"On the fourth I happened where the wolves had killed a buffaloe. — Here I satisfied my appetite by collecting all the meat that was left on the bones, made a fire by rubbing two sticks together, and cooked it."[i] -Recorded by Zenas Leonard[ii]

The lore of 'rubbing two sticks together' to produce fire enthralls and mystifies. There are undoubtedly many different ways to generate the needed heat and friction that produces the char dust and creates the coal. A careful study of the historical journals of men engaged in the fur trade, the archeological record, and eye witness accounts written after the fur trade shows, that in the geographic area known today as the western United States, the process was one of 'less is more'; no bows to rotate the fire-drill, no pump drill, no loops of leather over the top of the fire-drill. Only a hearth and a fire-drill that was rotated between the palms of the hands was used to make fire by friction among the indigenous people encountered by the men of the fur trade in the western United States.

Osborne Russell describes the fire making of the people he encountered this way: *"They are never at a loss for fire which they produce by the friction of two pieces of wood which are rubbed together with a quick and steady motion."*[iii] Taken in the context of what is described by others, 'two pieces of wood which are rubbed together with a quick and steady motion' fits the mental picture of rotating a fire-drill between the palms of the hands. It is significant that he doesn't mention the use of a bow or other mechanical aid to rub the sticks together with a quick and steady motion.

The process of using only a spindle, that is rotated between the hands, and a hearth to make fire was described by George Catlin. As he traveled among the people now known as the Sioux, he described the following:

> *"The fire is then removed, and with it the ashes, which together are buried in the ground, and new fire is originated on the same spot where the old one was, by friction, which is done by a desperate and painful exertion by three men seated on the ground, facing each other and violently drilling the end of a stick into a hard block of wood by rolling it between the hands, each one catching it in turn from the others without allowing the motion to stop until smoke, and at last a spark of fire is seen and caught in a piece of spunk, when there is great rejoicing in the crowd."*[iv]

In this example, we see the explicit statement that the stick was 'rolled between the hands'. There is no doubt as to how the fire-drill was rotated in this example. He also shares the additional detail of turn taking as the stick is 'rolled between the hands'. Speaking from

experience, it can be a great help to have more than one person taking turns rotating the fire-drill between the hands.

Zenas Leonard recorded this account: *"On the fourth I happened where the wolves had killed a buffaloe. — Here I satisfied my appetite by collecting all the meat that was left on the bones, made a fire by rubbing two sticks together, and cooked it."*[v] Again we have the description of 'rubbing two sticks together' to make fire without any mention of a bow or other mechanical device to aid in the process. This description is also significant because he is describing using this process rather than being an observer of the process. At least one of the mountaineers was able to use the indigenous method of making fire.

These three quotes serve as signals to the student of friction fire methods that the men of the fur trade, in the geographic region under consideration, were observing indigenous people making fire by rubbing or rolling sticks between their hands and also using this technology, as needed, to make their own fire. At this point, the student of friction fire methods would do well to ask the question, "Is it possible that mechanical aides were used to rotate the fire-drill prior to contact with Europeans and the practice fell out of use?" To answer this question, it is important to refer to the archeological record. The archeological record further supports the idea that fire-drills were rotated between the palms of the hands without any other method of assistance in the Western United States.

The author had the good fortune to personally examine a series of artifacts housed at the USU Eastern Prehistoric Museum, in Price, Utah that included a fire-drill matching the descriptions of fire-drills made and used elsewhere across the Western United States.

> *"The fire drill and fire-drill hearth were recovered from site 42EM1722, a rock shelter site in Oil Well Draw in the northern end of the San Rafael Swell. The fire drill consists of a curved wooden shaft 83 cm long and 1 cm in diameter. One end tapers to a point; the other end, which was used as a fire drill, is burned and slightly conical. Given its length, this fire drill was probably twirled by hand rather than used with a bow.*
>
> *The fire-drill hearth is made from a curved wooden shaft that appears to be part of a bow. It is subrectangular in cross section, measuring 84 cm long and a maximum of 1.5 cm wide. One end tapers to a point; the other end contains two drilled holes. The shaft is broken in the middle of one hole, a hole which is drilled most of the way through the shaft. This scar is 1.1 cm in diameter and has a notch on one side to allow the embers to fall from the hole. The drill and hearth fit together and were probably part of a single fire making kit."*[vi] (See Figures 1 & 2)

Across western North America, it was common for projectiles to be hafted onto short foreshafts that were then mounted into longer main shafts (See Figure: 3).[vii] In a similar manner, there is a strong body of evidence that this idea of a mainshaft and a foreshaft was used common in the Western United States when constructing a fire-drill. The system of a fore-shaft and a main shaft

being used together is referred to as a composite system. One hallmark of a composite system is that the mainshaft is often bound with sinew at the junction between the foreshaft and mainshaft to prevent the foreshaft from acting as a wedge and splitting the mainshaft.

> *"The total length, including foreshaft, is 21". The main shaft is hardwood, 7/16" diameter…The lower end is bound with sinew for 7/8". The foreshaft is 1 3/8" long and ¼" in diameter where it is inserted into the main shaft, but broadens out to 3/8" diameter. The tip of the foreshaft is blunt and charred from use in making fire."*[viii]

> Another artifact is described, *"…of elderberry, may once have been the lower end of a fire-drill shaft with the socket for the foreshaft, but was cut later. It is 2 7/8" long, 5/16" in diameter. One end is cut off square and wrapped with sinew for 1"; the other end has a socket, 3/16" in diameter, running back into it."*[ix]

There are many examples of these foreshafts in the archeological record (See Figure 4), USU Eastern Prehistoric Museum has several (See Figure 5). A close examination of these foreshafts reveal no evidence of burnishing on the proximal end from a handheld socket such as is used to provide the downward pressure when a bow is used to rotate the fire-drill. Additionally, there is no discernable evidence of crushing or burnishing from a bow string being wrapped around the circumference of the fire-drill to rotate it. The evidence suggests that these foreshafts were not used in conjunction with a bow friction set.

The use of foreshafts with a long, thin diameter mainshaft, similar to an arrow shaft provides multiple advantages. First, it is easier on the user's hands if the mainshaft is straight and smooth. However, there is an investment of time and energy to straighten and smooth a shaft. Gradually, over time a fire-drill will get shorter as bits of wood are consumed each time a fire is made. This means, that the labor involved in making the shaft will need to be repeated again. From a labor standpoint, it is more efficient to use a foreshaft because once a foreshaft wears out, it is much easier to replace that rather than an entire fire-drill. Secondly, throughout western North America, particularly the great basin, the preferred materials for use in a fire set, such as sage brush, rarely grow long or straight enough to be a hand fire-drill in one complete piece. By making a composite fire-drill, materials that couldn't otherwise be used in a fire set that employs only the hands to rotate the fire-drill are now readily available.

A report detailing the fire set artifacts housed at the Smithsonian described a Navajo fire-drill, "The Navaho fire set looks very much like a mere makeshift. The hearth is a piece of yucca stalk and the fire holes have but a shallow side notch. The drill is a broken arrow shaft, to which has been rudely lashed with a cotton rag a smaller piece of yucca wood."[x] This description matches many of the fire-drills collected from across the entire Western United States. Figure 6 shows a man in the position of using a fire-drill. The man is dressed as from a different cultural region than the Navajo, but his fire-drill matches the description of composite drills. The tool for generating fire remains the same across great distances and cultural groups.

The archeological record indicates that prior to the fur trade in the Western United States, a fire-drill that was rotated between the palms of the hands was the norm. During the fur trade of the western United States, the first-hand accounts shows that this was still the practice. How did the practice change after the fur trade in the Western United States? It didn't. Again, the available evidence points to an exclusive use of the hand fire-drill. The photo in figure 6 is post fur-trade era and the subject is still demonstrating the hand fire-drill. There are other well documented examples first-hand accounts showing that the hand drill was still used after the fur trade.

An account by George Redding, as he traveled among the Shasta people of Northern California in the 1880's, illustrates that over half a century after men like Ogden and Smith passed through the area, friction fires were still made with a hand drill:

> *"After long negotiations, and the exercise of considerable diplomacy, an Indian came to me, bringing his beaver-skin quiver filled with arrows. From among these, he took a dried branch of buckeye about as long as the shaft of an arrow, but much larger at one end. From his quiver he also produced a piece of cedar. This was about 18 inches in length, and inch thick, and 2 inches wide in the center, but tapering to a rough point at each end. Its general appearance might be described as boat-shaped. In the center of this piece of cedar, on one side, he had made a circular hole ¼ of an inch deep with a piece of obsidian, and from this hole he had cut a channel extending to the edge of the wood. He now gathered a handful of dry grass, and some fine dry, powdered wood from a decayed pine. Each end of the boat-shaped piece of cedar, with the side containing the hold and channel uppermost, was placed on a couple of stones and held firmly by another Indian. The dry grass was piled loosely under the center, and on it was scattered the fine powder of the decayed wood. The fine powder was also scattered in the channel leading to the hole in the center of the boat-shaped piece of cedar. He now took the branch of buckeye and placed the largest end in the circular hole, and spitting on his hands, commenced revolving it back and forth rapidly between his palms, and at the same time bearing down with considerable force. This constant exercise of pressure, while revolving the buckeye, caused his hands to be rapidly shifted to the lower end of the stick, when he would remove them to the top again and renew the process. At the end of five minutes he was perspiring from the exercise, and no fire had been produced. He stopped a few seconds and said something. I asked Sarah to translate his speech. Sarah told me he was saying, 'Fire, why don't you come to me now as you did when I was a boy?'*
>
> *He repeated these words several times and commenced work again. In another five minutes smoke made its appearance where the two woods were in contact. In a few seconds the powdered dust of the decayed wood took fire, and the fine coals communicated this fire to the dust in the channel, and rolled down the dust scattered on the dry grass. He now took the bundle of grass in his hands and, carefully blowing upon it, soon created a blaze."*[xi]

This account is very explicit in the description of the fire set and how it was used. It describes a fire-drill "about as long as the shaft of an arrow". This fire-drill was rotated between the palms of the hands with no other mechanical tools or assistance.

In 1911 an indigenous man emerged from the foothills of Northern California and became known as Ishi. He had lived his whole life as his ancestors had. He was a veritable walking time machine of knowledge. While it is true that he lived nearly 100 years after men like Ogden and Smith traveled through Northern California, it is also true that he was still living in his aboriginal state, just as his ancestors had. What he taught the anthropologists in 1911 his ancestors could have just as easily taught Odgen or Smith almost 100 years earlier. He is credited with teaching many of his daily skills to the anthropologists who worked with him. Among the skills he taught them was making fire by friction. Ishi's fire set was remarkably similar to the set described above and also carried in his quiver (See Figure 7). His set looks similar to the Zuni one pictured in figure 8.

> *"No manufactured object could be less complicated than Ishi's fire drill, which consists of a lower and an upper piece: a woman piece and a man piece, as he symbolized them. The hearth or lower piece is a flat slab of wood which should be somewhat softer than the wood of the shaft or twirler. Willow or cedar make good hearths, if seasoned and dry and not too old and brittle. One or more sockets are bored or gouged out with an obsidian knife to the depth of a quarter inch or so and notched at one side. The notch leads into a shallow channel cut from the socket to the edge of the hearth.*
>
> *The drill, or upper piece, is an ordinary round stick of a size to fit the hearth socket, about the length of an arrow shaft, but larger at one end. Ishi preferred buckeye for his drills, but sage brush, poison oak, or indeed any fairly hard wood will answer equally well. The making of fire with this drill rests upon the principle of concentration in one small spot, for only so can the human arm twirl fast and long enough to produce sufficient friction between hearth and drill to convert moving wood into heat.*
>
> *When ready to begin drilling, Ishi first strewed tinder—usually dried moss, or thistledown, or finely shredded inner bark of willow—along the notch and channel of the hearth and on the ground where the channel led off the board. He then squatted, holding the ends of the hearth steady against the ground with his toes, or he might occasionally kneel on the hearth to hold it. Next, he placed the drill upright, the larger end in one of the sockets, grasped it between the palms of his open hands as they were pressed together and then rubbed back and forth in opposite directions. With each motion the drill was forced to rotate, first to right, then to left. His hands at the same time were bearing downward, pressing the revolving stick into the socket. Small particles of wood were ground off the sides of the socket, becoming fine sawdust or wood powder which began to turn brown, to smoke a little, to turn darker and darker to charcoal, and to smoke in good*

> *earnest, at the same time being forced by the accumulating mass out of the socket into the notch, along the channel, and so off the edge of the hearth. Ishi, at this point, worked faster and faster as he approached his goal, keeping the stick twirling furiously until a tiny spark suddenly glowed within the charred and powdered wood."*[xii]

With Ishi's help, one of the anthropologists was able to make fire using Ishi's fire set:

> "*Waterman, instructed and aided by an amused Ishi, actually "made fire" in Ishi's drill. Enthusiastic as always, he announced to his class in Berkeley that no one, man or woman, who could not repeat his success need not expect a passing grade in a course with him. Then, brashly, he undertook to demonstrate before his interested and ultimately applauding audience in the old chemistry lecture hall on the campus, how it was to be done. Ishi was not there, and the operation did not go so well without him. Waterman's own temperature rose, he removed coat and vest, working with a will, but a tantalizing thin wisp of smoke was his only reward. The new course requirement died as did the unborn spark at the bottom of Ishi's fire drill."*[xiii]

The Catlin quote of three men taking turns, the quote of the Shasta man struggling to get fire to come for him as when he was a boy and the account of Waterman trying to replicate his success of making fire using Ishi's kit all highlight that it takes time and effort to develop the skill of using the hand fire-drill. The skill is also a degenerative one; meaning it must be used to be maintained. In addition to the actual time and effort required to acquire the skill it helps to have a basic understanding of what is happening during the process.

To generate a coal by friction, the secret is…friction! This is achieved by rotating a wooden fire-drill in a depression of another board (commonly referred to as a hearth). The faster the fire-drill is rotated in the depression, while at the same time applying an increasing amount of downward pressure, the more the friction increases. As the friction increases, the heat increases. As the heat is increasing, due to the friction, little bits and pieces of the wood wear off. These look like dark brown dust (See Figure 9). As the process continues, the newest pieces of dust appear almost black. Pretty soon wisps of smoke rise up. Eventually, the pile of charred dust gets hot enough that a small coal forms in the pile of dust. The hearth boards from the area under consideration almost always exhibit a notch in the side of the depression that allows the char dust to escape in one spot (See Figures 10-15)[xiv]. Thereby concentrating the valuable heat and charred dust in one spot, decreasing the time and effort required to create a coal.

In an effort to understand how the char dust creates a coal, engineer Dick Baugh conducted experiments. In one of his experiments, he used a thermostatically controlled soldering iron to run trials with "various grades of charred wood powder and found that the finer the powder, the lower the temperature needed for ignition…Once good powder reaches the critical temperature, it simply takes off, spontaneously oxidizes, and raises its own temperature, increasing the rate of oxidation, which is finally limited only by the available air. It is at that point of equilibrium a glowing ember appears." He discovered that "fire-drilled charcoal powder merely gives off a

little smoke below 800 degrees but above 800 degrees it smokes, then ignites, taking off on its own, and glows."[xv]

In light of all this evidence, the question remains, "Why is the use of a bow so popular to rotate the fire-drill?" Speaking from experience, it is physically much easier to use a bow not only to rotate the fire-drill but also with the hand held socket to generate much greater amounts of downward pressure. The tradeoff is that a socket, bow and string must be made, in addition to the hearth and fire-drill; a greater investment of labor. There is evidence that the bow was used in the extreme northern latitudes of North America and in some regions of what is now the Northeastern United States.[xvi] Given the fact that it is undeniably easier to make fire by friction with mechanical aides to rotate the fire-drill, perhaps the persistent reference to it in contemporary lore is an outgrowth of movements, such as the Boy Scouts, in the 20th Century, where ease of use was deliberately favored over historical accuracy. The Boy Scouts were never interested in historical accuracy. They were all about survival. The bow drill is an excellent tool to have in your bag of survival tools. Books, such as Larry Dean Olsen's "Outdoor Survival Skills" are about survival, not regional history.

The fact remains that the author only found evidence to support that the fire-drill was rotated by hand in the western United States. Based on this evidence, a contemporary re-enactor striving to portray the skills and experiences of men engaged in the fur trade of the western United States should refrain from using a bow, leather thumb loops or any other mechanical devices to rotate a fire-drill when demonstrating a friction fire. Figures 16 and 17 illustrate a collection of the author's personal fire-drills. All of these have been used to generate countless coals. These show the variety of diameters and lengths possible. Figures 18, 19 and 20 show some additional fire-drills and the variety of used hearths. All of these artifacts fit within the evidence in the archeological record and first-hand accounts. It is possible for the contemporary re-enactor to use the available information to make fire using the tools, materials and processes men engaged in the fur trade of the western United States would have observed and even used themselves (Figure 22).

In conclusion, men engaged in the fur trade of the western United States would have encountered friction fire making devices that consisted of a long fire-drill, some composite—with a foreshaft and a mainshaft, and a hearth. First-hand accounts and the archeological record both support this observation. As reenactors interact with the public to portray the skills these men knew and saw it is important that a similar fire set be used to accurately portray the use of friction to create fire.

Figure 1: Fragment of hearth from archeological record. This particular hearth is the broken end of the bow fragment that was found with the fire-drill in figure 2.

Figure 2: Long self fire-drill of unknown wood, from the archeological record, housed at the Utah State University Easter Prehistoric Museum.

Figure 3: A series of foreshafts made by the author for replica arrows such as would have been encountered by Ogden or Smith in Northern California. The tapered end was inserted into a main shaft and served with sinew and an adhesive agent such as hide glue or pine resin.

Artifacts Housed at the Utah Museum of Natural History That Demonstrate Fire Making in the Archeological Record

Collection	Catalog Number	Object Ty	Object Name	Materia	Site Nu	Other N	State	County	Country	Collector/Excavator
archaeology	42TO20 22132.3	tool: wood	fire drill	wood	42TO20	42TO19 ,U	Utah	Tooele	USA	Jennings, Jesse D.
archaeology	42TO13 23735.1	tool: wood	hearth,drill,fragment	wood	42TO13	U144	Utah	Tooele	USA	Jennings, Jesse D.,University of Utah, Department of Anthropology
archaeology	42TO13 17793.1	tool: wood	fire drill	wood	42TO13	U144	Utah	Tooele	USA	Smith, Elmer R.,University of Utah, Department of Anthropology
archaeology	42SA598FS94.60	tool: wood	hearth	wood	42SA598		Utah	San Juan	USA	Jennings, Jesse D.
Ethnography	ET23459.11	tool: wood	firestarter	wood						
archaeology	824	tool: wood	hearth,fire stick	wood						Cummings, Byron,University of Utah, Department of Anthropology
archaeology	42TO20 22116.15	tool: wood	fire drill	wood	42TO20	42TO19 ,U	Utah	Tooele	USA	Jennings, Jesse D.
archaeology	42BO268FS268.35	tool: wood	fire drill	wood	42BO268		Utah	Box Elder	USA	Jennings, Jesse D.,University of Utah, Department of Anthropology, Archaeological Center
archaeology	42TO20 22132.2	tool: wood	fire drill	wood	42TO20	42TO19 ,U	Utah	Tooele	USA	Jennings, Jesse D.
Ethnography	ET23459.12	tool: wood	firestarter	wood						
Ethnography	ET23459.10	tool: wood	firestarter	wood						
Ethnography	ET10855		fire making equipment	wood						
archaeology	42TO13 19313.9	tool: wood	hearth,drill,fragment	wood	42TO13	U144	Utah	Tooele	USA	Smith, Elmer R.,University of Utah, Department of Anthropology
archaeology	42GA288FS54.2	tool: wood	fire drill	wood	42GA288		Utah	Garfield	USA	Jennings, Jesse D.
archaeology	42SA598FS94.60	tool: wood	hearth	wood	42SA598		Utah	San Juan	USA	Jennings, Jesse D.
Ethnography	ET577.13	tool: wood	fire starter kit,group	wood						
Ethnography	ET23459.8	tool: wood	fire starter	wood						
archaeology	42BO36FS48.144	tool: wood	fire drill	wood	42BO36		Utah	Box Elder	USA	Aikens, C Melvin,University of Utah, Department of Anthropology

Figure 4: A listing, by catalog number, of artifacts housed at the Utah Museum of Natural History related to fire making as evidenced in the archeological record.

Figure 5: Fire-drill foreshaft of sagebrush, from the archeological record, housed at the Utah State University Eastern Prehistoric Museum.

[xvii]

Figure 6: Note the base of the spindle, that there is evidence it is a composite spindle with a foreshaft.

Figure 7: Ishi's fire spindle and hearth board. [xviii]

Figure 8: Zuni fire spindle and board. Note the similarities between this and Ishi's, in figure 7. [xix]

Figure 9: Distal end of a fire-drill next to the baseboard or hearth. Note how the char dust is pushed out through the notch in the side of the hearth.

Figure 10: Fragment of a hearth from the archeological record.

Figure 11: Fragment of a hearth from the archeological record.

Figure 12: Fragment of a hearth from the archeological record.

Figure 13: Fragment of a hearth from the archeological record.

Figure 14: Fragment of a hearth from the archeological record.

Figure 15: Fragment of a hearth from the archeological record.

Figure 16: Collection of the author's spindles showing the typical wear on the distal end. Over time a spindle gradually shortens as a little is worn off with each use.

Figure 17: The same collection of the author's spindles showing the comparative lengths. Exact length depends on available resources and personal preference.

Figure 16: This baseboard, or hearth, and these two spindles were removed from the author's quiver for the purposes of this article. They represent the 'average' everyday carry as used by the author.

Figure 17: Collection of base boards or hearths representing the author's average work.

Figure 18: Another collection of baseboards or hearths and a spindle or fire-drill representing the author's daily use.

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Figure 19: On a family walk through the desert of southern Utah, the author found a piece of chert, used it as a knife to cut a notch in a native yucca stalk that was growing along the path. This was used as a baseboard or hearth. Another yucca stalk was used as a fire-drill. This set was used to light the evening fire.

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