Route 1, Box 210
Kimberly, ID 83341

July 26, 1980

Mr. John Clark
New World Archaeological Foundation
Apartado Postal 140
San Cristobal Las Casas
Chiapas, MEXICO

Dear John:

Thank you for the information regarding the Pachuca project. Gene and I are most delighted and do look forward to this symposium.

Just recently met a most interesting young lady by the name of Janet Kearley working out of Tulane University on the Tulla site in Mexico. The project she is on will probably last two or three years. She is working on blademaking; also has found workshops and thousands of blades and numerous cores. I told her of the Pachuca project, and she would be delighted for an invitation and has already visited the site and spoke of exploration of some of the deep pits. She may be a source of good information. She attended the Jeff Flenniken Field School, Washington State University, this June-July session.

I am looking forward to your visit this coming month. I just got out of the hospital last week and hope by the time you arrive I am in considerably better physical condition than I am at the present - I'm drooping. There is so much to talk about, and I would love to have you fill me in on on your work and that of John Hanson in Miradoor.

I had the opportunity this last week of a nice long visit with an old friend that you may know, Dr. Lewis Napton, from the University of California. He has worked with Robert Huyser, on the Papalhuapa site in Guatemala, and with Tom Hester. We had a most interesting evening. He had been to Nairobi, District of South Africa, with Mary Leakey. Also there was a discussion about his working with Dr. Richard Gould in Australia.

Now I will look forward to your commentary on southeastern Mexico. Will finish this letter when I see you. Hasta Luego, Su Amigo.

Don Crabtree

DC:wt

CC.3.2.24.1

Don Crabtree

910

MESOAMERICAN PRISMATIC BLADE MANUFACTURE: AN ALTERNATIVE TECHNIQUE

Rough Draft

John E. Clark
New World Archaeological Foundation

May, 1979

The method used to produce obsidian blades common at Mesoamerican sites has long intrigued anthropologists (cf. Tylor 1861; Joly 1883; Courtes 1865; Stoll 188 in Hester 1979). Several Spanish friars described the technique, but recent experimentation has shown the descriptions to be unworkable (Cabrol & Coutier 1932; Ellis 1940; Barnes 1947; Crabtree 1968). Crabtree made a recent breakthrough and was able to produce exact replicas of the blades using a chest crutch and a vise. He suggested that portions of the Torquemada account may have been miscopied or mistranslated and, thus, postulated several small changes which are more in accord with his own experiments (1968). Crabtree has since been criticized for his "mis-use" of the ethnohistoric data (Feldman 1971; Fletcher 1970). More ethnohistoric material was brought forward and, consequently, there is now more description of pressure-flake production available. Although Crabtree's method works, it does not seem to fit the evidence now known (Sheets 1977: 143-144). The purpose of this paper is to describe another method for making prismatic blades, based upon a reevaluation of the ethnohistoric sources. Previous experimental work will be summarized and compared to the accounts of the Spanish chroniclers. The final portion of the paper will describe a method that resolves most of the discrepancies between previous work and the written descriptions.

The hypothesis guiding this research is that the ethnohistoric descriptions of the blade-making process are essentially correct and should be interpreted literally. The focus of the research was to determine whether prismatic blades could be produced in the manner described. Alternative techniques, which differed radically from the Spanish accounts, were not considered. Finally, it was assumed that the accounts of the blade-making process, although correct, may be incomplete in subtle and minor details.

To date, five major sources are known which describe various aspects of "knife" making. These are: (1) Francisco Hernández (1959) (quoted in Ellis 1940; Feldman 1971; Fletcher 1970; Marcou 1926; Tylor 1861); (2) Fray Torbio de Benavente o Motolinía (1969) (cf. Foster 1950; Hester, Jack and Heizer 1971; Kidder, Jennings and Shook 1946); (3) Mendieta-Las Casas-Torquemada (Fray Gerónimo de Mendieta, 1945) (Fray Bartolomé de Las Casas, 1967) (Fray Juan de Torquemada,). Translations of Torquemada are found in Cabrol & Coutier (1932), Crabtree (1968), Fletcher (1971), Hester, Jack and Heizer (1971), Holmes (1919), Kidder, Jennings and Shook (1946), Linné (1934), Tylor (1861), Wilson (1899); (4) Fray Bernardino de

Sahagun (cited in Fletcher 1970; Hester 1979); and (5) Sellers (1885). Sellers' account differs significantly from the others and is from a different cultural area, but it does offer clues to the possible Aztec technique.

Numerous other authors have mentioned possible methods for manufacturing prismatic blades (Stoll 1979; Fletcher 1970; Joly 1883; Cabrol & Coutier 1932; Sollberger & Patterson 1976), but Crabtree is the only one to discuss them thoroughly and to demonstrate one that works. Therefore, most of the discussion of previous experimentation will deal with the Crabtree technique. In the following, major discrepancies between the Crabtree technique and the Spanish accounts will be discussed. These are: (1) the tool used; (2) the manner of using the tool; (3) the position of the worker; (4) the method of securing the core; and (5) the rate of blade manufacture.

THE TOOL

Tylor was the first to discuss the production of prismatic blades (1861). In his Anahuac, he presents a translation of Fr. Juan de Torquemada's account as well as information from Hernández. Hernández apparently compares the wooden instrument to a crossbow (see Fletcher for a differing opinion 1970:), suggesting a 'T'-shaped instrument. Tylor suggests that the top of the 'T'-shaped tool was placed against the chest and then pressure was applied (1961:), in the way described by Crabtree (1968). Subsequent writers and researchers followed Tylor's interpretation and assumed that a chest crutch was used. This assumption was given greater credibility with the publication of Sellers' "Observations on Stone-Chipping" in which he illustrates two chest crutches and describes their use (1885: 874-875; Fig. 1, 2). More recent experiments have proved that it is impossible to use a chest crutch in the manner described. Consequently, the accuracy of the ethnohistoric descriptions was questioned. Crabtree's discussion (1968) prompted Fletcher to present more thorough ethnohistoric data, including a drawing from Sahagun of the tool used (1970: Figure 1, p. 210), reproduced in Figure 1. The accounts given in Mendieta-Las Casas-Torquemada (hereafter MLT) and Hernandez possibly describe such a tool.

Torquemada describes the pressure tool as a stick as "thick as a lance" and "3 cubits long (135 cm.)." He continues:

> "At the head of this shaft they glue on and firmly tie a section of wood of a palm tree (as thick as the upper arm and a little more and this has its face flat and cut /or notched/) so that it will weigh more." (Kidder, Jennings and Shook 1946: 135).

This piece of wood attached to the shaft could be the "projecting hook" mentioned by Hernández (Feldman 1971:). Hernández (Fletcher translation) says the tool "looks a lot like the stock of an harquebus." (1970: 212). Fletcher adds that the harquebus would refer to a musket rather than a crossbow (see also Marcou 1971:).

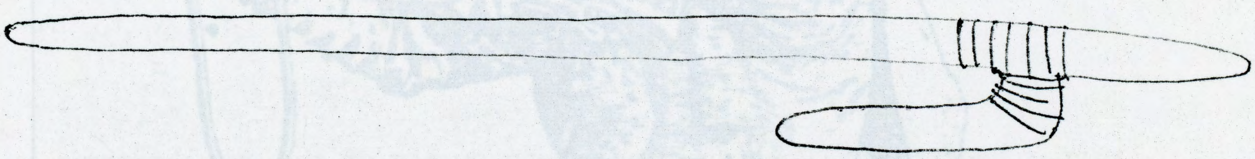

Figure 1: Pressure flaking tool illustrated by Sahagun(Taken from Fletcher 1970: figure 1)

Figure 2 : Arquebucero using an arcabus with a hook-like attachment at the stock end. (Taken from)

The harquebus of that time period had a straight stock which was held against the chest when fired (Fletcher 1970: 213). He gave this as evidence for a tool that was similarly used against the chest. Interestingly, examples of both crossbows and harquebuses of this time period had hook-like attachments at the stock end; see Figures 2 and 3.

Therefore, the analogy to the stock of an harquebus or even a crossbow would refer to a hook-like tool rather than a 'T'-shaped tool. The probable tool is shown in Figure 1. Because the ethnohistoric evidence now points convincingly to the use of a tool with a hook, the major unquestioned assumption underlying previous experimental work was incorrect.

The tool used by Crabtree had a copper bit inserted in the working end (1968:). Sellers mentions that bone, buckhorn, or walrus tusk could also have been used (1885: 874, 875). However, none of the Spanish accounts mention the use of a bit. Most describe a wooden attachment which is probably the projecting hook used to detach blades. The tip of this piece is "smoothed and trimmed" or "smoothed and notched" (Kidder, Jennings and Shook 1946: 135; Feldman 1971:).

Replication experiments have shown that blades can be detached with a wooden-tipped chest crutch (Crabtree 1968: 449, Sheets and Muto 1972:) or a wooden punch (Cabrol & Coutier 1932: ;

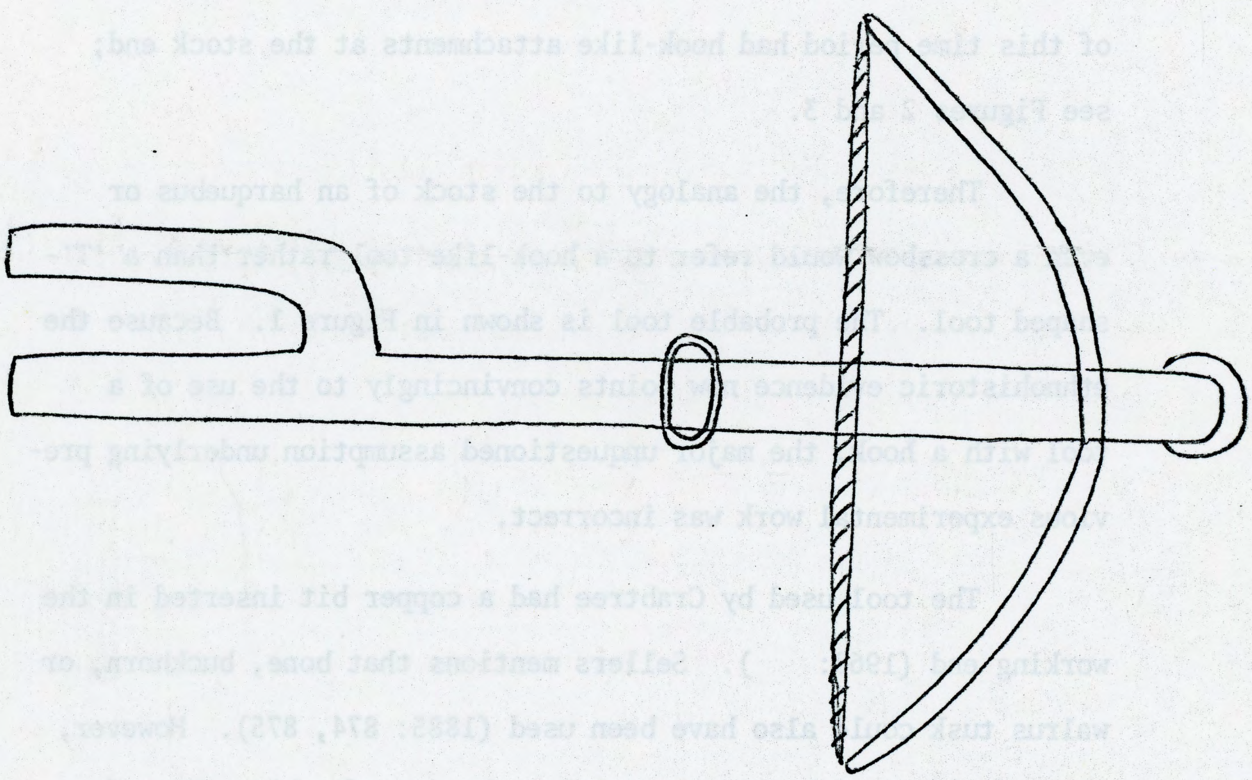

Figure 3 : Spanish crossbow of Conquest period showing a hook at the stock end. Redrawn from Craine and Reindorp (1970: plate 17)

Barnes 1947:   ; Sheets 1977: 143). The success of these tools supports the hypothesis that a wooden-tipped hook will also produce satisfactory results.

It is worth noting that Kidder claims to have found a tool fitting the MLT description in a Basketmaker II cave (Kidder, Jennings and Shook 1946: 135). The tool in question

> " ... consists of an antler or very hard bone point mounted on a wooden shaft ... The length ... is 3 3/4 inches [9.5 cm.], of which 6/16 of an inch [.8 cm.] projects beyond the end of the shaft; the width appears to be uniformly ¼ of an inch [.6 cm.]. The projecting portion tapers to 1/8 of an inch [.3 cm.] at the extreme end. The shaft is a piece of an old atlatl spear shaft 35 inches long [87.5 cm.]. The bone point is bound to the smaller end of this by seizings of skin overwrapped with sinew. The larger end is worked to a rounded point ... (Guernsey and Kidder 1921: 96).

Although the authors assert that this tool was definitely a "stone flaker," it varies significantly from the verbal and drawn representations left by the Spaniards (see Figure 4). The shaft is shorter and thinner and the wooden attachment does not fit the description of being as "thick as the fleshy part of the arm" (Kidder, Jennings and Shook 1946: 135); it is thinner. The stone flaker also has a bit, whereas bits are not mentioned in the Spanish accounts. Considering all of these differences, it is doubtful that the tool reported by Guernsey and Kidder is the same one described in the ethnohistoric accounts.

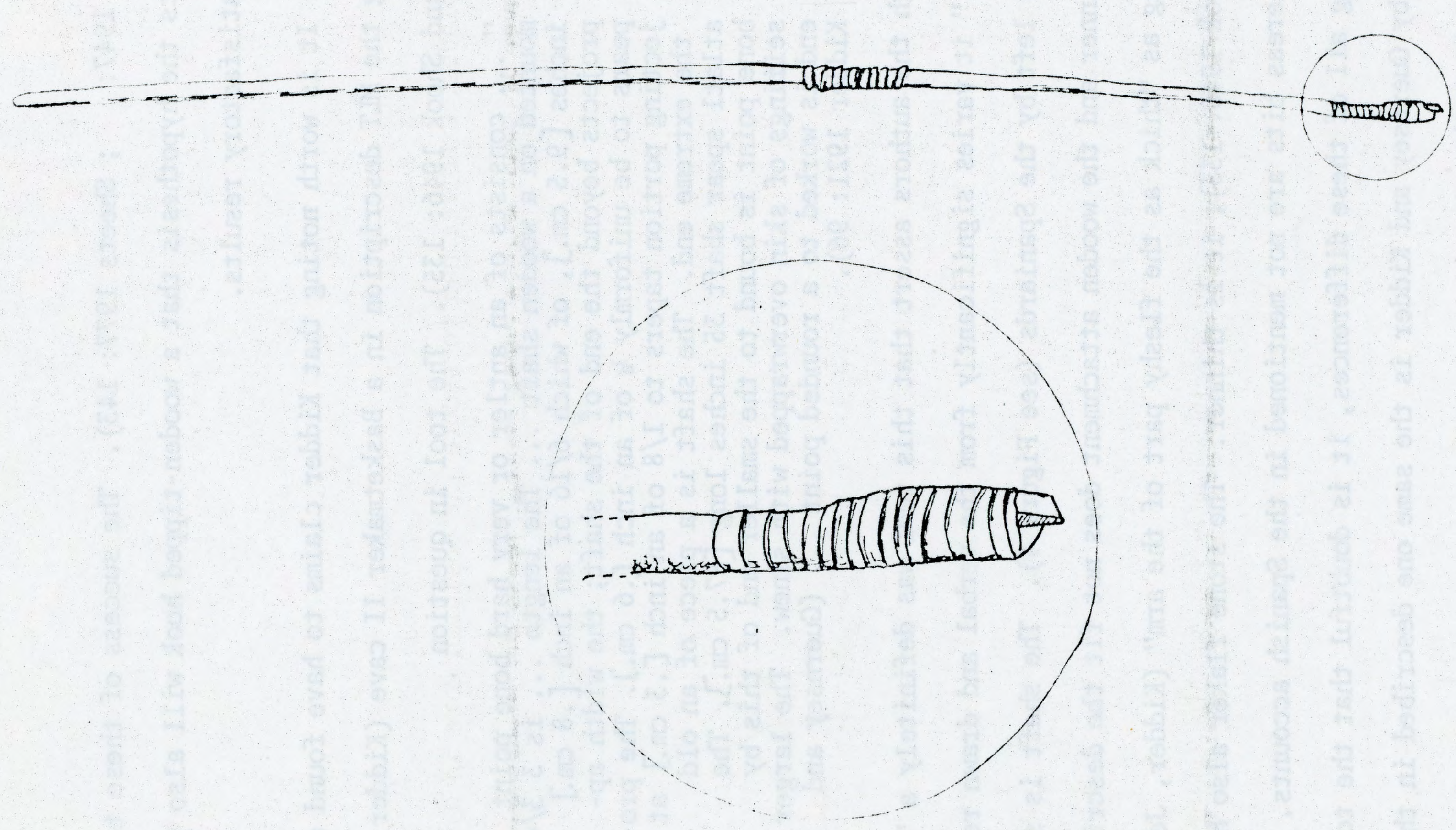

Figure 4: Tool illustrated by Guernsey and Kidder (1921 : Figure 15b,c)

USE OF THE TOOL

Neither Crabtree nor Coutier could use the chest crutch in the manner described by the early chroniclers (Cabrol & Coutier 1932: 580; Crabtree 1968). As explained, this was probably because they were using the wrong tool. In order to produce prismatic blades, Crabtree had to secure the obsidian core in a vise, stand over it, and, with a chest crutch, press off blades with a "downward and outward force." (1968:). This accords well with one technique recorded by Sellers (1885: 874), but differs significantly from the Spanish ethnohistoric accounts.

Hernández stated that the artisans "pulled" (arrancar) blades off the core (Feldman 1971:). This implies a motion toward the chest rather than away from it as described by Crabtree. (see Sheets 1977:) According to Torquemada, "they press against the chest." (Fletcher 1970:). However, Motolinía says that they pushed the tool (1969: 45). This is evidence for use of the tool in the manner described by Crabtree, but Motolinía may have used "pushed" in the same sense that MLT used "press," to "press against the chest." The differences between the described technique and that proposed by Crabtree undoubtedly arise from the use of different tools. This becomes evident when the position of the worker and the method of holding the core are considered.

WORKING POSITION

The major point made by Coutier and Crabtree is that one cannot sit on the ground, hold the core with the feet and press off blades with a chest crutch that is over five feet long (Crabtree 1968:). This problem is resolved when a different tool is used. All of the Spanish accounts state or imply that the worker sat on the ground while detaching blades froma core. Crabtree's interpretation of Torquemada's account to infer a standing position (1968:) has been corrected by Fletcher (1970:). Sellers also mentions that, for at least one technique, the artisan sat on the ground with the core between his feet. Hernández is even more specific; he describes the working position as "encogidas las piernas" (Marcou 1921: 23).

no # This could mean either "squatting or sitting on the ground with the legs flexed and the knees spread." (Fletcher 1970: 210-211). Feldman translates a parallel passage as "arching laterally the legs" (1971:). Feldman (1973:) later mentions that a picture of a pressure flaker at work, in the position described, is shown in plate 2 of the Chronicles of Michoacan (Craine and Reindorp 1970). The plate shows activities of numerous "officials," among which is the Cacari, "supervisor of the flint works" (Feldman 1973). Unfortunately, Feldman has incorrectly quoted his source which instead states that the Cacari "was the principal supervisor of all stone masons and quarries" (Craine and Reindorp 1970:); flintworking is not mentioned. The plate, therefore, might not picture a person working flint. However, it does show someone in a seatedposition (very similar to the one described by MLT and Hernández) holding what looks like a <u>coa</u> or Aztec digging stick (Craine and Reindorp 1970: Plate 2 bottom right hand corner). If this is indeed the drawing which Feldman refers to, it is difficult to accept it as a picture of a person pressure flaking. Feldman's reference to it is only important in that it illustrates the probable seated position assumed when working obsidian.

HOLDING THE CORE

The major problem which must be solved in order to produce prismatic blades is stabilizing the core. Crabtree stresses this point:

> "My experiments have definitely proven, for me, that it is impractical, if not impossible, to sit on the ground, hold the core with the naked feet, and remove prismatic blades by the pressure method. The outward force necessary to remove a blade is so great that no degree of muscular development would suffice to immobilize the core sufficiently to accomplish removal." (1968: 448)

Movement of the core during blade removal could ruin both the blade and the core. Crabtree's successful replication results from using a vise to immobilize the core. A similar vise used by North American Indians is described by Sellers (1885: 874). However, the Spanish accounts clearly state that the core was held with the naked feet. Hernández states that "grasping the stone with the three big toes and arching laterally the legs, the artisans pull off small thick [narrow] flakes ..." (Feldman 1971:). Motolinía also describes the artisan as holding the core "between the feet." (Feldman 1971:). Torquemada (Thompson translation) records that "they place their bare feet together, and with them they press against [apretar] the stone as though with pincers or the vise of a carpenter's bench." (Kidder, Jennings and Shook 1946: 135, emphasis mine). This is the passage that Crabtree suggests may have been miscopied; he proposed that "or" could have been "and" (1968:). He was later shown to be in error (Fletcher 1970:). The reference to pincers and a carpenter's vise is an analogy only. The Spaniards, who apparently were familiar with such devices, and would have mentioned their use, state that the core was held with the naked feet. Sellers describes a similar technique. However, he further adds that the cores were " ... commonly held by being sufficiently embedded in hard earth to prevent its slipping" (1885: 874). With .. "the stone in a slight indentation ... previously prepared, to give the proper angle and to prevent slipping" (ibid), the craftsmen were able to remove blades. The Aztecs, and other Mesoamerican Indians, could easily have made use of a "slight indentation" to stabilize the core. This could have gone unnoticed and unrecorded. In this light, Torquemada's description, "They press against the stone as though with pincers or a vise" (Kidder, Jennings and Shook: 1946: 135, emphasis mine), is more appropriate. They could have pressed the core into a small depression in the hard earth. The core would thus be held between the feet and, at the same time, be pressed firmly into the ground.

RATE OF MANUFACTURE

The Spanish accounts describe a more rapid rate of blade manufacture than is possible with the Crabtree chest-crutch-and-vise technique. With the Crabtree method, the core must be constantly adjusted during blade removal to expose a new working face and the vise reset. This process would undoubtedly be faster with an assistant, but the Spanish accounts specifically state that "an Indian, one of these craftsmen" manufacture the blades (Torquemada: in Kidder, Jennings & Shook 1946: 135; emphasis mine). They also mention that "in a very short time these craftsmen detach from the stone in the said manner more than twenty knives" (Torquemada: Kidder, Jennings & Shook 1946: 135). The length of time encompassed by "a very short time" is open to question; however, Clavijero placed this figure at 100 blades per hour. "They made these knives with such quickness that in one hour a craftsman removed more than a hundred." ("Hacian estas navajas con tal presteza, que en una hora sacaban [sic] un artifice mas de ciento.") (Clavijero 1964: 258. Translation mine.) The accuracy of this statement may be questioned, but such a production rate would certainly be possible if time were not wasted readjusting the core in a vise.

Because of the time required to change the position of the core in a vise, the author finds it more convenient to remove as many blades as possible from the immobile core before repositioning it. This results in a flat facet on the core face which is subsequently repeated on other sides of the core. The resultant core is rectangular in cross-section, whereas most prehistoric examples are round. However, if the core did not have to be secured in a vise, the blades could be removed in a continuous spiral all around the core as has been postulated in several reports (Holmes 1900 ; Kidder, Jennings and Shook 1946: 137). This can be achieved with the aid of a vise but would require even more changes in the position of the core and would probably not be executed "in a very short time" (Torquemada), or "with such quickness" (Clavijero).

Crabtree uses this same argument for the use of the vise. He reasons that much time would be wasted in repositioning the core in the feet after each removal (1968:). Though it is true that the core must be repositioned, the time required is negligible and, with practice, it could probably de done solely with the feet. This takes only a small fraction of the time needed to readjust a core in a vise.

SUMMARY OF ETHNOHISTORIC ACCOUNTS AND PREVIOUS WORK

In the above discussion it was shown that the Crabtree technique differs significantly from the descriptions given by the early Spanish friars. Crabtree states:

> "... if we are to take the translated version of the Friar's observations verbatim, we have the picture of an Indian sitting flat on the ground, legs straight in front of him, holding a very sharp core between his naked feet, and pressing off blades with a crutch that measures well over five feet. This simply will not work." (1968: 45)

Crabtree is absolutely correct in this assessment of the literal interpretation of the Spanish accounts. This is the author's view and was taken as the hypothesis which guided his research. In addition, one can see from the above discussion that the tool in question was not a chest crutch, as Crabtree and others have suggested, but a lever with a hook attachment at the working end. Apparently, the tip of the hook was placed on the edge of the core and blades were removed by pulling the shaft portion of the tool towards the chest. This method was tested with positive results.

EXPERIMENTS

In accordance with the hypothesis that the ethnohistoric accounts are essentially correct, several experiments were carried out to test the various aspects of blade manufacture outlined above.

Special emphasis was given to those problems which previous research had found particularly difficult (i.e., sitting on the ground and holding the core in the naked feet).

Several assumptions were made at the start of this research. First, that the tool illustrated by Sahagún is correct and that its given proportions are accurate; see Figure 1. It was also assumed that the working portion of this tool was the hook mentioned by Hernandez (1959). An alternative use of the tool was suggested by Fletcher (1970: 212), but the technique seemed to be less likely than the one assumed for this study; however, Fletcher's suggestion should be tested.

Given the above assumptions, several experiments were conducted to resolve the major discrepancies between the Crabtree technique and the ethnohistoric accounts. These are: (1) the form of the tool; (2) the working position; (3) the method of securing the core; (4) the method of tool use; and (5) the material used as a working bit for the tool.

The first experiments tested the functional adecuacy of the tool itself. A tool was constructed following the proportions given in the Sahagún drawing. Because of the author's greater size, a cubit was calculated at 50 cm. The resultant tool was 150 cm. long with an attached piece 33 cm. long. This was attached 22 cm. from the distal portion of the tool, placing the working bit 55 cm. from the distal end (see Figure 5). For the first tool, a copper bit was

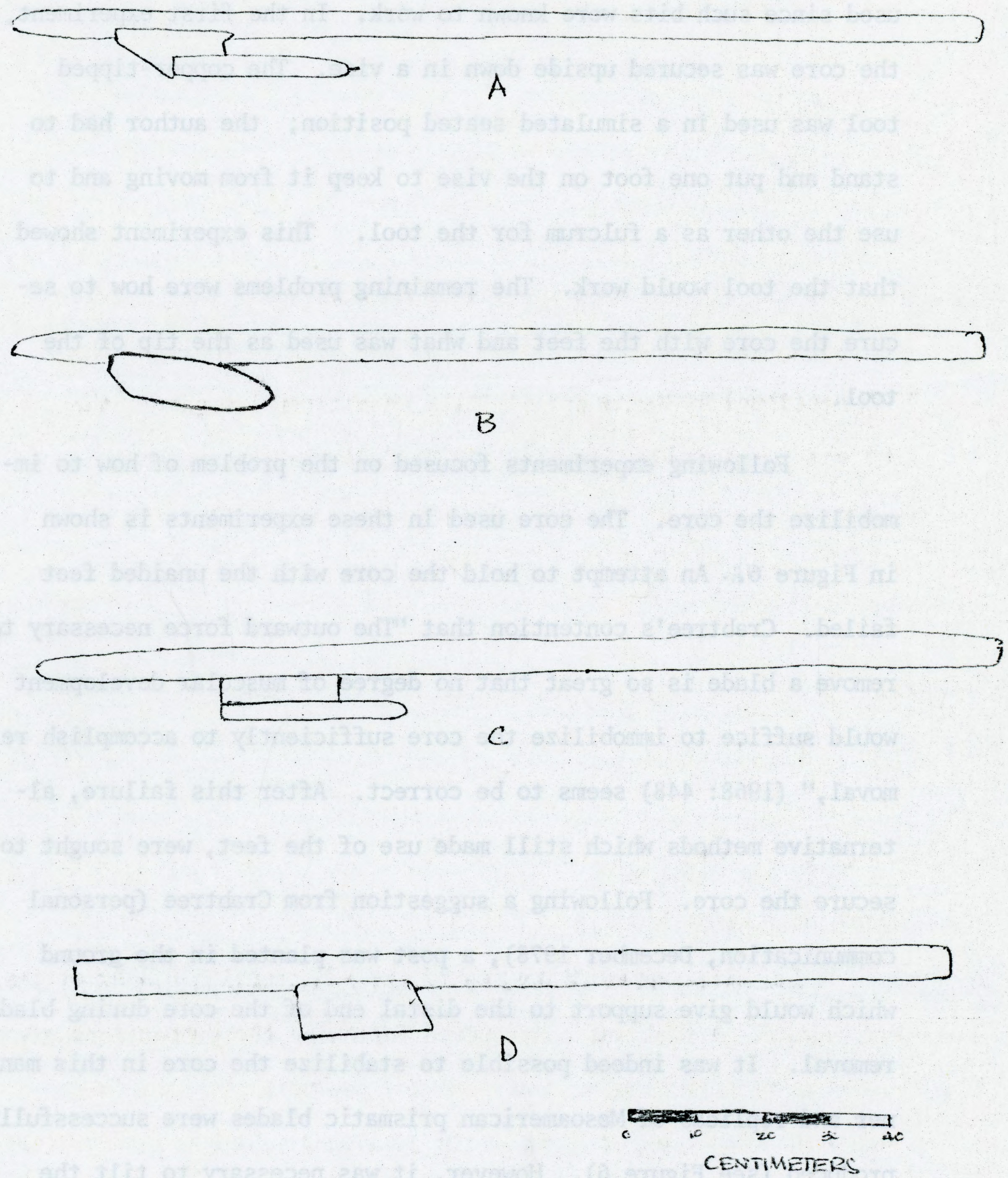

Figure 5: Tools used in experiments. A Tool with copper bit. BandD. Tools with bits of granadillo; C. Tool with oak bit. All bits were secured with a pair of long bolts.

used since such bits were known to work. In the first experiment, the core was secured upside down in a vise. The copper-tipped tool was used in a simulated seated position; the author had to stand and put one foot on the vise to keep it from moving and to use the other as a fulcrum for the tool. This experiment showed that the tool would work. The remaining problems were how to secure the core with the feet and what was used as the tip of the tool.

Following experiments focused on the problem of how to immobilize the core. The core used in these experiments is shown in Figure 6A. An attempt to hold the core with the unaided feet failed. Crabtree's contention that "The outward force necessary to remove a blade is so great that no degree of muscular development would suffice to immobilize the core sufficiently to accomplish removal," (1968: 448) seems to be correct. After this failure, alternative methods which still made use of the feet, were sought to secure the core. Following a suggestion from Crabtree (personal communication, December 1978), a post was planted in the ground which would give support to the distal end of the core during blade removal. It was indeed possible to stabilize the core in this manner and replicas of Mesoamerican prismatic blades were successfully produced (see Figure 6). However, it was necessary to tilt the core platform about 60° from the plane surface of the ground. A small hole was dug for the distal end of the pressure tool so that

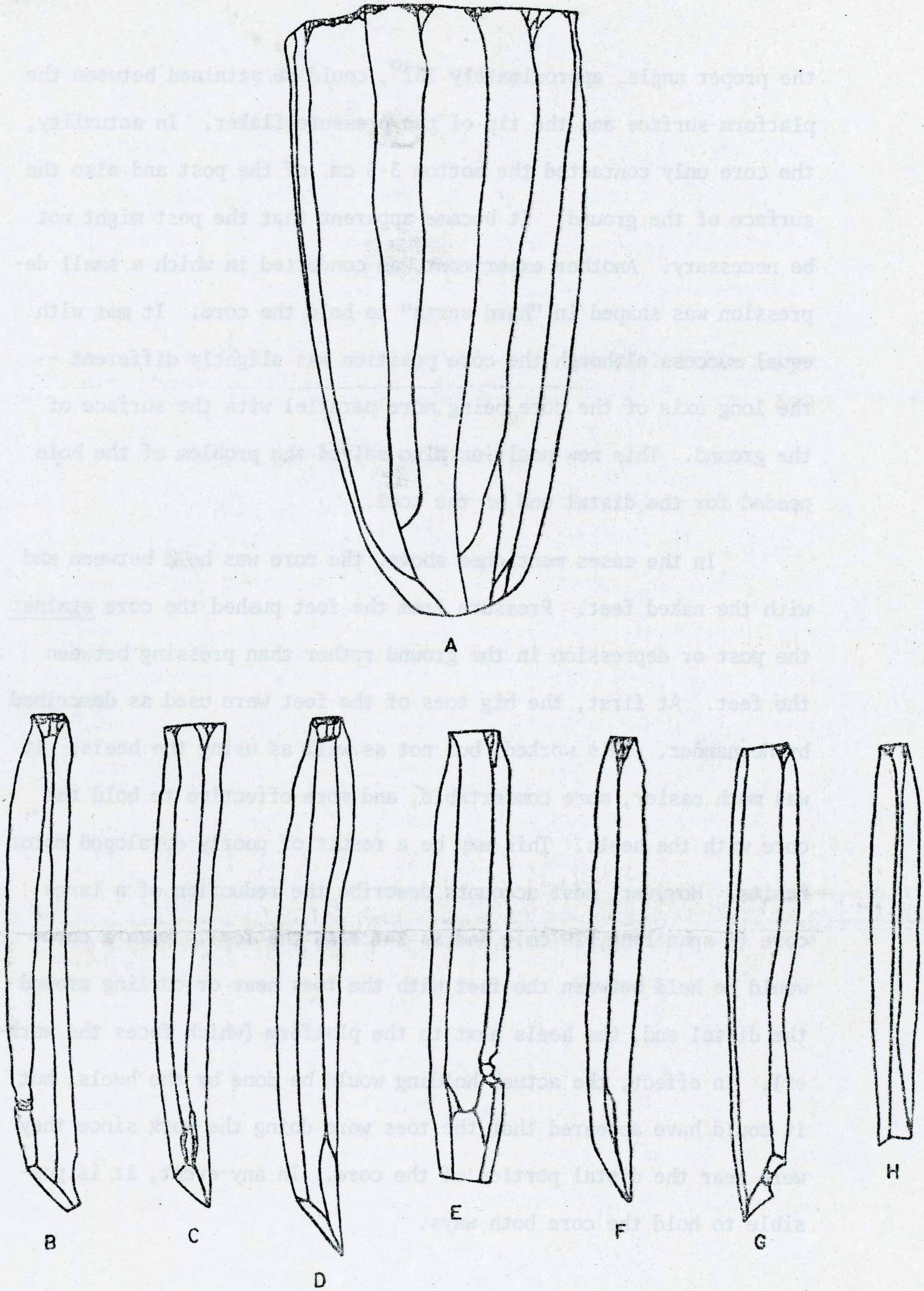

Figure 6: A. Large Polyhedral core used in experiments. B-H Prismatic blades removed from core A.

the proper angle, approximately 102^{o}, could be attained between the platform surface and the tip of the pressure flaker. In actuality, the core only contacted the bottom 3-5 cm. of the post and also the surface of the ground. It became apparent that the post might not be necessary. Another experiment was conducted in which a small depression was shaped in "hard earth" to hold the core. It met with equal success although the core position was slightly different -- the long axis of the core being more parallel with the surface of the ground. This new position also solved the problem of the hole needed for the distal end of the tool.

In the cases mentioned above, the core was held between and with the naked feet. Pressure from the feet pushed the core against the post or depression in the ground rather than pressing between the feet. At first, the big toes of the feet were used as described by Hernandez. This worked, but not as well as using the heels. It was much easier, more comfortable, and more effective to hold the core with the heels. This may be a result of poorly developed motor habits. However, most accounts describe the reduction of a large core (a span long, 20 cm., and as thick as the leg). Such a core would be held between the feet with the toes near or curling around the distal end, the heels next to the platform (which faces the worker). In effect, the actual holding would be done by the heels, but it could have appeared that the toes were doing the work since they were near the distal portion of the core. In any event, it is possible to hold the core both ways.

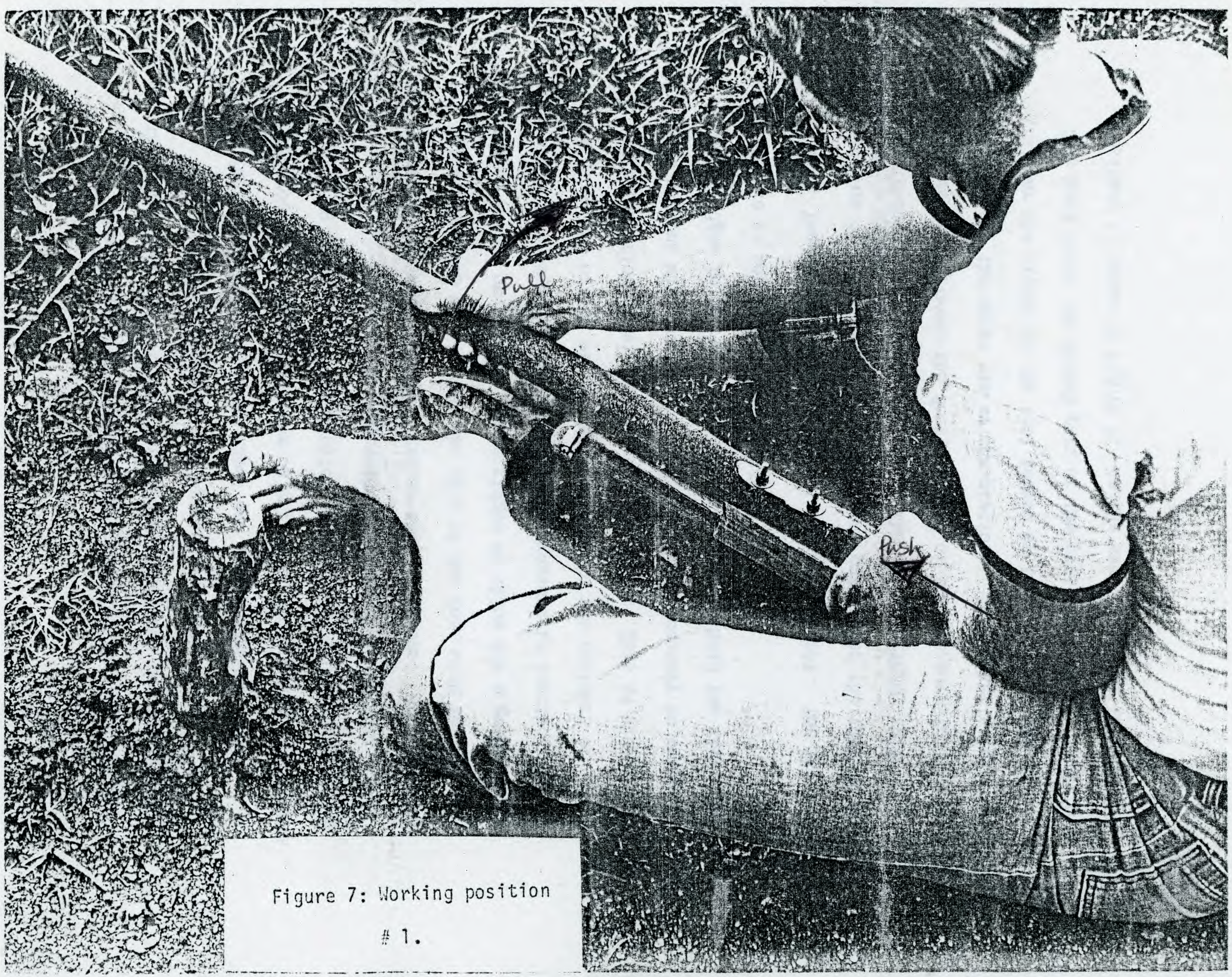

Figure 7: Working position

1.

One of Crabtree's objections to holding the core between the naked feet is that the sharp ridges would cut the feet (1968:). Fletcher addresses this by mentioning the "horny" state of feet which have not known shoes and rarely sandals (1970:). Crabtree later negates his own objection by showing that the obtuse angles in question are best suited for planing rather than cutting ( ). The author's experience was that a well-prepared core was "slippery" rather than dangerous. An unsuccessful attempt was made to cut the skin of the feet with the obtuse-angled ridges on a core. These ridges do allow for a grip on the core in the same way as a vise. When pressure is exerted, the flesh on the bottom of the feet conforms to the contours of the ridges and flutes and prevents core movement. This is similar to what happens with the use of a vise. It is necessary to embed these ridges in the wood of a vise in order to hold the core when pressure is applied (Crabtree 1968:).

Two methods were employed in using the tool. The first made use of a small hole for the distal portion of the tool in order to obtain the proper angle with the core platform. With the core secured between the feet, the tip of the pressure tool is placed near the upper rim of the platform. The worker's left hand is near the crotch of the tool formed by the shaft and the hook. This hand holds the distal part of the pressure tool in place; this position is shown in Figure 7. At the same time, the left hand is

Figure 8: Working position
2

pushing the hook into the core face. This holds the tip of the tool secured to the platform. Next, the worker pulls towards his chest with the right hand, which is situated midway on the shaft. Pushing with the left and pulling with the right forces a blade off the core. This technique worked very well, but was unsatisfactory because a hole was needed for the distal portion of the tool and because of the spread position of the hands. The Spanish accounts do not mention a hole (which is very noticeable) and seem to imply that both hands were used in pulling the tool toward the body. In order to do this, the distal portion of the tool has to be held stationary in some other manner to free the left hand. The easiest way to do this would be to brace it against the body. This constitutes the second technique; see Figure 8. The distal portion of the tool is placed on the abdomen and both hands on the shaft's midsection. The tip of the hook is forced into the core face by pushing with, or flexing, the abdominal muscles. Once this pressure is exerted, the worker pulls towards his chest with both arms and a blade is removed. This method solves the problem of the hands and eliminates the need for a hole. It also allows, or dictates, that the core be flat on the ground, the platform facing the worker. The depression needed to hold the core is very slight. It was also easier to hold the core with the feet in this position.

The above experiments resolved most of the major differences between the Crabtree technique and that recorded by the Spanish chroniclers. The only remaining problem is that of the working bit.

The Spaniards describe an attachment of palm wood. They also mention that this is to make the part weigh more. The weight attributed to this piece suggests that "palm" may be an emic not an etic category; in other words, it could possibly be of a heavy hardwood and not an actual palm. Crabtree previously removed prismatic blades using a wooden tool. However, he needed to resharpen his wooden tip after each blade removal. Also, "In order to remove a blade from a core, the platform must be isolated so that just the platform area of the blade will contact the wooden pressure tip" (1968: 449). The tip of the tool used in this process "is not sharp, but it is very blunt in order to give it strength" (1968: 449). Crabtree also suggests that some of the tropical hardwoods would make good tool tips (1968: 450). The experiments with wooden-tipped tools followed these observations from Crabtree. The wood used was extremely hard granadillo (Dalbergia granadillo); a cubic meter of this wood weight 1,142 kilos (Miranda, 1976: Vol. 2: 21). It was found that the wood was so hard that it was slick and would not "grip" the core platform as does copper. Two tool tips of different morphology were unsuccessfully tried; these are pictured in Figure 5 b, d. Another tool bit was made using a pick handle of oak wood. The working portion of the tool was very blunt as suggested by Crabtree. Two blades were removed with this tool, but the process of blade removal compacted the wood making it slick, and the tip could not be used a third time (without resharpening). The apparent rapidity with which blades were made is evidence against this constant resharpening. It was mentioned previously that the word tajada can also mean notched. To check this possibility, a notch was made in the tip of the oak wood pressure tool. Several blades were removed with the tool, but it also became slick from compaction. However, it was more effective than the blunt and rounded tip because it allowed for a better "grip" on the core and thus more pressure could be applied. This phenomenon is also known for antler pressure-flakers which become notched from use. Although these notches result naturally with use, they help prevent the tool from slipping.

Several blades were removed using hardwood bits, but the results were less than satisfactory. Palm wood has not yet been tested, but may be an improvement. The wood in question must have great internal strength and yet be soft enough to allow penetration of the core platform. This would prevent slippage while, at the same time, allow greater pressure to be applied.

In summary, the technique used to detach prismatic blades from a large polyhedral core corresponds more completely to the Spanish descriptions. The worker uses a tool approximately three cubits (135-150 cm.) long which has a smaller piece of wood attached at one end; this forms a hook. The tool is used while the worker is in a seated position holding the core between his naked feet. The distal portion of the tool is near the crotch of the worker or can be placed on his abdomen. The tip of the hook is carefully placed on the top rim of the platform which faces the worker. Pressure is exerted outward, either with the left hand or abdominal muscles, forcing the tip of the tool into the core face at an angle of approximately 102°. Just after this outward pressure is applied, the worker pulls the shaft toward his body and a blade is forced off the core. A well-removed blade flies a few centimeters into the air directly above the core, rotates, and falls harmlessly near the core. The Spanish described the blade as "springing off the stone" (Torquemada: Kidder, Jennings & Shook 1946: 135). This is an accurate description of blades removed by this technique. Improperly removed blades can fly into the face or over the shoulders of the worker and so safety precautions would be necessary to protect the face.

The above-described technique fails to adequately deal with the problem of the working bit of the tool. This is described as "a section of wood of a palm tree (as thick as the upper arm and a little more and this has its face flat and cut [or notched]) so that it will weigh more." (Torquemada in Kidder, Jennings, and Shook 1946: 135). Palm has not yet been tested but it may work. However, the tool shown in Figure 1 has a hook which has the same diameter as the shaft or "the thickness of a lance" and so it is possible that two tools of similar properties are being discussed in the ethnohistoric sources. If the piece of wood did not have a space between the shaft and bit as shown in Figure 5d, then this problem would be resolved.

The reason for the weight of this piece is unknown. Perhaps Feldman is correct when he translates the passage from Mendieta as "thick like the fleshy part of the arm and sometimes larger and has its front flat and notched, and this piece serves as the heaviest part." (1971: , emphasis mine). No function is equated with the weight as translated here. However, this may merely be poetic license on the part of the translator since Mendieta clearly states that the purpose of this piece is so that it will weigh more: (" ... y sirve este trozo para que pese mas aquella parte" (1945: 57). The thickness may have been necessary to give strength to the tip. Marcou suggests that "The smaller piece, attached to the end of the lance or baton, no doubt served to shift the center of gravity and to bring the weight of the lance, which the artisan had to hold in a somewhat tilted fashion, onto the point in contact with the obsidian" (Marcou 1921: 22; literal translation by Olivier de Montmollin). This would explain the need for a heavy piece of wood but fails to explain both the Hernández account, which refers to a hook, and the drawing from Sahagun. Marcou assumes that the working portion of the tool is the end of the lance and not the attached piece.

CONCLUSIONS

Replication experiments have shown that prismatic blades can be produced using the method described by the Spanish chroniclers.

Almost all of the major differences between the method described by Crabtree and these ethnohistoric accounts have been resolved. The only major difference between the experiments described above and those of previous researchers was the form of the tool used. Previous to Feltcher's article (1970) it was assumed that the accounts described a chest crutch, albeit, a very long one. A change to a lever tool with a hook attachment resulted in a general confirmation of the accuracy of the Spanish descriptions.

This implies that the as yet untested portions of these descriptions may be similarly accurate. For example, a prismatic blade is described as having "a prominent central ridge on each side, two backs and two cutting edges. They are more or less a cuarta [palm] long and a little more than a dedo [finger] wide; the point is so keen that it cannot be made any sharper but it is fragile, it quite easily becomes dull and with a blow breaks into pieces." (Hernández in Feldman 1971) This is a very accurate description. The accuracy of these accounts suggests that much research should be required before any portion of them can be proven incorrect. Therefore, the unsatisfactory results obtained using wood bits does not mean that wood was not used.

The experiments described above are preliminary and are not a final resolution of the problem. Several sub-problems still remain. It was noted that more experimentation with the working bit of the tool needs to be done, preferably with wood. Other materials should also be tested as bits (i.e., chert, jade, bone, antler, shell, limestone). Manufacturing errors resulting from the technique described here are similar to those resulting from the chest crutch method (Crabtree 1968, Sheets and Muto 1972, Clark 1979); however, the recovery techniques most assuredly are not. Experimentation must continue to determine the limitations of the hooked tool. The author found it difficult to remove hing fractures. This was accomplished with the side-by-side technique (see Sheets & Muto 1972:   ), or by reversing the core. It was not possible to place the working tip of the tool directly on the hinged mass as is possible with a chest crutch. (This may, in part, explain the presence of bidirectional prismatic blade fragments found at Mesoamerican sites.) Finally, part of the argument against the Crabtree technique was the rate of manufacture. This argument was very subjective and needs to be quantified; it should be easy to determine how many blades can be produced in a given period of time with each technique.

Although the technique described above was presented as the Aztec technique witnessed by the Spaniards, it may not have been pan-Mesoamerican. The changes noted in prismatic blade platforms through time may be indicative of different techniques (MacNeish et. al. 1967; Sheets 1974: 1978; Rovner 1975; Johnson 1976   ). The Early and Middle Preclassic technique is one in which each platform was individuall prepared. Crabtree mentions that such preparation was necessary when he used a wooden-tipped chest crutch (1968:). Similar platforms are found on percussion blades characteristic of the Preclassic period. Crabtree has replicated these blades. For the percussion blades the platform size is a function of technique, in other words, preparation is needed to isolate the platform sufficiently so that a large, flat surface of the hammerstone will contact the core at only that point (Clark 1979:). The platform preparation of prismatic blades could be analogous. Epstein has noted that prismatic blades from the Aztec period are very different from earlier blades (1964). Sheets also proposes a major shift in the obsidian blade industry at this time; he sees a move from careful craftsmanship to mass production (1979). Part of this shift could be a change of technique. It is quite probably that there was more than one technique. The presence of the chest crutch and vise method in the western United States (Sellers 1885) suggests that it could have been known in Mesoamerica. Perhaps the technique originated in Mesoamerica and is part of the Mesoamerican cultural heritage adopted by Indians of the southwestern United States. If true, then there were at least two techniques in Mesoamerica and maybe more. Research needs to be conducted on alternative techniques to see if subtle technological peculiarities of each can be discerned. In particular, indirect percussion should also be given greater consideration (as argued by Sheets 1977), especially since it is still used by the Lacandon Indians of the Mexican tropical lowlands (Maler, Tozzer 19 , Mulleried), and Coutier has claimed to have made perfect replicas of prismatic blades by this technique ( ). If and when the technological peculiarities of these various techniques have been demonstrated experimentally, the archaeological record can be assessed more accurately to see if there was more than one technique. In this regard, Crabtree's observation is very apropo: "No amount of theorizing by merely examining a flake or blade scar will give a true picture of these techniques; only by replicating can we change theory to fact" (1968: 478). Technological studies of minute details of both cores and blades will have to be combined with a similarly rigorous program of experimental replication in order to determine the number of techniques present in Mesoamerica and their spacial-temporal coordinates.

The experiments described above accord with Crabtree's apparently overlooked observation: "The actual removal of prismatic blades from the core is not a difficult technique. The problem lies in preforming the core in the proper shape with ridges to guide the blades, and in the proper positioning of the tip of the crutch tool" (1968: 451). Granted, a certain degree of instruction and mental concentration are required, but beyond this it is a fairly simple procedure. This has various implications for the study and interpretation of ancient obsidian trade in Mesoamerica. Anyone with a tool and proper instruction could make blades. The determinants of this craft specialization would likely be more influenced by a person's access to obsidian and a tool rather than skill.

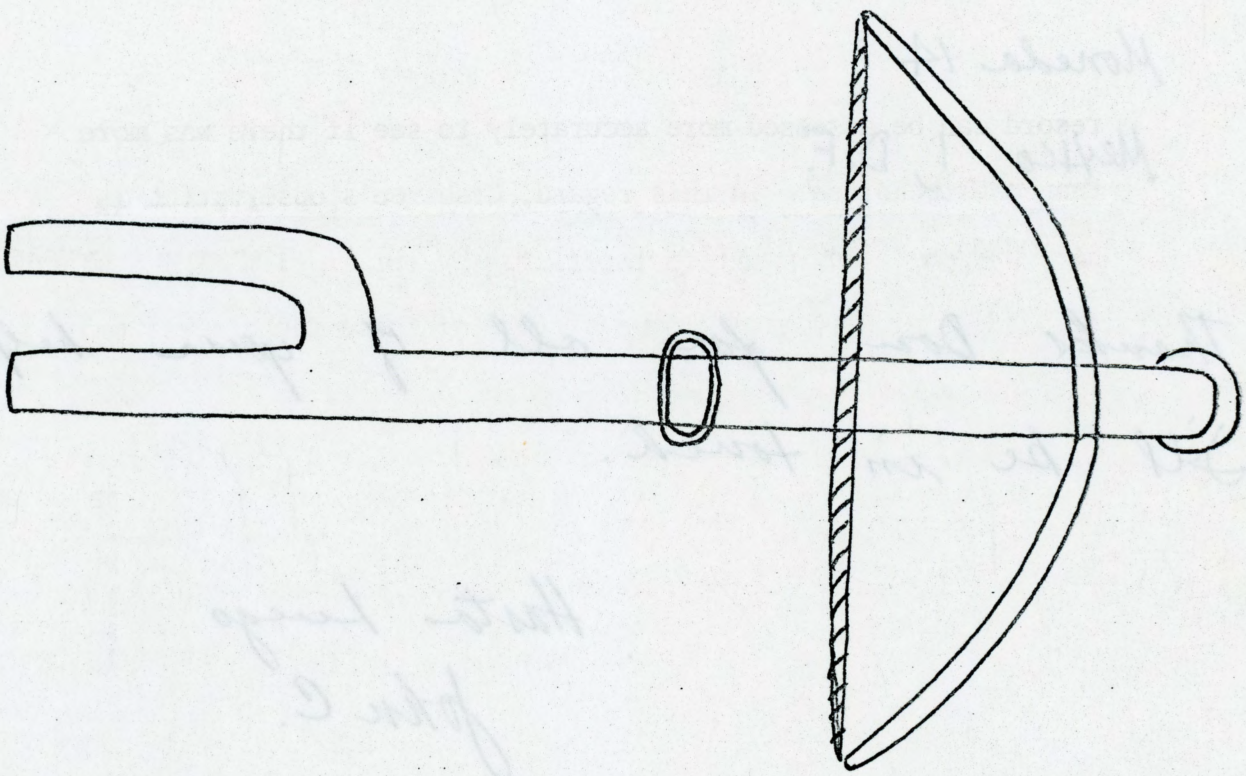

Figure 3 : Spanish crossbow of Conquest period showing a hook at the stock end. Redrawn from Craine and Reindorp (1970: plate 17)

Lorena Mirambell's address is

INAH

Departmento de Prehistoria

Moneda 14

Mexico 1, D.F.

Thanks Don for all of your help.
I'll be in touch.

Hasta Luego

John C.