is decreased to a degree that will not permit the blade to travel to the distal end of the burin core and the outward pressure is applied. It appears that two types of burin blades were useful; one with a sharp termination or at least modified by flaking its distal end until it was sharp and the other style that has a hinge fracture at its termination, a most useful tool for bone working. Repeated hinge fractures require considerable control on the part of the knapper to regulate the proper downward and outward pressures, yet there are many burin cores that bear evidence the technique was repeated many times on the same core. Another type of burin blade is made on the margin of a blade using the sharp edge of the blade to make this scapel like tool. The back of this type of a burin blade is lunate with the curved surface at right angle to the sides. The cutting edge is flat and opposite the curved back. The burin blade make on a blade is a superb cutting implement. The burin blade using the margin of the blade is in reality a very specialized flake and has little resemblance of the normal concept of a blade, yet its technique of manufacturing is much the same as that used in blademaking. The core too has little resemblance of the common concept of a core, Having only one flake removed from one to four margins, usually only one margin was used. In section it is a very steep triangle with its apex being the cutting edge. The technique being the same as a normal burin except that the downward and outward pressures are exerted simultaneously with the downward pressure controlling the length. The blade is first trucated to make a platform surface to apply the pressure tool. I have found that if the burin blade is to terminate in a hinge fracture it helps to have the rest directly under the downward force. The burin blades are usually rectangular in section with the exception of the first which will generally be triangulate. Blades removed from the polyhedral core will be either trapozoidal or triangulate and at their proximal ends some technological traits show that the overhang or lip left by previously removed flakes was left intact while others removed the overhang left by the bulb of pressure, which appears to be a cultural difference or preference. Those that removed the overhang to help isolate the platform area made cores of slightly better quality. (Charles Borden and J. L. Giddings)

Further comments on the technique of manufacturing are to be considered. Some may be apprehensive regarding the pressure method used as a means of removing burin blades and blades from micro cores. The area to be fractured is most certainly not beyond the limits of pressure flaking, yet most still cling to the phrase that they were struck or calling the burin blade a spall which indicates that it was removed by a spalling hammer (stone mason's hammer for rough dressing stone). Direct percussion is used to preform the core but the platform preparation on both burin cores and micro cores show that pressure was used. The actual detachment of the blades requires considerably more accuracy than can be had by direct percussion. From the results of numerous experiments, conclusions drawn would lead one to believe that the majority of microblades and burin blades were pressed off.

When the burin core is used to perform a function it is necessary to have a sharp cutting edge at the intersection of the platform surface and the lateral margin of the core. When striking on anvil No. (9) using the hammerstone free hand No. (10) or indirect percussion with rest No. (24) will cause the cutting edge to be bruised and rendered unfit for cutting, however these techniques are useful for the burin core preparation.

No. (30) PRESSURE WITH SHORT CRUTCH

The use of pressure with a short crutch permits the user to put forth more pressure than any hand holding technique. The objective piece may be held in either the hand or a holding device. The short crutch is made by affixing a cross piece to a short staff about sixteen inches long or to the comfort of the worker. The crutch can be used either on the chest or rested against the shoulder. The artifact held in the hand can be bifacially flaked by the use of shoulder crutch, the left hand holds the objective piece in the palm with the thumb extended and the fingers stabilize without the application of great pressure. The edge opposite that being worked on rests edgewise at the base of the fingers. Such a position permits the strength of the left hand and arm to oppose the pressure of the right shoulder with out unduly tiring the fingers of the left hand. The left hand is also assisted by the support of the thigh of the left leg. The necessary platforms are prepared either individually or the entire margin of the leading edge by grinding or micro flaking. The pressure tool is positioned in line with the ridge of the proposed flake if it is to be of the parallel style of flaking or a flat surface is chosen if the flakes are to be expanding. The style of flaking being determined by habit or the proposed function the artifact is to perform. This technique is useful for making large bifacial artifacts such as knives, lance points or spears, but slightly cumbersome for small projectile points.

The technique is to firmly seat the tip of the pressure tool on the prepared platform near the proximal end and then by pulling with the left hand and pushing with the right shoulder with force adequate to remove the flake, however, the flake will not part from the artifact until the right hand presses towards the wrist of the left hand and the left hand will turn the artifact by slightly straightening the left wrist. These motions are done slowly until the flake parts from the artifact. Also increased padding is needed to protect the left hand. Generally the pressure is applied at right angles to the long axis which causes the flakes to be removed collaterally rather than diagonally. The angle of the flaking is dependent on the habits and rhythms of the worker and the manner in which he is accustomed to holding the objective piece.

The short crutch is also an ideal pressure tool for making micro blades and burin blades. In order to use the short crutch, the objective piece must be secured by a holding device and the worker positioned kneeling over the core. The shoulder is used to bestow the downward pressure first while the hands press outward until the blade is removed. As the blade is being removed, its path must be unobstructed to prevent breakage. The platforms on the core must be prepared in order to provide the proper seating of the pressure tool to prevent the pressure tool from slipping and crushing the leading edge. The character and the angle of the proximal end of the blade will indicate the type of platform preparation and the type of core that was used if the core is missing. The crushing of the leading edges of the core is the usual cause for abandonment rather than core exhaustion. Also if the blade is broken before it is entirely removed from the face of the core will be cause to abandon the core before it can be entirely utilized.

I can site no reference in literature of any observers noting that the short crutch was used aboriginally. The shape of some of the composite pressure tools used in the Arctic does however suggest the use of this implement, and because of the nature of the material used to make a crutch (probably wood) the ravages of time limits the possibilities of finding such an instrument intact. The same situation also probably eliminates the finding of clamps and holding devices. I have found this implement most useful for conducting experiments that appear to replicate certain aboriginal techniques.

(32) PRESSURE WITH LONG CRUTCH

The use of this technique has been previously described in a separate paper, Polyhedral cores of Mexico. However, other experiments have been made to employ the use of this flaking device to make large bifacial artifacts. The results have not been too impressive because of the method of holding. The biface cannot be secured in a holding devise in the same manner as the Polyhedral core and because of the length of the pressure tool the flakes cannot be curved over the face of the artifact. The method is not to be abandoned and needs additional experimentation. An answer may be the use of wooden pegs driven into a log to support the artifact and the preformed artifact be flat and thin rather than biconvex. Several experiments have been conducted with the long crutch and a combination of pressure and percussion. To perform this technique a second person is needed to apply the percussion while the one induces both downward and outward pressure. The crutch can be used with a cross piece for resting against the chest and with a crotch or projection fairly close to the tip of the pressure tool to receive the blow delivered in conjuction with the pressure. Or the pressure tool can be used without the projection in a similar manner if the staff of the crutch is lengthened and held so that it protrudes back of the right shoulder so that the second person can deliver the blow directly in line with the shaft. It is most important that the forces be coordinated perfectly to remove a blade. Blades of considerably larger than those using pressure alone may be removed. The intensity and type of blow must be delivered by a person familiar with the amount of energy required to detach a blade of given dimension in combination with the applied pressure.

Only a few experiments have been done using this technique because of the shortage of massive material of good quality and an assistant with a knowledge of stone flaking. The first experiment was done in 1940 with the aid of H. Holmes Ellis at Columbus, Ohio using Harrison Co. Indiana flint. We used a percussion prepared core which was placed in a hole in the ground with about a half-inch of the top exposed, so that a foot could be placed on its top to hold it firmly. The hole in the ground was then elongated to provide clearance for the blades to prevent their breakage. The pressure tool used was one with a straight shaft and the blow delivered at the end opposite the pressure tip. The results were encouraging, but the blade lacked the uniformity desired. This was due, I find now to improper core preparation and coordination of the forces. Since the initial experiment and bystudy of the behavior of flint -like materials recent experiments with my colleague Gene Titmus, we have been able to remove blades twelve inches in length and two inches in width, using obsidian for the material by the use of this technique. There is still need for additional experiments because of some paradoxical results caused by improper support and the use of silicious materials instead of obsidian.

(33) PRESSURE (NOTCHED TOOL)

The use of the notched tool as a pressure implement is only useful for removing short flakes because the fulcrum is only the distance the notch is deep and the length of the flake cannot exceed this distance. The notched tool is much the same as the set of indentations on a glaziers glass cutter. It is useful for material with parallel sides and since most artifacts are convex on at least one surface the tool will slip before a flake may be detached. Plate glass or sawed slabs may be roughly shaped by a notching tool. Metal or antler is better than bone because of its additional strength.

(34) PRESSURE WITH LEVER AND FULCRUM

This device was made from a seven foot bar of hickory wood with a heavy duty strap hinge affixed to one end and a slot made in the center of the shaft to insert a copper bar and then drilled and a bolt inserted so that the copper bar could be moved with the long axis of the shaft. The hinge was then made secure against a six by six upright timber also well secured. Sash cord and pulleys were then used to manipulate the wooden bar vertically, a loop was made for the foot to involk the pressure. A clamp held the objective piece allowing the use of both hands to move the copper bar towards the operator to provide the outward pressure. The slot in the wooden bar was six inches from the hinge making it simple to calculate the ratio of force necessary to remove a blade of a given dimension. With this device the experimenter by the use of weights and scales can formulate the amount of downward force, the amount of outward force and measure the plane of fracture. It can also be used to show the differences in the amount of applied force necessary to cause fracture in materials of different textures. Some testing has been done but final conclusions are still to be evaluated. It is doubtful such a device was used aboriginally. The device is only to determine the consistency of flake character under controlled conditions and then relate them to problems that confronted the experimenter and the aboriginal.

(35) PRESSURE WITH FIXED PRESSURE TOOL

A method of removing flakes from the objective piece by holding the piece between the thumbs and both forefingers and pressing the lateral edge on an antler tine set at an angle in a wooden socket. The socket may be drilled into a log with the tine firmly affixed and slanting towards the worker sitting astride the log. The pressure is applied on a prepared platform on the edge of the proposed artifact. Both hands holding the objective piece press first forward and then downward to detach the flake. The flake is removed from the top of the artifact rather than downward and is removed between the thumbs, they being separated to allow clearance for the flake as it is removed. The use of this technique has a serious drawback and that as the flakes fly directly towards the knappers face and could easily cause blindness if the worker is not properly protected. Another disadvantage is that the work is being done on the lateral margin opposite that of the worker, making it difficult to place the platform on the antler tip with accuracy. The experiments in using this technique have been limited because of thumb exhaustion. The technique does, however, have merit because the flakes can be removed without any obstruction and the ridges may be aligned with accuracy. The fixed pressure tool inhibits the movement of the pressure tool and, therefore, it is difficult to cause a flake to curve over the median line of the long axis ~~of the long axis~~ of the artifact. The flakes are flatter than when the pressure tool is held in the right hand. The tip of a projectile point is difficult to make using the fixed pressure tool. To my knowledge there is little reference of this technique being used aboriginally, so intensive experimentation was limited to testing this method of flaking. It was tried briefly for unifacial notching and serrating, being a quick means of making denticulate edges when the edge of the pressure tool has been shaped that it has a sharp leading edge. When the artifact is turned over to deepen the notches wedging occurs and the dentates are broken often, perhaps continued practice would overcome this drawback.

(36) PRESSURE ON ANVIL

This technique is probably the simplest of all techniques of pressure flaking. It can be used with some diversity from the making of a very simple projectile point, scraper graver, perforator or simply turning the edge for platform preparation. The anvil can have a wide range of sizes depending on what is to be accomplished. A small waterworn pebble of medium hardness is held in the right hand and on the second joint of the first finger with the hand partly clenched. The thumb holds the flake or blade against the pebble while the left hand holds the balance of the blade between the first finger and the thumb. The right thumb then presses the flake against the pebble while the right hand turns the objective piece. The flaking is started at one end of the flake to be modified and then as each flake is removed there is left a slight projection to be used as a platform for each successive flake to be removed. A flake that is flat and of the correct thickness may be transformed into a rough projectile point in a few minutes. There is no need for a pad or pointed pressure tool. A thin pebble or flake may also be used for notching the base and is done by using the same technique. The lateral margins as well as the flaking is alternated to make the artifact regular in form. The flaking surface of the projectile point in this manner will not have sharp edges and the flakes will be short and irregular. This technique may be used while standing or walking and if the tip of a projectile is broken it may be repointed by the hunter as he still persues the quarry. Flakes and blades used as cutting implements indicate that this method of backing was used to prevent injury to the hand while using the sharp flake. Many aboriginal flakes have the one edge modified by the use of this technique that can be easily mistaken for use flakes while in reality the opposite side of the flake was the one that was used and the flake or blade was merely dulled to prevent injury to the user. It is a technique that can be done hurriedly with little effort and a minimum amount of equipment the anvil-like pressure tool may be picked up most anywhere. I find that the pebble is a most useful pressure tool for turning the edges before more refined retouch with a pointed pressure tool. The edges are apt to be dulled as it is most difficult to keep the pebble from contacting the sharp edge as the flake parts from the artifact. The pressure tool or anvil does not necessarily need to be a pebble. It may be of any material hard enough to remove a flake even hard wood. The wood will not crush the edges as readily as stone and antler horn and bone are quite satisfactory. The same technique may be employed to turn edges but the anvil is placed on the thigh or on the ground and the artifact is held in the two hands while applying pressure. One cannot expect the control using the large anvil as when the objective piece and the anvil are held in the hands.

(37) IMPLEMENT USED TO DETACH THE FLAKE

The device used to cause a plane of fracture in materials with isotrophic qualities. The tools used to produce fracture by impact (force, mass, motion, and inertia) are called percussion tools or percussors. The implements used by gradually increasing force with the minimum amount of motion to a mass of isotrophic material that is caused to become stationary. The material is compressed to the point of fracture. The implement is a pressure tool or a compressor. There are two different means of applying force indirectly. One is the technique previously described in No. 32 (the use of the long crutch) which is a combination of both pressure and percussion when a blow is delivered to the crutch. The staff of the crutch is used to transmit the percussive force to the objective piece being already assisted by the application of pressure. The tool could be called a compressor percussor. The other is the indirect tool used to transmit only percussive force to the objective piece. In order to fully comprehend the magnitude of the lithic industries and the tools used to fabricate artifacts from the most minute to the massive requires tools for removing micro-flakes to giant spalls and quarrying operations. Therefore, the size of the percussors will have great range. The tool size may be reduced by increasing the velocity of the percussor. Force is simply an effort exerted by or upon bodies at any instant. In order explain the perplexities of the type of blow when using a percussor and the stability or instability of the objective piece. In order to induce fracture the wielder of the hammerstone may not be conscious of the physical happenings but only in the desired results. A common problem in physics will help to illustrate the variables that confront the stone knapper. If a block of flint is struck by a hammer weighing 20 pounds with a velocity of 30 feet per second, what is the force of the blow? What happens when the velocity is increased or decreased? What happens if the objective piece moves with the blow and what happens when the hammerstone is smaller than 20 pounds? A simple formula is the mass is M pounds weight divided by 32. Then the momentum would be 20/32 X 30, or 18 and 3/4 units, and if this is to be destroyed (the hammerstone stopped) in 1/100 of a second, the average force against the flint would be 18 and 3/4 divided by 1/100 or 1,875 pounds. But if the hammerstone had struck the flint placed in sand and was stopped in 1/5 of a second sirc e the force was in effect twenty times as long, it was only one-twentieth as great or less than 100 pounds. By the same token a two and a half pound hammerstone traveling at 30 f.p.s. and stopped in 1/100 of a second would only have 84 pounds of force, and a one pound hammer around thirty-three pounds. One can readily see that any changes in the velocity, the weight of the hammerstone or the type of support can greatly alter the effect of the percussor on the objective piece. A hammerstone larger than the objective piece will cause the piece to be projected with and in the same direction that corresponding with the trajectory of the percussor. Also to be considered is the center of gravity of the percussor as a glancing blow will not deliver the entire force potential. Experiments in using the hammerstone will soon cause one to realize how many variables confront the knapper. Indirect percussion tools are usually thought of as a cylinder or a punch like object used to transmit force from the percussor to the objective piece.

Implements used for pressure flaking are generally hand held and used to apply force directly to the objective piece by the gradual application of pressure in two directions, generally inward and outward. Details are furnished in tool paper.

The use of certain stone working tools may be identified by examining flake assemblages and repetitious flake scars. The percussion technique rather than pressure indicate that percussors with certain qualities will cause flakes that may be related to specific implements. The more resilient the percussor the longer the interval of contact between the percussor and the objective piece. Such an interval permits a more gradual application of force and reduces the amount of compression on the objective piece. Similar flakes and flake scars can result from the use of both a polished pebble of agate and the ball part of the ball part of a ball pein hammer if they are used with equal velocity and all other conditions were the same. The other conditions are the same trajectory or path of flight of the percussor, the same platform angle and preparation, the same distance from the leading edge and the surface of the objective piece the same. The flakes will then be the same with the platform showing a part of the cone truncation that corresponds with the area contacted by the hammer or hard stone percussor. There will be accentuated compression rings with their prominence increasing as the flake becomes thinner. An implement of wood will not cause the cone to be truncated and in some cases crushed because of the nature of the wood. The type of work that is being done is to be considered, whether it be blade making or making a biface. The proximal end of the flake will penetrate a soft percussor and will be pulled from the artifact causing the bulbar part to have a distinctive lip and a diffused bulb of applied force. The part of the proximal end of the flake contacting the soft tool will be greater than with the hard hammerstone. The degree of resiliency is variable in the percussors, minerals for hammerstones, Antler, bone, shell, horn, and woods of different hardness. Each will produce characteristics that will blend from one to the other depending on its structure.

Predominance of characteristics in flake assemblages will indicate that certain tool types were used to perform certain techniques of flake and blade removal. The exact material used for the percussor may be questioned but its relative hardness or softness will be indicated by an examination of the debitage. See H. Mewhinney, Vol. 30, No. 2, part 1 A skeptic views the billet flake. I'm afraid Mewhinney failed to replicate each flake by the use of different percussors. Before one makes final conclusions the conditions in which the flakes were removed must be the same, the dorsal surfaces the same, and the area of the ventral surface, the platform part the same and the termination of the flake the same.

The flakes must be designed for the same purpose, such as flakes to be made into projectile points, flakes made by thinning a biface, or specialized flakes such as blades. Flake types fall into certain categories depending on what stage or phase of stone tool production they were made. There are flakes that are typical to certain techniques and there are those that are aberrant forms and one must judge accordingly. Flakes removed when a platform surface is being prepared or the form of the artifact is altered to make it more symmetrical have little diagnostic value because of the random nature in which the flakes are removed. The flakes segregated from flake assemblages must have attribute characteristics that will separate them from others with different characteristics before they may be related to tools and technological traits. Upon separation from the chipping debitage the groups of flakes selected must have certain similarities even though they have slight variations. The platform angle should be consistent to its relation to the longitudinal axis. The preparation of the platform is grinding, polishing, relieving, and isolation of the platform. The width of the platform or the distance from the leading edge to the point of impact governs the thickness. The curvature of the flake, the undulations or the compression rings, the flakes dimensions such as length, width, and thickness --- The termination of both margins and distal end. These are but a few of the aspects to be considered that are common to most flake assemblages.

The flakes removed by indirect percussion is difficult to relate to the tool material because the force is transmitted to the objective piece by the use of an intermediate tool. Sharp lines of demarcation make it difficult to separate a well controlled percussion technique and the use of the indirect tool. The use of the punch indirectly does however permit the knapper to achieve superior control in placing the punch with great accuracy and also is an aid in calculating both the vertical and the angle that the punch is struck. Flakes that have platforms that are consistently smaller than one-eighth of an inch in area will indicate that an intermediate tool was used. At the present time the writer feels that no amount of human skill could be developed to remove flakes consistently by the use of simple direct percussion. The flakes removed by the use of indirect percussion are generally with well prepared platforms, sometimes being isolated and not uncommonly ground. The flakes are considerably flatter with edges that have no margin or in other words feathered. The flakes ventral surface is parallel to the working face of the core or the objective artifact. The bulbs of applied force are generally diffused and the ventral side of the flake has little or no compression rings because the shock is eliminated by the use of the intermediate tool and the blow delivered with a reduced velocity.

The implements used to remove flakes by pressure are difficult to identify from either the flakes or the flake scars. There are, however, a few characteristics that should be noted. The amount of pressure that may be used to detach flakes is limited unless a lever used with a fulcrum or the chest crutch is employed. Flakes in excess of a half-inch in width, not length, will be a rarity in most aboriginal sites as such a technique is commonly used to refine and sharpen artifacts made by employing the percussion method. Blades and micro blades as well as pressure made burins and other exotics are an exception rather than the rule. The use of pressure permits the worker to accurately remove flakes with precision and at the same time leave razor sharp edges to serve as superb cutting, scraping, and perforation implements. The artifact can be made more regular and symmetrical as well as being serrated and notched for hafting purposes than by the use of percussion. Repetitious flakes removed along a margin can have much diagnostic value because a population of like flakes may then be studied to interpret the tool used to remove them and the technique. Flake series such as these may then be related to the type or character of the artifact, and then in turn be related to a functional analysis of the flaked stone tool. (George C.F. Frison, A Functional Analysis of Chipped Stone Tools, University of Michigan, Ann Arbor, May, 1967) Frison has reassembled flakes of similar characteristics and materials and reconstructed the margins of artifact edges even though the artifact was not found. The flake study revealed techniques that were unique and undiscovered until this study was done with aboriginal material. The remodification of artifacts was noted and concentration of certain industries were noted. The flakes showed a rhythm that was almost mechanical being spaced with exactness and precision with their platforms being designed to indicate that a pressure tool with a broad flat tip was used to remove them as the contact surface of the platform was as wide as the tip of the pressure tool. This caused the resultant flakes to have bulbar parts almost completely diffused and the pressure being disseminated the width of the tool. (Personal Observation).

The techniques of applying pressure are both traditional and individual there being numerous methods of holding both pressure tool and artifact as well as techniques of applying pressure. The different amounts of both inward and downward pressures the spacing of the flakes and the nature of the tool tips all result in flakes that have distinctive qualities that may be identified as diagnostic traits. Both artifacts and flakes must be appraised individually, then grouped into categories that indicate technological traits to see if the same patterns to show a continuum in both time and space. Individual and traditional traits characterized by single sets of components yet not sufficient to create a complex until additional information is made available on other components exhibiting similar diagnostic technological traits.

The material in which the pressure tools are made will always be a matter of conjecture unless there is a direct association of the tool kit and the artifacts. However, it is entirely possible by a study of pressure flakes to form conclusions with some degree of accuracy the type of a tip on the part of the pressure tool contacting the artifact as the flake is being removed. A very pointed tip of the pressure tool will cause the pressure to be confined to a limited area, it being the apex of the cone or the beginning of the bulb of pressure and will cause the bulb to be salient. On the other hand a broad pressure tip will distribute the pressure and will cause the apex of the cone to be elongated and cause the beginning of the bulb of pressure to be diffused. Should the point of contact with the margin of the objective piece be broad, then there is little or no definition of the bulb. The width of the pressure tool contact may be determined by measuring the truncated part of the cone. Such is true when determining the contact zone or platforms of flakes removed by either direct or indirect percussion and the nature of the hammerstone or percussor. It should be noted that certain percussion techniques cause the platform surface to collapse. Such flakes and blades render the flakes and blades as far as being able to relate them to the type of tool used for their detachment. The absence of the platforms is usually the result of a glancing blow delivered near the margin at a steep angle.

The examination of flake assemblages will disclose enigmatic groups of flakes that will be difficult to relate to any certain tool types but will indicate that techniques were used that caused the platform part to be shattered as the flake was removed, such a technique would still be useful for indicating a particular trait.

(38) SIZE AND WEIGHT OF FLAKE

The size and weight of the flake or blade is useful in determining what stage or phase of the artifacts development from raw material to the completed implement. The size and weight is also indicative of what tools were used to produce flakes of variable sizes. The size of the flake would ordinarily suggest that the weight would be comparable but thin flakes would have greater area than those that are thick and massive in relation to their plane of fracture. Massive flakes may be associated with the natural occurrence of the material to be used as artifacts, such as quarries and alluvial deposits. Such large flakes suggest the use of direct percussion with the aid of a hammerstone, hafted or unhafted. The flakes will have well defined bulbs of percussion with the point of impact inward from the leading edge in various degrees.

Flakes that result from reducing the raw material into workable forms will be quite random by nature of the task at hand because platforms and angles must be created to receive the blow of the hammerstone at the correct angle. The flakes that result from platform preparation are usually short and thick and because the conditions of surfaces that are generally most irregular the flakes will also lack uniformity except the manner in which the blow was struck causing the platform area to be similar. The debris that results from such an operation will be characterized by rejected flakes that lack homogeneity and are aberrant in form. Also will be exhausted cores that have been distorted and bruised from miscalculations of the knapper and beyond recovery. A source industry yields an assortment of sizes and weights of flakes with similar platform surfaces and a general lack of refined flaking. Pressure flakes are usually absent.

The size of the artifact produced will govern the size of the flakes and the stage of making. As the artifact nears completion the flakes will normally be reduced in both size and weight. The thinning flakes that result from a large biface will be much lighter in relation to their plane of fracture because of their thinness and expansion from the point of applied force. The size and weight of pressure flakes will be limited because of the amount of force a person can exert. The exact limitations of strength of the human animal is unknown, but he is restricted without the aid of levers or mechanical devices to aid him. The quality and kind of materials also will limit the size and weight of flakes that may be detached by the use of simple hand held pressure. Unfortunately, flakes removed by hand held pressure technique are usually broken during removal because of the supporting pad held in the left hand. Pressure flakes can be removed in their entirety if clearance is provided between the artifact and the protective pad. Quanities of pressure flakes found unbroken will indicate that a special technique was used to preserve the flakes for further utilization as small cutting implements. Also because of the curvature of the pressure flakes made by retouching an artifact they are easily broken if they are stepped on. The proximal ends of the pressure flakes will usually suffice in denoting a technique and their mode of detachment. Generally the width of hand held pressure flakes are less than one-half inch and the retouch flakes on a projectile point much less. Their small size limits , recovery with the common screening methods, and full recovery would probably require special recovery techniques. Exceptions are pressure flakes removed by methods other than hand holding are those of making blades by pressure to be used as cutting tools. Examples of pressure blades are those from the Arctic, Valley of Mexico, (Jose Louis Lorenzo) and the Hopewell (Raymond Baby). There are many other examples though not quite so well known and without the refinement of the examples mentioned. One of the most diminutive is the burin blade which is difficult to recover. (James Giddings, William Irving, and Charles Borden) Blades removed by percussion and indirect percussion will be greater in size and weight than those removed by pressure ordinarily. Obsidian blades from Colima, Mexico and those from Guatamala are notable for their large size and weight and are larger than many removed by the percussion technique. The size and weight of flakes and blades are to be considered to denote techniques and the implements used to remove them from a core.

(39) PRIMARY AND SECONDARY FLAKES

The primary flakes can be considered as those detached initially from quarry operations or from large cobbles and nodules and commonly retain some of the original surface on the exterior of the flake, such as natural planes of fracture, cortex, or the bruised exterior common with cobble and boulder forms. The cortex is common with the flint and chert nodular forms being the partly silicified or heavily weathered surfaces. The primary flakes are usually removed by the use of heavy direct percussion tools with the points of impact in from the leading edge approximately the thickness of the flake. The bulbs of percussion usually show good definition and are salient. The exception is those removed by the bipolar technique which have little or no bulbs. The first primary flake will be entirely covered with the natural surface on the dorsal side. The second primary flake will have a portion of the first flake scar usually being divided along a median line from the proximal to the distal end on the dorsal side of the flake. Should the first primary flake be removed to prepare a platform for a core and cause a flat surface that will serve as a platform for the removal of additional flakes or blades, then the second flake will be the one covered with the natural surface. The flakes are then removed from the entire perimeter if the objective piece is to be used as a core for making blades or flakes. The first series of primary flakes are recovered by certain aboriginal people to be used as knives and saws depending on the texture of the material. The natural cortex is used as a backing because of its smoothness is comfortable for the user. The backed knives and saws appear to be designed for this particular function. Should the raw material be used for a biface and the core method be used instead of using a primary or secondary flake, then the entire natural surface of the objective piece is removed and all of the exterior surface will be reduced to primary flakes. The primary flakes are often abandon unless they contain usable material that may be used for diversified artifacts and commonly being scrapers rather than projectile points. The exterior surface is commonly flawed or covered with a rind that will not flake because of its softness or bruises. The primary flakes are useful in determining the sources of the material. Cobbles indicate the secondary source was from alluvium while primary deposits of the silicious material may still retain some of the matrix in which the material was formed. The cortex on flint and chert may contain some limestone or diatomite that would be identifiable.

The term spall is used for any large flake and was derived from modern quarrying operations for securing building stone. The blocks from the quarry were trimmed by the use of a spalling hammer. The resultant flakes were called spalls. Both large primary and secondary flakes could fall in this class but a separation by using the terms primary and secondary flakes would be useful if one has an interest in technology.

Secondary flakes are those removed after the exterior of the objective piece are removed. Should the secondary flake be specialized to form a blade, then the dorsal side of the blade will bear two or more longitudinal scars originating at the proximal end of the blade to form one or more parallel ridges. A secondary flake may have flake scars on the dorsal side that are transverse, oblique, collateral, longitudinal, and be of a random nature depending on the exterior surface prior to striking off the flake. If it was removed by percussion, the same is true if removed by pressure. Debitage and debris that results from the flaked stone industries that accumulates at some distance from the source of raw material will have a predominance of secondary flakes in the remains. The trimming, thinning, and sharpening flakes removed by percussion are quite common while the pressure retouch flakes because of their size are easily lost unless means of special recovery are used. The pressure retouch flakes do not account for mass or weight, but only in number. From the results of experiments the pressure retouch flakes could be further separated for technological studies as is a common practice to first remove any irregularities from a preform by the use of pressure, then one or two and sometimes three series of flakes are removed from the entire surface of the artifact. The purpose is to make a very regular surface in order to remove all flakes from one margin, or to accomplish the various styles of precision flaking. The dorsal surface of flakes removed after the first series of pressure work will naturally bear the scars of the previous pressure flaking. (See examples of the primary and secondary flakes, detached by both pressure and percussion.)

(40) FLAKES WITH PRONOUNCED UNDULATIONS AND WAVES

Flakes that bear accentuated undulations waves and concentric rings of force show that materials with isotrophic qualities received force in the form of a blow induced in such a manner that shock was caused and the material compressed along its plane of fracture. The waves when extended will for concentric rings around the point of applied force causing an effect much the same as dropping a pebble into still water. The greater the velocity of the percussor and the hardness of the percussor causes the waves to be magnified and accentuated. There are several factors that are involved besides the velocity of the percussor and the material used for a percussor others are the texture of the material and the relative thickness of the flake. It might be of interest to note that at the obsidian quarry in Glass Buttes, Oregon, the surface is littered with rejected obsidian in the form of broken artifacts, flakes, partly exhausted cores and material tested and found to be inferior. The site was occupied aboriginally and now almost continually occupied by the rock hounds and mineral collectors. The obsidian broken aboriginally and that fractured in recent times is very simple to identify because of the fractures made by rock hammers and mauls used by the recent collectors. The metalic hammers have caused shattering and a predominance of flakes bearing the accentuated concentric rings while those made aboriginally are relatively smooth showing that the flakes were pulled from a core with limited velocity and the use of a soft hammerstone. Flakes that have been removed from a core with pre-established ridges will not have the undulations of a thin flat flake. The spine on the dorsal side of the flake stiffens the flake and eliminates a great deal of the bending. The same is true when a thick flake is removed from a core, excessive compression is prevented. The waves provide a clue to the technique, the type of percussor and the velocity of the blow. Waves are sometimes found in some materials that have planes of weakness that will cause the flake to undulate. Such materials are those silicified sediments with varves, those with differences in crystallography, the flow structer in some volcanic glasses, and planes of weakness due the crystal structer as in quartz crystal.

The material used for the artifact is to be considered when making an appraisal of the undulations of flakes, the course granular textured material appears to dampen the formation of the waves as the force is not transmitted from one granule to the next thereby reducing the shock producing waves of force. The waves become larger and further apart as the distance from the point of applied force is increased and the energy is dissipated.

(42) THE ANGLE OF THE PLATFORM IN RELATION TO THE LONGITUDINAL MEDIAN AXIS

The study of platform angles is most useful in determining the type of a core that was used to make the flake or blade. It is necessary to project an imaginary line from the dorsal edge of the platform to the ventral edge in order to visualize the whole platform surface of the core. The flake or blade can then be held with the platform angle corresponding with an imaginary 180 degree line. For an example a flake removed by downward and outward pressure from the corner of a rectangular core would have a platform angle that would be 180 degrees in relation to the longitudinal axis, it being 90 degrees. Another aboriginal example is the polyhedral cores from Meso-America that result from making the pressure blades.

The principle of the cone is involved in the design of the core prior to the removal of flakes and blades. Assuming and from conclusions reached from the bases of experiments in cone behavior the angles of the cone remain fairly constant. The core must then be designed in such a way that the plane of fracture of the cone will correspond with the flake or blade. When direct percussion or indirect percussion is used the force must be directed at an angle corresponding to the angle of the cone and the core must be prepared with a platform corresponding to the style and for the flake or blade desired. Before mentioned was the rectangular core with a blade removed by the application of both downward and outward pressure. On the other hand, if the applied force was accomplished vertical or at 90 degrees to the 180 degree platform, the resultant flake will be one quarter of a cone and from the truncated part of the cone the flake would expand as the forces radiate and cause the flake to be thick and expanding at its distal end and generally of no functional value. If all corners were then removed from the four sides, the core would then start to resemble a polyhedral core. Then if the force was applied in the same manner as flakes or blades were removed the angles of the flakes on the platform area would remain the same and the core would be polyhedral or faeted (?) cylinder. Such illustrates only one technique which could be a technological trait. There are numerous other core types and methods of flake and blade removal and after the core is prepared in a certain fashion and the flakes removed using the same tools and the same technique the angles of the platforms will correspond to the long axis.

The varients in the platform angles have a direct bearing on the technique used. A conical core will have a platform angle that will be approximately 70 degrees when the flake or blade is removed by direct percussion when the percussionary force is applied at a 90 degree angle to the face of the core. The anterior surface of the core can be designed in a multitude of forms to receive the force necessary to remove a blade or flake. The style and forms of cores range from the most rudimentary to very complex and, of course, the more refined cores will have a greater uniformity of flakes and blades bearing platform angles that will also be uniform. Some residual cores show that the lithic material received percussionary force that was random in nature and the flakes were removed on any surface that presented an angle that could be used as a platform. Flake debris made by the use of indiscriminate blows of the hammerstone on the objective piece are distinctive only because of their random nature and each flake would be variable in both platform angle and form. Such informal flaking results in core residue that is gobular and usually reduced in size until no additional flakes may be removed that could serve a functional purpose or the surface has been crushed from repeated blows until no further flake s may be removed.

Recent examination of flake debitage at Field Schools conducted by University of Arizona at the Grasshopper site, Dr. William Longacre, Director and also Field Museum of Chicago at Vernon, Arizona, Dr. Paul Martin, Director allowed the direct application of selecting of flakes with like platform angles and then examining the groups of flakes having similar platform angles. The flake s automatically showed a similarity of form and also a similarity of techniques used to remove the flakes. Also of interest were the flakes that showed little or no platform or measurable platform angle and were without the usual bulbs of force that showed that a special technique was used to remove the flake. The flakes selected that had these features were without exception covered with the exterior surface characteristics of pebbles and cobbles and that from experiments done by the writer that they were removed by severing one end of the pebble by the use of the anvil technique that causes the cone of applied force to be severed causing the elimination of the bulb of force. The technique is to place the pebble on an anvil stone and then striking the pebble in such a fashion that the anvil will cause the objective piece to become inert while the force imparted by the hammerstone will cause the cone and the end of the pebble to become severed. Such a fracture is easily recognized after the examination of a few of the flakes removed by the use of the described technique. Such flakes were found only at Vernon and none were observed at Grasshopper. Edwin Wilmson is now in the process of surveying lithic material from Paleo-indian sites using the computer analysis system to make an investiagation of the flake forms and the angles of the platforms,(Personal communication A.A.A. Ann Arbor, 1967) The results promise to be rewarding. There are, however, many other features to be considered besides just the platform angle. The angle of the platform is often impossible to measure because of the technique used and the flake being incomplete. An example of a complete flake with a platform that is unmeasurable is one that has been isolated and ground such as a channel flake or the flakes removed from the edge of a biface for thinning purposes.

(43) WIDTH OF PLATFORM SURFACE

The width of the platform surface depends on two factors one is the amount of platform surface contacted by the percussor and the other is the distance from the leading edge that the force was imparted. The first is useful in determining the type of instrument used to apply the force. If direct percussion was used to remove the flake or blade the contact surface of the percussor will be the truncated cone part or the area that contacted the hammerstone, hard round hammerstones will limit the area of contact while a soft hammerstone will contact a greater area and cause the truncated cone part to be of greater area. By the same token a billet of wood will show little or no definition of the cone or its truncation. The wood upon impact will allow the leading edge to penetrate and cause the bulb or cone part to be diffused. The amount of diffusion or definition will depend on the nature of the material used as a percussor. The more the percussor conforms to the objective material and the flatter the area between the contact of the percussor and the objective piece the broader the platform and also the softer percussor material will conform more readily than one of greater hardness. The use of the punch as in indirect percussion permits the worker to limit the contact area by isolating the platform as well as accurate placement of the indirect percussion tool. Pressure techniques show the same principles are involved as a pressure tool with a wide tip will contact a greater portion of the material being worked and cause a broader bulb of pressure to be formed than when using a pressure tool with a wide tip will contact a greater portion of the material being worked and cause a broader bulb of pressure to be formed than when using a pressure tool with a narrow tip thus causing a limited bulb of pressure to be formed. The hardness or softness of the pressure tool does not cause any apparent change in the character of the flake or bladelett. The width of the flake platform area may be controlled to a degree by placing the tip of the pressure tool in from the leading edge, and as the flake is removed a greater platform area is also removed. The wider the flake the greater is the pressure necessary to remove the flake causing the width of the flake to be limited to the amount of pressure the worker is able to exert.

The second part of controlling the width of the platform is the distance from the leading edge that the force is applied (mentioned under pressure in previous paragraph). Upon applying direct percussion or indirect percussion the point of contact between the objective piece and the percussor is inward from the leading edge the platform area will spread towards the leading edge causing a platform area to be formed that would be larger than if the force had been applied on or near the leading edge. An example of the use of the technique of striking away from and back from the leading edge is the Levoiseloian flake causing the expansion of the platform area from the point of impact to the dorsal side of the flake. Flakes of this nature are designed on purpose to serve a certain function and are usually removed by the use of a hard hammerstone to concentrate the point of impact.

(44) THICKNESS OF THE PLATFORM SURFACE OR THE DISTANCE FROM THE DORSAL EDGE TO THE VENTRAL EDGE OF THE PLATFORM SURFACE

The thickness of the flake or blade is partly discussed in No. 43 and those factors must be considered. The distance in from the leading edge does, however, cause the flake to be at least as thick as the distance in from the leading edge but the width of the platform area can be controlled by the design of the core or the isolation of the platform area. For example, a core that is very narrow will allow a very narrow thick blade to be removed. The burin blade is a good example of the thickness being equal to the flakes width. The thickness may exceed the width of the flake or blade many times if the flake is severed by the use of the burin technique. A brief description of this technique is that the point of applied force either percussion or pressure is applied at a point back or away from the leading edge the same distance as the desired flake or blade thickness. Should the core be flat on the face to have the flake removed from the flake will expand and the lateral margins will be caused to gradually thin until their termination and the flake will be plane convex and thick in its midsection. A longitudinal ridge or a narrow core will confine the applied force and cause the flake or blade to be of approximately thickness its entire width and length. The complete control depends on the workers ability to prepare conditions on the objective piece and to impart the applied force with the proper intensity to produce a fracture of a predetermined dimension. There are, however, methods of making flakes that will be thicker at the distal end than at the proximal end. Usually such a technique is accomplished by a specially prepared platform, often by grinding to prevent the platform from collapsing, and then a blow with increased velocity is imparted upon the platform which causes a flake or blade to be removed that will be thicker at its distal end than at the proximal end. As the flake is removed from the core the base of the core is removed with the core. These flakes appear throughout the various time horizons and widely separated geographical regions and have been used for a variety of tool types. They are found being designed for a special purpose and made accidentally. Those made by accident commonly occur when the worker is thinning a biface by using a percussion technique rather than the pressure method. The flake removes the opposite lateral margin and the distal end of the flake has bifacial flake scars that cause the flake to resemble a tool of undetermined function while in reality it is a flake that results from the over exuberance of the worker. A similar occurrence is caused when removing blades by both pressure and percussion. These flakes and blades have the distal end of the core at the end opposite that received the force.

Such flakes and blades have a name in French terminology and are called, "Eclat otrepassé," and " Lamelles otrepassées," page 44 in Typologie De L'epipaleololithique du Maghreb, by Jacques Tixier, 1963.

In order to replicate flakes and blades that go over and behind the base of the core one permits the core to rotate with the force whether it be pressure or percussion. As the core turns, the flake will have an accentuated curve and will be concave on its ventral side. Such flakes are well designed to be modified into scrapers with a minimum of retouch. Others removed in the same fashion but from a core that has a flat surface can also be modified into projectile points with ought major preforming as the transverse and distal ends of the flakes are used. These specialized flakes at there terminal parts are flat which is an advantage over using a normal blade which is generally slightly curved. The distal ends are bipointed and sub-triangulate and could be used as they are when the platform part has been removed.

(45) TYPES OF PLATFORM PREPARATION

The platform part of a flake or blade is the key to understanding the flaked stone industries. It is this portion of a flake that determines the behavior of the isotrophic material when subjected to force, whether it be pressure or one of the forms of percussion. The techniques used in fracturing the stone will make themselves apparent when flakes are sorted by separating them according to the likeness of platforms. The platform parts will bear a remnant of the core from which they were removed. From this core remnant, one will be able to reconstruct the type of a core that the flake was removed from. The angle of the platform in relation to the longitudinal axis will show the face of the core. It will also show what pains if any were used to prepare the area that received the force to detach the flake. The platforms will range from the most embryonic to the most meticulous preparation. Examples are the use of the natural surface and the isolation and polishing of the platform. The platforms are selected or made by the worker to receive the type and kind of force necessary to remove the flake or blade. Each fabricating tool and technique require surfaces to be used as platforms. The platforms are designed in a variety of ways in order that flakes and blades may be removed that have certain form and dimension, whether an artifact is being formed or specialized flakes are being removed. Should a specific artifact flake or blade be desired in quantity and each be uniform in size, shape, and of the same character then the platform and other conditions must also be the same. Because the platform is the first consideration in making flakes that will be uniform, they are most useful in proposing technological traits.

The kinds of platform surfaces are the use of the natural surface that presents a facet to receive the force. The platform with facets prepared by flaking, the isolation of platforms, platforms made by artificial grinding, platforms made by polishing, the absence of platforms on completed flakes, the platform crushed and shattered, the orientation of the platform with the longitudinal axis, and the angle of the platform. Following will detail the various aspects of the platform part of the flake.

(46) THE USE OF NATURAL SURFACE FOR THE PLATFORM

Lithic material found in its natural state must be reduced into forms that will lend themselves to stone implement making. In order to reduce the raw material into core tools or simply to make usable flakes and blades the material must be fractured with techniques that will conserve the material and still retain qualities that will make useful artifacts. Our experiments have shown that there definite advantages in using material that still retains its natural cortex. When working flint to make a series of uniform blades, the cortex acts as a cushion to dampen the blow (when using direct percussion). The blow delivered with a hammerstone on the cortex surface reduces the platform shattering. The cortex will yield with the blow because it is the partly silicified rind on the exterior of the nodular forms of this material. The hammerstone is projected at an angle to the surface of the flint and the cortex because of its nature will not permit the hammerstone to glance or ricochet and will transmit the force into the objective piece. The cushioning of the cortex reduces the end shock and by the same token reduces the breakage of the blades or large flakes. Upon using the flint nodule for a core tool the cortex is removed and serves no purpose for that particular type of tool making. The naturally rough and eroded surface of material other than flint reduces the glancing of the percussor. The use of the natural surface on obsidian was used to prevent the pressure crutch from slipping as is in evidence on the platform surfaces of many of the polyhedral cores from Meso-America and also found to furnish a distinct advantage when experimenting with similar techniques because it eliminates individual platform preparation and or artificial grinding.

(47) PLATFORMS WITH PREPARED FACETS

A platform that bears one or more negative flake scars, (often called a facet) is flaked for the purpose of either seating the pressure tool or to form an area to receive the force from a percussor to remove a flake or blade. Each shows the need of uniform preparation to remove a preconceived flake or blade. The preparation of platforms becomes a second nature to one familiar to working flintlike materials. The platforms may be prepared individually or a whole margin may be prepared at one time.

Individual preparation of each platform is usually necessary when making a core tool from a cobble or nodule as each flake is removed from a surface that is deviant from the previous condition and because of the lack of uniformity of the raw material the flakes and platforms will by necessity be variable and each platform will have to conform to the condition. Upon trimming the surplus material from a core tool the worker will usually remove as large a flake as possible without endangering the proposed artifact. When using the core technique the platforms will be variant because the flakes will be directed into the objective piece from around the perimeter of the objective piece. Since the flakes will vary in thickness the point of impact by the percussor will be struck at variable distances from the leading edge causing the platform surface to vary in breadth and thickness. The initial reduction of the nodule to a biface is generally done by the use of a hard hammerstone and will the bulb of percussion to be salient or well defined. Such flakes will usually have but one facet or plane of fracture to be used as a platform. When the preforming is completed and the objective piece is ready for thinning the edge can be beveled on the margins (one of many techniques) and the bevel will be used for the platform surface or the platforms made for each individual flake to be removed for thinning. The thinning flakes will have platforms that will be considerably more uniform than those made when roughing out the preform. Should the material be of a tabular nature such as silicified calys and sediments the natural margins are usually with right angle edges. These must be removed in order to be able to flake the proposed artifact bifacially. This flaking is usually done by the use of direct percussion and a hard hammerstone. After the first flake is removed the flake scar will be used for a platform for the next flake and these flakes will have platforms with a single facet. The objective piece will be turned and the flakes will be removed alternately, in this case a series of flakes will be quite uniform.

Upon using pressure flaking techniques the same methods are used only the flakes are pressed off rather than being struck off. Pressure usually requires more meticulous platform preparation and the preparation must be done with great care, because a platform properly prepared does not require nearly the amount of pressure as unprepared or improperly prepared platform. In contrast by using percussion the worker can usually remove the flake by increasing the velocity of the blow while when using pressure there is a limitation of the workers strength. Pressure flakes removed by preparing each individual platform are usually multifaceted because the worker will remove one or two micro flakes on the margin to remove ridge left by the bulb of pressure and then remove other micro flakes horizontally for the platform surface and the remove of one or two other micro flakes to free the platform.

The platform surface or facet is positioned directly over the ridge left by the previously made flake scar. The amount, number, and size of the micro flakes that were removed from the lateral edge to free the platform will depend on the spacing of the flakes. Should a wide collateral flake be desired then the ridge is not used and the flake will be allowed to expand. The faceting of the platform will depend on what flaking technique is used and the angle of the retouch flakes in relation to the long axis of the artifact. The angle that the retouch flakes are removed from the margins will depend on the thickness of the artifact desired. Some types are quite thick and are diamond shaped in their transverse section such as the Eden as an example while others are thin in section with flat flaking on the surfaces of the blade part. Each technique requires variations of the platform preparation and if not polished or abraided will have characteristic faceting. Projectile points for an example, that are thick will have the platforms faceted in such a manner that they will be isolated and away from the leading edge so that when the flake is removed the bulb of pressure will not remove the lateral edge with the flake, and cause the edge to be quite irregular.

A feature commonly noted is the technique of making small facets on the dorsal side of the flakes near the proximal ends to remove the overhang left from prior flake removal such as preforming and the first pressure forming of the artifact. The removal of the overhang changes the surface from being concave to one that has a slight convexity causing a little more material to support the platform and prevent the flake from collapsing and causing a step fracture. This technique is used for both pressure and percussion. The word facet is not uncommon in archaeological literature and is but a term to denote a fracture plane made by intention or naturally and signifies no direction of the flake scar and is relatively unimportant in denoting any technological differences in the scars and how they were made. It is a term that has meager significance and should be used in the most general way when one is ignoring the features shown in a flake scar. Facet is a good word but it does not mean much.

(48) ISOLATION OF THE PLATFORM

The isolation of a platform is to either put by itself, place apart, or to segregate. The isolation of the platform is used for several reasons. First, to provide a protuberance that may be contacted with greater accuracy when using percussion. Second, the flake can be removed with less force when using either percussion or pressure. Third, the platform may be prepared by the removal of flakes to make the desired angle, ground, or polished. Fourth, the platforms may be spaced at the desired intervals. Fifth, the platforms may be isolated and extended away from the proposed edge to eliminate deep bulbs of force and at the same time reducing the shock to the artifact. The five reasons are further explained as follows:

(1) The accuracy is increased because it is much easier to strike a projection extended in such a way that that part will be contacted by the percussor before it can contact any other part of the objective piece. By the use of this technique one may be able to govern and select the point of impact at the discretion of the knapper. This form of platform isolation may be used for removing flakes, blades, and in forming the artifact. A simple example of the use of platform isolation is the preparing of a ridge at the top of a Levalloisian core in order to remove a flake of predetermined size and form. (2) It requires less force (pressure or percussion) to remove a flake or blade because the initial shearing of the flake begins at the proximal end or at the bulbar area and since this part has been reduced in area the amount of lithic material is not so great, and once started the balance of the blade or flake requires less force. The differences in the amount of force is quite obvious when the knapper is performing pressure work. One can immediately note that much

less pressure is needed if the platform has been freed from the objective piece by platform isolation. Noticeable is that one must cause fracture to either side of the bulbar area before the flake will part from the objective piece if the platform has not been isolated. Both the flake and the bulbar scar show a hackled or fissuring from the increased force necessary to cause a detachment at the proximal end of the flake. Platform isolation is not necessary but is usually associated with the more refined techniques of flaking. The isolation of the platform makes use of the principle of the cone. The truncated part of the cone is extended because of its isolation from the objective piece. Such an extention permits the knapper to apply force more directly in line with the proposed flake without using the normal plane of fracture of the cone. One needs to only apply sufficient outward pressure to cause the proximal end of the flake to part and then the entire cone will be removed with the flake. An example of the use of this technique is the platform isolation of the channel flake preparation of the Folsom projectile points. (3) The angle of the platform may be prepared more easily when the platform part has been relieved and the angle can then be adjusted to the technique being used to remove the flake. One technique is to alternately remove a flake from the lateral margin and each flake scar provides a platform for the next flake. This is a preliminary procedure for the final flaking. After the lateral margins have been flaked in this manner the edges will appear saw-edged with projections like the set in a rip saw. These projections or the individual saw-teeth can then be used as platforms to complete the flaking of the bifacial artifact and the edges will be slightly sinuous or undulating. Because the tips of the saw-teeth to be used as platforms are sharp and pointed they must have the points removed by minute flaking or be abraided by grinding or polishing to prevent the flake from collapsing. The polished platform will withstand more force than the flaked or the ground surface. (4) The individual isolation of platforms permits the knapper to place accurately on the core or artifact a platform in exactly the desired selected point and at the correct interval for uniform flaking procedure. Techniques of platform isolation may be prepared by using a variety of techniques and not only the example cited. (5) The isolation of the platform further aids in eliminating part of the shock to the artifact and helps reduce accidental fracture, particularly when making thin bifacial implements. The shear of the flake from the objective piece can be caused by reducing the force necessary to remove a flake of equal size with an unisolated platform.

(49) GROUND PLATFORMS

The use of grinding in preparing platform surfaces is not uncommon aborginally and I find that it is an aid for certain techniques. The grinding can be used to cause the proximal end of the flake or blade to part more readily from a core or it can be used to give more strength to the platform part and also act as a medium to prevent the pressure implement from slipping when using outward force, also when using percussion. A common practice in using the grinding technique appears in the obsidian blade making industries in Meso-america, the preformed core was either ground or the natural rough end surface was used for the platform area. Upon examination of the ground cores the platform part was ground not by the use of a grinding stone but by rubbing the top of the core on a flat surface that was covered with coarse particles or grains of abrasive material. The grains of abrasive rolled and brusied the surface rather than causing striations if the grains were fixed as in sandstone. In order to get a similar texture on the platform part of the core I have used silicone carbide on a piece of plate glass or a flat cast iron surface. The grit size is No. 60. A surface that has been treated by this sort of an abraiding process is weakened in much the same manner as a repeated scribbing and scoring with a modern glasscutter. It is common knowledge that vitrious material roughened by sandblasting or other means is considerably more friable than a polished surface. The grinding of the top of the core allows the blade to be parted from its proximal end with a lessened amount of force than one with a plane of fracture made by removing a flake and then using the scar as a platform surface. The grinding also prevents the tip of the pressure tool from slipping as outward force is used in conjunction with the downward force. The grinding is used not only for weakening but also for strengthening the platform part but by a slightly different application of the grinding principle. In order to strengthen the platform it is slightly rounded to remove any sharp projections and edges that are too thin to withstand the force necessary to remove the flake or blade. This principle is best understood and used in modern industry in grinding and beveling glass plate mirrors to prevent their having an edge that is fragile. Glass tubing and drinking glasses are fire polished to cause the edges to be strengthened. The ground edge of an artifact permits a flake to be removed without the platform collapsing and prevents its breakdown causing step fractures. Platform grinding is useful for the preparation of platforms either individually or on the entire margin to be subsequently flaked by the use of pressure or percussion. Flakes and blades that have had the platforms slightly rounded by grinding will permit the knapper to remove and cause to fracture an area larger in size than one unground with the same restricted platform size. Flakes and blades with the platforms prepared by grinding generally have a platform area that only makes up the apex of the cone part and expands in various degrees as it reaches its termination. The rate of expansion depends on the exterior surface of the flake or blade. The bulb of force is lacking in prominence. The grinding of platforms is not to be associated with the shaping and forming of stone implements as in the Neolithic period but appeared rather early in time as a means of special platform preparation and has continued into modern times and was observed in 1961 by Norman Tindale when filming pressure forming of artifact by the Australian Aboriginals. They were observed and recorded by motion photography of first rubbing the lateral margins of the preform prior to pressure flaking. After the first series of flakes were removed from both margins the artifact would then be rubbed against an abrasive stone to remove irregularities and edges that were sharp and too fragile to withstand the pressure without crushing. After the last series of pressure flakes were removed from the lateral margins the artifact was serrated by the use of a pointed bone causing the projectile point to be a very formidable and sharp artifact.

My own experiments in the use of grinding in preparing edges, platforms, and the entire platform surfaces of the tops of polyhedral cores has been a great step forward in replicating certain techniques. I had been using the grinding technique for several years before I found the technique of grinding used aboriginally. Also while visiting with Joseph Barberri an experimenter in stone working and collaborating with Dr. J. A. Harrington, Southwest Museum, Pasadena, California, had independently discovered the use of platform grinding. I have found more recently that platform grinding is not uncommon in North America and was particularly prevalent among the Paleo-Indians. The previously described technique of grinding the polyhedral core is an exception of normal platform grinding. The difference is that the top of the core is ground to weaken the platform surface while the other uses are to strenghten the platform. When in the laboratory I use a course scythe stone made of silicone carbide because of it being harder than sandstone it abraides more rapidly and is not so time consuming. When thinning a large bifacial artifact by the percussion the lateral margins are abraided only on selected portions opposite that of a proposed flake to be removed, and usually where there is a protuberance or irregularity that needs to be removed. When the surfaces of the artifact have been made regular then the entire margins with the exception of the tip are abraided if the artifact needs additional thinning. When the margin is rubbed with the abraiding stone from the base towards the tip the platforms are automatically exposed because the ridges left by the previous flake scars make an edge that is thicker at the origin of the ridges and these thick end parts on the lateral margins are the most suitable platforms. The pressure techniques are accomplished in a similar manner. The margins after being ground permit the knapper to place the tip of the pressure tool on the edge at regular intervals and by experience will know at what interval to place the pressure tool in order that the ground edge will be removed with the flake and a sharp edge left on the lateral edge. Wide collateral retouch demands that much pressure must be exerted and in order to prevent the platform part from crushing or collapsing it is necessary to grind the margins. Scrappers and cutting implements that have been dulled by use have the edges abraided by function and no planned grinding is necessary to pressure retouch them.

(50) <u>POLISHED PLATFORMS</u>

Polished platforms serve the same purpose as platform grinding except that the higher the polish the greater the strength. The polishing usually is used on individual platforms and when specialized flaking occurs. The folsom channel flakes are characterized by this feature, they require a special preparation in order to give strength to such a small platform part to remove a relatively large flake from the base to the tip without causing the platform to collapse. When certain specialized flakes are needed functionally or to manufacture a special artifact demanding that the flake or blade be of a size relatively large in relation to the platform, then the platform requires the special treatment of polishing. Lou Napton, University of Montana, Missoula, exhibited long thin flakes made of jaspers and other silicious materials found on the Madison River that had platforms that had been polished, because of the arrangement of flake scars on the dorsal side of the flakes they appeared to have been abandoned during the thinning process of making large bifacial artifacts. Examples shown me by Richard Dougherty had similar characteristics but with the dorsal side of the flake having a plane surface and used flakes on its margins and appearing to be a cutting implement of a highly specialized nature. There are no doubt many occurrences of the polishing technique when other collections of flake assemblages are studied for this feature. Grinding is preferred to polishing the margins when the preparation is to be used for hand held pressure flaking. The polished surface allows the pressure tool to slip before a flake may be removed, when the entire margin is polished rather than being polished individually.

(51) ABSENCE OF PLATFORMS ON COMPLETE FLAKES

Egnimatic flakes and blades occur aboriginally that do not bear platforms. Their method of removal is not fully understood and is still in the theoretical stages and is in nned of further exploration by a series of experiments. I feel that whatever technique was employed it is worth mentioning since flakes of this nature occur in some sites. The Proverty Point Site is one that has quantities of blades made from pebble cores and quite a number of them have the characteristic absence of platforms. Fred Wendorff, personal correspondence, 1965, also Robinnson Bonichson exhibited micro blades collected by him that had the same features of probable independent development. The only similarity being the character of the platform part. There are large flakes from the terraces of the Fraizier River B. C. (Borden). Several of the specimans examined have the absence of platforms. These specimans are the result of either striking directly on an anvilstone or placing the objective piece on the anvil stone and then by direct percussion removing a flake. Such a method causes the cone of percussion to be severed with no bulb of percussion nor a platform. This is a technique described under bi-polarism.

I have found that flakes and blades may be removed from a core with little or no platforms when the co re is placed on soft earth or sand. When the percussor (antler or soft sandstone) is directed at a low angle across the top of the core and as the percussor contacts the leading edge the hammerstone is pressed downward causing the force to be mainly outward rather than downward. The results are not uniform and the flakes and blades often step fracture, but some of the blades are without platforms. Additional experiments will be necessary before such a technique is entirely understood. Blades from the Proverty Point site would have to be carefully appraised and compared to the results of experiments before any final conclusions may be drawn relative to the actual technique used.

There are also flakes that have no bulbs of force and no platforms caused by rapid thermal changes (freezing of absorbed water) mineral growth within the lithic material and exfoliation from internal pressure will cause the exteriors to be spalled off. Flakes such as these will have no rings of force originating on a margin and caused by impact. These flakes do not necessarily indicate that man involved in their making. The flakes do in some cases resemble pot lids and are plane convex in section and if any compression rings are present they are in complete circles around a nucli in the center of the ventral or convex side of the flake.

(52) PLATFORMS CRUSHED UPON REMOVAL FROM THE CORE

Flakes and blades will be noted that have the platform part of the proximal end absent. Such occurrences are due to the technique, errors in judgment, and the nature of the material being used. When the platform is not prepared to suit the conditions of the technique being used and the velocity of the blow is too great for the size of the platform surface then the platform will probably be shattered and crushed, however, because of the increased velocity the flake or blade will still be removed from the core. The action of removal is so fast that the force is transmitted through the crushed part and into the flake causing it to be fractured from the core. Flakes or blades that have the proximal ends absent or missing create a problem in when an attempt is made to reconstruct the entire flake to determine its probable mode of manufacture. One must then look for other diagnostic features shown in the balance of the flake or blade such as a consistency of form, straightness or curvature, termination and undulations as well as the character of the dorsal side. Should a predominance of flakes or blades occur with this feature then a distinctive technique will be indicated. The crushing of the platform usually causes the flake to be truncated and is not to be confused with flakes or blades that have had the proximal end removed intentionally. Lithic material that is not vitreous and is of a granular nature or has been poorly silicified will allow the platforms to collapse more readily than material of better quality and homogeneity.

(53) PLATFORMS ORIENTATED WITH THE LONGITUDINAL AXIS

The form of the flake or blade will depend on the selection of the platform on the objective piece. The exterior surface is the first consideration in deciding the form. The platform must then be orientated to the surface conformation of the core or artifact. The selection of the platform in relation to the proposed flake of blade is the number one consideration between failure and success in removing a flake or blade from the objective piece. The position of the platform on the objective piece must be placed at a distance from the leading edge to insure sufficient strength of material to remove the proposed flake and yet make a flake of the desired thickness because the farther into the objective piece the platform is positioned the thicker the flake will be. There cannot be a concavity under the platform and the vertical axis must be in line with the center of the predominate mass that will make up the flake. The platform must be positioned both vertically and laterally with the axis of the proposed flake. The angle of the platform cannot slant towards the dorsal side of the proposed flake and must be either at right angles or less to prevent the percussor or pressure implement from ricocheting or slipping on the surface. Also the platform must be positioned in such a manner that there will be no obstruction to hinder the path of the percussor when it is projected to the platform surface. When using pressure or indirect percussion the top or face of the platform which receives the impact must be in line with the trajectory of the percussor or the axis of applied force. The axis of applied force may be directed from the right or left or oblique from vertical. The axis of applied force is not perpendicular to the proposed plane of fracture which would be 90 degrees but less than a right angle generally about 70 degrees depending on angle of the platform. The relationship of the platform angle will indicate the manner and the angle in which the force was applied. A singular example of platform orientation is blade making on a polyhedral core. The platform is selected on the margin of the core to make a blade of a predetermined form and thickness. Should the blade desired be triangulate in section then the platform is positioned directly above a marginal ridge left from the removal of a former blade and if the blade is to be trapezoidal in section the platform is placed directly above the channel with the marginal ridges on either side and in both cases whether the single ridge was used or the two ridges the platforms position from the leading edge will control the thickness of the blades. However, there are limitations of thickness and if the platform is too far in from the leading edge the entire face of the core will be removed as well as the distal end of the core. Considerable thought and planning is necessary to position the platform in relation to the axis of the proposed flake and particularly at the stage when the knapper is making an irregular surface regular. The platform must be selected with the thought that it will serve to remove as much unwanted material from the artifact without the possibility of fracturing the objective piece in the wrong place. Should there be a protuberance or an unwanted lump on the face of the artifact then one must study the nature of the obstruction and then attempt to select and design a platform in such a position that a flake can be removed that will eliminate the irregularity with the flake. The longitudinal axis of the proposed flake must be considered before the platform is selected. The platform in relation to the axis of the flake is positioned in such a manner that sufficient material will be encountered and that the platform must be placed as near the offensive area as possible. Another example of positioning the platform in relation to the proposed flake axis is that a flake has collapsed slightly in from one lateral margin and at its termination is a step fracture that must be eliminated. A platform area is selected on the opposite margin so that the axis of the flake will be directed so that the second flake will intersect the step fracture left by the first and on the same plane of fracture. The treatment of the platform in regard to the axis of the flake is most necessary when one is to accomplish precision retouch on an artifact such as a projectile point, an example is the type of retouch that each flake is parallel with the next and the flakes have been removed diagonally from both lateral margins. The platforms must be very carefully positioned so that the longitudinal axis of the pressure flakes will intersect those removed from the opposite margin. When one examines pressure flakes that have been removed from the surface of a projectile point at its last stage of retouch and the flakes were removed parallel to one another their direction of flaking will be evident by relating the platform to the longitudinal axis of the flake. The styles and methods of the flake removal may be important in recognizing traits characteristic to certain cultural groups of people.

(54) DEPTH OF BULB OF FORCE

The depth of the bulb of force is related to the technique used in detaching a flake or blade and can be an important diagnostic feature. The bulbs of force are remnants of the cone part and are caused by the application of force by a variety of techniques incorporating the use of certain tools to remove the flakes, use of percussion, indirect percussion, pressure and combinations of pressure and percussion and the variety of materials that are involved in the flaking of lithic material. The application of force by these methods tools and materials cause differences in the character of the bulb of force. The depth of the bulb is due to portion of the cone and the deepest bulb of force rarely is greater than one half of the cone. Examples of more than one half of a cone causing an accentuation of the depth of the bulb of force is the technique of notching and serrating by the use of a pressure tool. When the notch in a projectile point is within the margin and the notching flake is removed in one flake rather than several flakes the single flake will be lunate with the tips of the moon like flake extending around the point of pressure. Another example is made by the use of percussion in which a hard hammerstone is used to strike in from the margin of a thick tabular flake to cause a fracture on the margin that will be U shaped. The blow is struck on the ventral side causing a notch to be formed on the objective piece as a negative bulb of percussion. This specialized fracture on the margin of the objective piece makes an implement that would be most usable for shaping the wooden shaft of a spear or an arrow because the concavity is designed to fit the curvature of the shaft.

The tip of the stone working implement or the contact surface permits the force (either Pressure or Percussion) to be concentrated and causes the cone of force to have a small truncation which is removed with the flake, it in turn is the positive bulb of force and the flake scar is the negative bulb of force. The accentuation and depth of the bulbar scars are useful in denoting technique variations. Pressure or percussion applied at right angles to the lateral margin of an artifact also causes the bulb to be accentuated while if the angle is less than a right angle a smaller part of the cone will be removed and lessen the depth of the bulb of force. (See Figure)

The bulbs of force that have good definition are commonly found on flakes and flake scars (negative bulbs) that have had the point of force selected in from the leading edge or lateral margin.

(55) FLAKE WITH DIFFUSED BULB OF FORCE

Both flakes (positive scars) and the flake scars that bear the negative scar that have flatter bulbar areas are caused by the type of a percussor used, the manner in which the objective piece is held and the type of platform surface. One cannot help but notice the outstanding differences between bifacially worked artifacts with regular smooth lateral margins and compare them to those with irregular scalloped edges caused by the deep bulbs of force. In part this sharp definition and lack of definition of the bulbar area of both flake and flake scars is caused from the angle of striking. The higher angle or the nearer to perpendicular to the long axis of the objective piece the deeper will be the cone part if the point of the percussor is small which causes a cone to be formed with a small apex. On the other hand if the angle is lower and the percussor is will make a wide contact on the objective piece. The truncation of the cone part will be wide and the cone will not have the definition that is shown when using a percussor that contacts a small platform area. A fair example of causing the bulbs to be diffused is the use of the wooden baton as with the billette technique. The margin of the objective piece penetrates into the wood and shows no definition of the cone part on the bulbar area. Because of the yielding nature of the soft billet the time of contact is increased which reduces the shock to the objective piece and shattering of the platform part. As the time of contact between the soft percussor is increased it allows the flake to be pulled away from the artifact. The soft percussor removes a part of the leading edge with the flake and just under the point of force and on the flake there will be a semi-circular ridge running transversely from one lateral margin to the other. The ridge is lunate and one edge or the top which makes up the ventral side of the platform and the other edge of the rim is concave which is the reverse of the flake normally removed by direct percussion. The flake scar in the platform area is convex and usually without the typical eraillure scar. It has been noted by the writer that during the course of experiments flakes with similar attributes as the billet struck flakes will occur when using direct percussion and a platform prepared by grinding and the point of contact between the percussor and the leading edge is in too far from the margin. Because the strength of the platform has been increased by grinding the force is allowed to spread and eliminate the formation of a cone and also causes the bulb of force to be diffused. Flakes and flake scars that have a diffusion of the bulbar part can be made by the use of the pressure technique. The lateral margins are first rounded by the removal of small flakes either individually or by the shearing process or by abraiding the edges. The pressure tool tip is broad and blunted and the tip of the pressure tool is placed in from the leading edge far enough to permit the flake to spread and in doing so removes part of the edge of the artifact on either side of the pressure tool. Typical of the diffused bulbs of pressure is the Eden projectile point with collateral flaking, (Ancient Man In North America, H. M. Wormington). When using the principle of the diffused bulbs of pressure or percussion there is no need to pre-establish ridges to guide the flakes and they are spaced farther apart than parallel flaking. Also the artifacts are usually thicker with the flakes feathering out or terminating at the median line of the artifact. Often the aboriginal alternated the flakes on the edges to take advantage of there being more material to withstand the pressure caused from the application of the pressure tool. The tip of the pressure tool was placed on the opposite margin and between the flake scars on the opposite side. I find this to be an advantage because the wide flakes require considerably more pressure than the narrow flakes. The diffused bulb technique is used to an advantage because the lateral edges of the projectile point will be convex and having a hollow ground character with very sharp cutting edges. See figure _________ and drawings of typical flakes and flake scars with diffused bulbs of force.

(56) ABSENCE OF LIP ON VENTRAL SIDE OF PLATFORM

Flakes without the lip on the underside of the platform on the ventral side are fare more predominant than those with the diagnostic lips. This is due to several steps and stages of making implements from the rough material to the final stage that will make use of the diffused bulb. Also the technique of making flakes with lips is not practiced by all aboriginal stone flakers and therefore, has limited distribution. The range of curve of the bulbar part can be concave as with the flakes with a lip to those without a lip or curve as those that were a product of cone splitting that the ventral side is flat and parallel with the long axis of the flake or blade to those that have a ball like appearance at the proximal ends of the flakes that makes up the bulbar part. These that have strong fat convex bulbs of force and are usually caused when the force was directed well into the objective piece and then the force dissipated before the flake could complete its path accross the face of the artifact or core. Such flakes do not terminate with a step of hinge fracture but are very short with thick proximal ends. The bulbar part on the ventral side of a flake or blade can range from a high convexity through flat to being concave. The varying degrees depending on what technique was used to remove the flake. See illustrations Figure ________

(57) PRESENCE OF THE OVERHANG LEFT BY THE BULBAR SCAR OF THE PREVIOUS FLAKE

The overhang occurs at the top of the core and is the negative of the bulb of force left when a type of flake is removed and found on the dorsal side and near the proximal end of the flake. Upon examination of certain flake assemblages one will note that the overhang was not removed while others indulged in more formal preparation of the core before the flake was removed. If the overhang was removed from the core prior to the removal of the flake then the flake will bear evidence that the core was prepared before the flake was removed. Certain Arctic cultures when making micro-blades did not bother to remove the overhang from the cores which is of course evident on the blades - a minor cultural difference yet a diagnostic trait. (David Sanger, S.S. A. 1967, Ann Arbor). The removal of the overhang permits the worker to place the tip of the pressure tool, punch, or apply the percussor to the leading edge without danger of the overhang collapsing and assists in positioning the platform with the longitudinal axis. Also fewer cores will be abandoned or have to have their platform part rejuvenated when the overhang is removed.

Some techniques do not require the overhang to be removed. For example, When I am making blanks to be modified into preforms and then pressure flaked into arrow points I select a suitable piece of material that will serve as a core and then by simple direct percussion and the use of a hammerstone remove a series of flakes from around the perimeter of the core. The technique does not require that the overhang be removed and the point of impact is placed far enough from the leading edge that there is no danger of the platform collapsing. Since thicker flakes are desired for the blanks one has plenty of tolerance without the danger of crushing the platform, also any protuberance left on the flake from not removing the overhang will be removed when the blank is made into a preform. Typical of the flake with the overhang present is the Chapue Gendarme, found in both the old and new Worlds. For those not familiar with this flake type is that when the platform part is facing the viewer the proximal end resembles a policeman's hat. This feature is caused by the stoneworker's removal of one flake directly behind the first. The flake then has on its dorsal side and near the platform part a negative bulbar scar and on the opposite or ventral side the positive bulb of force. The Clactonian flake (The Old Stone Age, Miles Burkett) also has the feature of commonly having the overhang on the flake and seems to be characteristic of early morphology or at least a technique that involves simplicity and little or no preparation.

Flaking debitage that results from the preforming of artifacts generally bifaces made singularly by the use of the core technique and direct percussion make it unnecessary to remove the overhang before striking off individual flakes. The platform is selected by making use of fracture planes made by previous flake removal and the angles of the percussor changed to conform with the existing angles of the previously made flake scars. Any special platform preparation is unnecessary until the preform is to be thinned. The flakes removed in this stage of implement making will generally have the overhang present on the dorsal side of the flake at the proximal end if they are not primary flakes still bearing the natural or cortex surface. See Illustrations of blades, flakes, Chapeau Gendarme and Clactonian flake. Figure ____________

(58) ABSENCE OF THE BULBAR OVERHANG SHOWING SPECIAL PLATFORM PREPARATION

The absence of the overhang on the dorsal side of the flake or blade indicates several technological traits of purposely removal of this part of the flake prior to the removal of the flake from the core. The technology of removing the overhang is done to permit the worker to align the longitudinal axis so that the platform will be in line with the proposed flake. The surplus material left by the bulb of applied force when the previously removed flake was detached from the core. As each flake is removed from a core to form an artifact or to remove flakes and blades to be used as blanks or left unmodified to be used as cutting implements. It causes a depression to be formed from the bulb leaving a depression that must be eliminated before the next flake may be removed. The method of removing the overhang can be removed in a variety of ways and each may be a technological trait. Upon using percussion the overhang is removed by using the same technique. I have found that during the course of experiments that flakes and blades have distinctive flake scars on the dorsal sides and at the proximal ends of the flakes and blades that result from the removal of the overhang. The ideal method is to drag the percussor along the platform face of the core at right angles to its long axis, and at the same time press into the cores leading edge which causes the percussion tool to pull the flakes away from the core without causing the leading edge to be crushed and cause step fractures. The dragging motion of the percussor pulls the flakes away and causes the flakes to feather out at their distal ends. It would appear that the removal of the overhang is a minor step in platform preparation but mechanically it is difficult if the platform part of the core is at right angles to the long axis of the core. The angle of the cores top in relation to the angle of the overhang is so great that the percussor is caused to glance or ricochet from the surface unless pressure is applied to the percussor simultaneously as it contacts the leading edge of the core. It is not uncommon, however, that when examining aboriginal flakes to find that the dorsal sides of the flakes were crushed at the platform part to remove the overhang. In order to obtain a thin blade or flake the platform must also be thinned by removing the overhang and by examining the flake scars on the dorsal side of the flake at its proximal end. A variety of flake scars will be noted that indicate the use of certain techniques. It has been noted that certain cultural groups had individual rhythms of removing the overhang when and if it was removed.

On the other hand the removal of an overhang left by the previous flake scar is a simple matter if the platform face of the core is not at right angles to its long axis and is beveled or less than a right angle. The percussor or pressure tool can then be applied directly to the leading edge without crushing or causing step fracturing. The flakes on the dorsal side and at the butt of the flake will terminate by feathering. The depth of the bulb of applied force will be indicated by the amount of material that is removed in order to align the platform with the long axis of the flake or blade. The alignment of the flake in relation to the core is that the vertical axis of the proposed flake or blade must be in the center of the transverse section as well as longitudinally. When the platform is isolated and the force directed so that the cone of force will follow the long axis of the blade or flake the depth of the bulb of force is reduced and the overhang is almost eliminated and then requires little or no need to prepare the leading edge for removing the next flake. Flake s that have been made in this fashion will not bear signs of overhang removal. (Show examples and drawings)

(59) PRESENCE OF THE LIP ON VENTRAL SIDE OF PLATFORM

The occurrence of a lip on the ventral side of the flake or blade is an egnima in part. The lip, when an occurrence is noted is an important diagnostic trait and is the result of a special technique or techniques. The occurrence of the lip on the proximal end of the flake or blade is different in that it leaves no overhang on the core as the overhang is removed with the blade. The presence of the lip is characteristic to the use of a soft hammerstone or billets of soft material and the preparation of the platform. Also blades recently examine from the Middle and Upper Paleolithic cave of Jerf Ajla which is located near Palmyra in the middle of the northern Syrian Desert of the Near East and collected by Mr. Bruce Schroeder Columbia University (personal communication) bore the distinctive features of having the presence of the lip. The angle of the platform was less than a right angle to the longitudinal axis of the blade. There was also a notable absence of erailure flakes on the bulbar part. The size of the platform was very small approximately two millimeters which because of their uniformity would indicate that they were removed by the use of a punch like implement and struck indirectly as it is inconceivable to have repeatedly struck off these blades by simple direct percussion and the blades are too large to have been removed by the application of pressure directly to the objective piece or the core. The occurrence of the lip seems to be characteristic to a soft percussor or at least the interval of contact between the percussor and the objective piece has been increased and causes the platform to be uncrushed and the compression rings reduced or eliminated as the ventral sides of the flakes are notable because of their smoothness. The presence of the lip has been observed as occurring when experiments have been done by using a percussor of a yielding nature by myself, Francois Boardes, Jaques Tixier, Gene Titmus (personal Communication). Problems regarding the exact duplication of several aboriginal techniques still remain unresolved and call for the need of more experimentation. Another phase of the use of soft percussors and is duplicated by experiments is the forming and thinning of bifacial artifacts. This is that a lip is formed on the flake because the lateral margin of the artifact is removed with the flake because the leading edge penetrates the soft percussor and is pulled from the artifact. The character of the flakes removed from the margins is that at the proximal ends of the flakes or the platform part will bear the flake scars that will be bifacial rather than unifacial. The removal of the flakes with the lip will not make an overhang on the artifact. The flake with the lip will be without an eraillure flake and the cone will have no definition and be diffused. Flakes removed in this manner will resemble artifacts themselves as the flake will appear to be intentionally bifacially at its proximal end and terminate with a feather edge. The platform part will extend laterally and have on its ventral side a lunate overhang rather than the normal bulb of force. The lunate overhang is the lip and is found on the flake rather than being found commonly on the core. The high part of the platform part may also show signs of abrasion that could be misinterpreted as use or function rather than grinding to strengthen the platform in order to prevent its crushing or collapsing.

Pressure flakes derived from retouching an edge that has been dulled through use or by intentional grinding and or abraiding will have lips on the ventral side and at the proximal ends if the technique used to remove them from the objective piece is done by removing the entire margin of the artifact with the flake . Flakes removed with the lip will cause the lateral margins to be left very sharp with little or no crushing of the retouched edges. Flakes of this style with the lip will occasionally remove the opposite lateral margin of the biface and can consider accidental. Single flakes and blades are not sufficient to establish a technological trait but a series is necessary to show that a rhythm and a pattern was incorporated in their making. The exact mechanical and physical problems that cause the lips to occur is not fully understood and at this time can only be theorized. It appears that because the flake is pulled away from the parent piece without excessive shock causes the truncated cone part (when blade making) to be compressed without shattering and also without causing the material around the cone to be damaged. While with forming and thinning bifacial implements one can readily understand the margins being pulled away with the flake as it is removed. The edges of the artifact and the proximal end of a core have different problems of angles. The obtuse angle of the artifact permits the flake to be released and also furnishes an adequate footing or platform for the soft percussor. While the core when blade making has an angle of 90 degrees or less from the long axis which does not permit one to use a billet and confine the force to such a small platform which is common when blade making. Blades made by prehistoric people of both the New and Old Worlds do appear and their exact mode of manufacturing is still a matter of conjecture.

(60) FLAKE BEARING SHARP DEFINITION OF TRUNCATED CONE PART

The apex or truncated cone will be indicative of the area contacted by the percussor. A percussor with a wide face will cause the truncation to also be wide and a percussor that is strongly convex at its striking part will cause the truncation to be limited to the surface contacted. The size of the truncation will suggest the style of p ercussor that was used to remove the flake. One must bear in mind that there is a relationship to the size of fracture plane to the size of the cone trucation because the truncated part must have sufficient strength of material to withstand the force necessary to remove the flake or blade. Should the hammerstone be either too hard or the velocity of the blow too great, the apex of the cone will collapse or shatter.

The majority of the flakes and blades that at the proximal end or butt/end will be thick from the dorsal side to the ventral side. The platform face will commonly bear one or more scars of impact. If more than one, they show the inaccuracy of the knapper and demonstrate that they (the blows) lacked velocity or were too far in from the leading edge. They are common when the hard hammerstone was used when making simple flakes and blades. The truncated part will be slightly less than a half circle and will be lunate in appearance. Eraillure flakes are common and a flake removed by simple direct percussion without an eraillure flake will be an exception.

Unsuccessful attempts to remove flakes will cause cones to be formed that will be complete and will still be contained within the objective piece. The cones that are complete and still within the objective piece are the result of the percussor being too light or the velocity of the blow not sufficiently great to remove the flake or blade. Repeated abortive attempts to remove a flake or blade will cause the cone angles to intersect one another and ultimately render the part of the objective piece useless because of the indiscriminate planes of fractures caused by the intersecting cones. The overlapping of cones also occurs in nature from repeated pounding of one stone against the other. The repeated pecking of a hammerstone on an objective piece results in the causing of incipient cones and an ultimate collapse of the surface of the material being worked on (common to the Neolithic period).

When techniques other than simple direct percussion is used to remove flakes and blades the truncation of the cone part assumes a quite different character. When the platforms are specially prepared by isolation, grinding, removal of flake (faceting) or flakes to seat the percussion implement or pressure tool, the apex of the cone part will be isolated and be an integral part of the proximal end of the flake. Depending on the angle of the prepared platform to the long axis of the flake or blade will cause the truncation of the cone part to conform with the truncated part of the cone and will be the platform. There will not be the additional bulk of material adhering around the truncated cone as with the simple direct percussion technique.

(61) FLAKE HAVING NO CONE DEFINITION

The lack of cone definition is characteristic to flakes that have been removed with a soft percussor such as a billet or at least a hammerstone that makes a large contact area in relation to the size of the flake. Flakes that retain a lip as previously described under No. 59 will fall into this category. The trunciated cone part is spread over a broad area because of the wide contact between the percussion or pressure tool causing the bulb of force to be diffused. Platforms that have been isolated and the entire cone is forced to shear from the face of the core that has been supported by a rest causes the cone to lose definition.

Flakes that have been removed from a core and supported by an anvil cause the cone to be split because of the opposing forces will cause a shear to take place between the anvil and the point of percussion. Both flake and core have no definition of the cone and a flake removed by the shear technique. The positive and negative scars are much the same and without bulbs of force. This characteristic is caused by splitting the cone by application of force at the same angle as the plane of fracture. A technique common to pebble and cobble industries. Borden, Fraizier River Terraces, and others E. M. Davis

(62) FLAKES BEARING NEGATIVE BULB ON DORSAL SIDE AND POSITIVE BULB ON VENTRAL SIDE

There are flakes that are characterized by one or more flake scars on the dorsal side of the flake at the proximal end. The flakes are usually removed by simple direct percussion if the overhang is present and the platform has not been isolated. Both dorsal and ventral sides generally have deep bulbs of percussion and the presence of an eraillure scar on the ventral side and occasionally the eraillure flake still remains in the negative scar on the dorsal side. When a single rapidly terminating flake has been removed from the cone and then another flake struck at the same angle as the first but with greater velocity in order to cause a larger plane of fracture, the second flake must be struck into the leading edge of the core the same distance as the thickness of the makers design. When the flake is viewed vertically and looking at the top of the flake it will appear to resemble the wings of a flying bird. In the Old World it is called a Chapeau de Gendarme or policeman's hat. The Chapeau de Gendarme flake does not have the overhang removed before it is removed from the core. After removal the ridges on the dorsal side are occasionally removed. This style of flake is admirably suited for making arrow points and is preformed when it is removed from the core. The flake can be used as it is struck from the core or by a minimum of pressure retouch be made into a projectile point. When the flakes have more than one flake scar at the proximal end, they are usually on the lateral edges and from the compression rings show that prior to their removal from the core were taken from the core before the Chapeau de Gendarme flake was removed causing scars on the lateral margins of the principle flake. The flakes removed on either side of the main flake allow the flake to be expanded at its base or proximal end. Naturally the best of the flakes made in this fashion were used by the people that made them and only those that were ill formed and aberrant were left for the archaeologist. By the same token if the flake was retouched over its entire surface there would be no clue left as to its mode of manufacture.

(63) PRESENCE OF ERAILLURE FLAKE

Eraillure flakes and flake scars found on the bulb of applied force and at the proximal end of the flake scar indicate that the flake was removed by being very suddenly compressed and that the cone of force was compressed and the flake caused to exfolliate from the bulb. There may be several other causes that permit the eraillure flake to be formed. Such as a plane of shear being formed that has exceeded the elastic limits of the material and cohesion and planes of shear. These are problems of Physics that must be explored further before final conclusions can be arrived. The simple field experiments conducted in stone flaking do, however, show that these egnimatic eraillure flakes occur more frequently when the interval of contact between the percussor and the objective piece is lessened. Their presence usually indicates that flakes that bear the eraillure scar denotes that the percussion technique was used to detach the flake. Flakes that have been removed by blows of low velocity and a heavy percussor do cause flakes to be formed that have no eraillure flake. Pressure flakes that have been removed at right angles to the lateral margin and by the use of pressure in one direction downward without outward or inward will cause the formation of eraillure flakes. The formation of eraillure flakes is characteristic to certain techniques of percussion and pressure and they may be used for diagnostic purposes. Eraillure flakes have no rippling on the side next to the core that indicate any direction of force while on the ventral side of the eraillure flake or that was attached to the bulbar part of the flake do have compression rings that show that the force originates towards the top but at an oblique angle. This I fail to understand.

Eraillure flakes were made intentionally by Pre-Colombian people in the vicinity of Colima, Mexico and possibly there were other occurrences of the eraillure being used for ornaments. The eraillure flakes were perforated by making a hole opposite one another at the margins and then attached to one another to make a necklace and if there was a variation in size they were graduated. The size of these eraillure flakes ranged from three-quarters of an inch to an inch and a quarter. The dorsal side was convex and without force lines and the underside was concave which caused the flakes to be transparent because of their thinness. The flakes were trimmed to roundness when they were oviate or slightly irregular. The use of the eraillure flakes for decoration demonstrates their ability to cause these flakes to form at will and expresses a complete understanding of the behavior of this particular lithic material, Obsidian.

(64) ABSENCE OF ERAILLURE FLAKES

Bulbs of force that have no eraillure flakes indicate that either percussion or pressure was used to remove the initial flake or blade with a long interval of contact between the point of force and the objective piece. When using percussion' the percussor must be of a material that is yielding to dampen shock and the velocity of the blow must be reduced in order that the cone of force will not expand and cause the eraillure flake to be released. The use of the billet or soft hammerstone is indicated rather than that of using a hard hammerstone. There are however, exceptions and one is that when a thick flake is removed from a core by the use of the hard hammerstone the eraillure flake is absent and is apparently due to the resistance of the material from being compressed sufficiently to cause the eraillure flake to be formed. Because of the additional material at the platform part the cone is not allowed to compress to its limit of elasticity. The cone upon exceeding its elastic limit will apparently cause an exfoliation which results in the formation of an eraillure flake.

(65) PRESENCE OF RADIATING FISSURES ON BULB AND VENTRAL SIDE OF FLAKE

Flakes removed by use of hard hammerstones and a blow of considerable velocity cause a fissuring radiating from the point of force and away from the direction of the blow towards the distal end of the flake or blade. The presence of the radiating fissures is indicative of the type of implement and the intensity of the blow. A slow or low velocity blow reduces the interval of contact between the percussor and the objective piece and eliminates the formation of the radiating fissures. The fissures are apparently caused by the bulb of force being compressed to almost its elastic limit and weakening the structure of the cone part of the flake and simultaneously as the plane of fracture is caused the cohesion between the flake and the core causes the fissures to be formed. The fissures are not simple cracks and are on the surface of the bulb and only if the intensity of the blow is too great will splintering occur and on the same planes as the fissures which are areas of weakness caused by the semi-collapse of the cone. Fissures will occasionally be extended in long sweeping curves to the lateral margins of the flakes and at this time do not understand whether they start at the point of force or at the margins of the flake but by their character they appear to start at the bulbar part of the flake. Upon close examination the fissures and hackeling resemble a step with a rounded tread and riser with occasionally a loose piece of the material between the tread and riser reminiscent of wave motion which is possible in materials that are solids with the properties of a heavy liquid. There appears to be a connection between the formation of an eraillure flake and the fissuring of the bulb because they commonly occur together both due to rapid compression of the platform and cone expansion.

(66) ABSENCE OF RADIATING FISSURES ON BULB OF FORCE

The absence of fissures in the bulbar part of the flake on the ventral side is an indication that force was applied with a long period of impact using a low velocity blow with a yielding percussor. Pressure flaking rarely has significient fissures though they may have eraillure flake scars. Useful in determining methods of applying force. Vitrious materials will permit the formation of fissuring more easily than those of a courser chrystalline structure. The fissures are useful to determine the direction of force when a flake or blade is broken and the platform or bulbar part is missing. The fissures radiate as tangents from the point of applied force.

(67) NATURE AND OCCURRENCE OF FISSURES ON THE LATERAL MARGINS OF FLAKE

The lateral margins of flakes that have this peculiar characteristic of fissuring of one or both edges on the ventral side of a flake or blade and on the core. Slight sweeping curved grooves are directed from the margin toward the origin of the applied force, generally the platform part on the ventral side of the flake or blade. The fissuring is more common on a thin lateral margin than on an edge that is thick. The striations are usually quite evenly spaced and graduate from the proximal to the distal end of the flake or blade. Upon becoming familiar with the character of marginal striations the markings will show the direction of applied force, thereby aiding in the reconstruction and sequence of flake removal. If the flake is fragmentary or incomplete and the platform part missing, the flake may be oriented with the direction of force. The definition of the striations will depend on the texture of the material. The more vitrious the more obvious, for an example, course grained quartzites will not show marginal striations due to its inelasticity. The striations are not cracks in the material but a series of changing planes much like the risers and treads on a staircase.

(68) TERMINATIONS OF THE LATERAL MARGINS OF THE FLAKE

THE FLAKE TERMINATION of the lateral margins of a flake are due to the character of the surface of the core. A perfectly flat face on the surface of a core will allow the flake to expand and cause a chonchoidal fracture with both margins feathering and cause the flake to be plane convex in transverse section. The outline of the flake is controlled by the surface of the core and any irregularities will cause the flake to be irregular. Duplicate flakes therefore, have to be removed under duplicate conditions and since both man and nature have subtile discrepancies of major or minor degrees one will not expect to find duplicate flakes but only those that have characteristics in common. Flakes may be compared to fingerprints and only the flake that caused the flake scar to be formed will fit that scar, even though the same material and technique was used to make the flake. The termination of the edg es of the lateral margins indicate overlaps, and sequence of the flake removal and indicate technique, stage, and the intention of the worker.

(69) LENGTH OF FLAKE

Length of a flake is the longest dimension between the proximal (point of applied force) to the distal end (termination). The length of a proposed flake may calculate before it is removed from a core by the preparation of the core and the manner in which the applied force is directed, relative to the angle of the platform. Specialized elongated flakes are called blades if the length is twice the width and the flake scars on the dorsal side of the flake bear flake scars that show that they were removed in the same direction as the flake was removed from the core. Such is not true of the first blade removed from a core. It may be crested by the removal of transverse flakes to prepare a guiding ridge or it may be a natural ridge selected by the knapper. A flake struck from the right angle leading edge of a tabular piece of material will be several times as wide as it is long and the sides will be bi-pointed. Naturally the length of the flake or blade cannot exceed the length of the material being used but only expresses the wide range of flake sizes from the most diminutive to the very massive. Thinning flakes that result when making a bi-face can be used to approximate the width of the artifact by placing flakes from opposite margins end to end or doubling the length of the thinning flake.

THE END

(THATS ALL YOU WROTE)