Chapter 2

Literature Review

2.1 Patented Geometries

July 7, 1936, four patents were awarded to Henry F. Phillips inventor of the famed Phillips-type screwdriver bit and screw. These patents are listed under the areas of "Screws" (U.S. Patent #2,046,343), "Means for Uniting A Screw with a Driver" (U.S. Patent #2,046,837), and two separate patents on "Screw Driver[s]" (U.S. Patent #2,046,840 and U.S. Patent #2,046,838), the latter of which was co-authored by Thomas M. Fitzpatrick. These four patents have one common claim over other fasteners of the time, namely, the Phillips geometries allow the driver to be self-centering when mated with the screw.

2.1.1 U.S. Patent 2,046,837

In U.S. Patent 2,046,837 "Means for Uniting a Screw with a Driver", Phillips claims a bit geometry that when united with a screw is self-centering and creates a firm wedging engagement. According to Phillips, this alignment and engagement is superior when driving screws in difficult-to-approach areas. Unlike when driving slotted screw, with the Phillips both hands are not needed to guide and stabilize the screw during advancement. Phillips further claims that the failure of a slotted bit to retain contact with the screw in power driving applications is dangerous to both operator and work piece. His geometry claims to improve upon this.

2.1.1.1 Cam-Out Claim

Phillips additionally claims that his geometry is such that any foreign particles found in the recess of the screw will be dislodged by a camming or wedging action. This camming action is a result of the bit and screw's angular planes

approaching one another with respect to any particle lodged in the recess. Phillips claims a simple downward thrust of the bit into to the screw will create this camming force. It is important to note that this camming action claimed by Phillips is not the same as the phrase "cam-out" that is used by industry and cited by Bailey in his September 15, 1988 article. In a later patent "Hy-Torque Drive Tool" [Cummaro] "cam-out" is referred to as "throw-out". In modern terminology, "cam-out" refers to the separation of the bit and screw that can occur when torque is applied to a driver. "Cam-out" is further defined in sections 1.3 and 5.4.1 of this thesis.

2.1.2 U.S. Patents 2,046,343 and 2,046,838

Phillips, understanding the need to look at both the bit and screw together, filed for two additional patents in 1934. These patents titled "Screw" (2,046,343) and "Screw Driver" (2,046,838) were awarded to Phillips in 1936. These patents were designed specifically for operative engagement with one another. Phillips specified that the driving contact surfaces of both bit and screw be flat, which he claims allows maximum surface contact. He additionally claims that the screw and driver combination is self-centering.

2.1.3 U.S. Patent 2,046,840

Phillips fourth patent, awarded to him in 1936 with Fitzpatrick as co-author, is also title "Screw Driver" (2,046,840). It is also self centering. This patent presented a new geometry, which, like his 2,046,837 patent, he felt was ideal for use with power drivers. What made this patent significantly different from his others is that he claimed this geometry not only as a driver but also as a punch in the process to manufacture screws. This approach allowed the manufacturing of screws, by the processes of cutting, rolling and stamping, that could mate with his geometry. Since casting screws was costly and broaching left screw heads extremely fragile, this invention provided the first manufacturing method to reasonably produce screws with a cruciform recess.

2.2 Cam-Out

Bailey, a columnist for the Wall Street Journal, said that Phillips bits are one of the worlds least loved inventions because of their tendency to slip out of the screw recess while attempting to drive the screw [Bailey]. This "cam-out", as it is referred to in industry, was not a result of an innocent design flaw claims Bailey. According to Bailey, Phillips designed the bit so that when used in automated assembly lines the bits would pop out, he claims the bit was designed to "camout". However by reviewing Phillips's patents, this does not appear to be the case. Unfortunately, Phillips's claim of a camming or wedging action to dislodge foreign particles found in the screw recess has created confusion. Phillips's claim of camming out or crowding out of substances found in the screw recess [Phillips 2,046,837] has nothing to do with the term "cam-out" as Bailey and industry uses it today.

2.2.1 Damage Due to Cam-Out

Although Phillips claimed that, because of the perfect fit of his bit geometry with the screw, screws could be driven and removed innumerable times without the slightest indication of mutation to the screw head [Phillips 2.046,837], that is not the case. Even Ben Taber, President of Phillips Screws, admitted his frustration with the Phillips fastener. Apparently Taber had stripped the heads of the Phillips screws on his storm windows at home and had considerable trouble removing them [Bailey].

2.2.2 Designing Against Cam-Out

Many attempts have been made to eliminate cam-out. In 1958, Louis Cummaro was issued a patented "Hy-Torque Drive Tool". The primary purpose of this new design was to significantly reduce "cam-out" or as he called it "throw-out" [Cummaro]. Cummaro's patent documents the problems of "throw-out" and the

large axial force that is needed to overcome it, especially in applications with heavy driving torque, as with power drivers. Cummaro also addressed the issue of off angle driving and the problems associated with it, namely damage occurring when the bit gouges into the screw.

2.3 Driver Standards

The American Society of Mechanical Engineers (ASME) and the Department of Defense have both issued standards pertaining to the specifications of acceptable Phillips bits. The ASME standard specifies many of the geometrical features of the bit in addition to material specifications. Examples are the diameter of the terminal end and tolerance of the angle between the wings. The surface contact geometry however is not clearly specified. The drawings of the bit and the gages to check the bits imply that the contact surface of the bit does taper with respect to the long axis of the bit [ASME]. The Department of Defense standard like the ASME standard specifies several geometrical dimensions but does not specifically define the surface contact geometry. The drawings of the bit geometry appear to taper, but the gage block drawings are not clear [DODSTD].

2.4 Screw Standards

The standards for screws with crucifix recesses published by the National Aerospace Standard Committee, formerly the National Aircraft Standard Committee, clearly list exact material and geometrical specifications for the screws. To define the geometry of the recess, most simply refer to the recess as "Phillips Recess". Although many refer specifically to Phillips Recess Standard #2, #3, and #4 [NAS 204 to NAS 211], others refer to the recess as simply "Phillips Recess" [NAS 200, NAS 201 & NAS 1402 to NAS 1406]. A single standard specifies the crucifix recess to be a "Frearson Recess" [NAS 212]. Two of the standards published by the Screw Research Association do not define the recess geometry [SRA-PHS-1A, SRA-PFD-6], but the standard for the recess punch does [SRA-PP-1A].

The contact walls of the Phillips screw recess do appear vertical (meaning parallel with the long axis of the screw, or non-tapering) in most standards [NAS 200, NAS 202, NAS 204 to NAS 211 & SRA-PP-1A]. In a few standard however, the recesses are not vertical [NAS 1402 to NAS 1406]. These recesses are not vertical despite the fact that they call for the Phillips recess just as some of the previously mentioned standards (which appear to specify straight walls) do [NAS 200, NAS, 202]. A single standard does call for a crucifix recess but its geometry is specified as a "Frearson Recess" [NAS 212]. The "Frearson Recess" does not have vertical walls.

2.5 Design Methods

Metal hardening and improving geometry can be used to develop bits with improved wear resistance. Metals can be hardened to reduce wear by selecting high carbon and silicon-based steels such as S2 and 8660 as well as implementing heat treatments in the manufacturing process [Becher; Becher & Withefered; Kirkaldy]. Improving wear performance via geometry can be achieved by designing bits based on force transmission and surface contact laws [Mabie & Reinholtz; Shooter, West & Reinholtz].