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M3 Design Product Teardown
Kobalt Double-Drive™ Screwdriver

Why do the product teardowns?
Part of the product development process is to apply knowledge gained from prior experience during the concept development and design phases. Some experience comes from actively designing something in the past while other experience is gleaned from more indirect sources. It is this indirect product development experience that we gain via product teardowns.

Teardowns are different from reverse engineering
Reverse engineering is nothing more than figuring out the design and manufacturing methods of a product, typically for copying. Conversely, M3 Design views product teardowns as ways to gain insight into the design to become better product developers. We focus on "why" questions.

• Why did the designer make the choices they did?
• Why were specific construction techniques chosen?
• Why were certain features included and others left out?
• Why was the particular design approach chosen?

This serves to gain more in depth understanding into the product's design rather than a superficial once-over.

How does M3 Design approach product teardowns?
Our teardown process is a rigorous approach to carefully catalog the product’s deconstruction in both pictures and written descriptions. This procedure serves two purposes:

1. It forces the deconstruction team to carefully investigate the product pieces and learn as much about the design details as possible.
2. It provides a detailed record of the process for future reference by other designers.

The end result of this meticulous process is the beneficial expansion of applicable knowledge regarding product designs. We employ the lessons and insights garnered from these teardowns during brainstorms, design, prototype development, and troubleshooting. This method of obtaining indirect product development experience is just one of many important tools that sets M3 Design apart from other product development firms.
Overview

The Kobalt Double Drive™ screwdriver (Figure 1) sounded like a violation of mechanical efficiency: 2X output from 1X input. We had to figure out how this mystery mechanism functions – time for a teardown! The kit came with two Double Drive™ screwdrivers: large and small. Ironically, we used the small screwdriver to disassemble the large screwdriver (Figure 2). How cannibalistic...

External Construction

On the surface, the Double Drive™ screwdriver looks like any typical multi-tip screwdriver. It behaves like a typical ratchet screwdriver—the Handle drives the tip when turned in one direction but spins freely when rotated in the opposite direction. However, there is a blue aluminum Trim Ring (Figure 3) that, when held with a second hand, makes the tip turn in a single direction when the Handle is turned both clockwise and counterclockwise! Clearly there is an interesting mechanism inside that allows this.

Additionally, the Direction Switch translates along the axis of the screwdriver body to toggle between drive directions. On many ratcheting screwdrivers the Direction Switch rotates radially. The next step was to get some tools and take the thing apart.
Systems
After some work to remove a retaining ring deep in the Handle (which included a trip to the band saw), we were able to access the internal mechanism.

The overall system consists of several subsystems (Figure 4):
- Input Gear (permanently fixed to the Handle)
- Transmission
- Output Gear
- Clutch Sleeve
- Drive Shaft
- Direction Switch

The aluminum Trim Ring is held to the Transmission with four screws. There are multiple parts within each of these subsystems that enable the one-way drive and change the drive direction, which will be explained in detail later.

Figure 4: Exploded view of the Double Drive screwdriver
Input Gear

The Input Gear is a straight-cut bevel gear with the Handle overmolded around it (Figure 5). We didn’t try to separate the two but did notice that the Input Gear has six spline features that allow very high torque to be transferred from the Handle to the Input Gear (Figure 6). The Handle/Input Gear slid over the Drive Shaft, Clutch Sleeve, and Clutch #1. The bore appeared to be post-machined to obtain the final diameter required for the Clutches to function correctly.

Figure 5: Input Gear & overmolded Handle

Figure 6: Input Gear splines to transmit torque
Transmission

The Transmission consists of a Molded Carrier with two smaller straight-cut Bevel Gears mounted on either side (Figure 7). The carrier/gear assembly fits inside of the blue aluminum Trim Ring (Figure 8). Looking closely at the Bevel Gears we determined that they are cast steel parts but do not appear to have any post-cast machining done to clean up the bores. Each Bevel Gear also has a separate flanged Bushing that fits between the Bevel Gear bore and the Molded Carrier post. This serves as the rotational contact surface for the gears, thus avoiding wear on the Molded Carrier.

Also, because of the slanted teeth on the Bevel Gears, any axial input force on the tool pushes the Bevel Gears in a perpendicular direction (radially outward). The flanges on the Bushings act as thrust bearings to eliminate wear between the Bevel Gears and the aluminum Trim Ring (Figure 9).

![Figure 7: Transmission on screwdriver (Trim Ring is slid forward)](image)

![Figure 8: End view of Transmission inside Trim Ring](image)

![Figure 9: Close up of disassembled Transmission](image)
Output Gear

The Output Gear is similar to the Input Gear, except that it is not permanently fixed to another part (Figure 10). Instead the back side of the Output Gear has a radial array of Roller Balls (Figure 11). These Balls press against a steel thrust washer set into the plastic Direction Switch housing, creating a custom thrust bearing assembly. This thrust bearing provides smooth rotary motion between the Output Gear and Direction Switch without wearing the plastic of the Direction Switch housing. The bore appears to have been post-machined to the final diameter, just as the Input Gear has been.
Clutch Sleeve and Drive Shaft

The parts that allow the Double Drive mechanism to transmit torque are two rolling-element friction Clutches housed within the Clutch Sleeve. Each Clutch consists of three Rollers arranged equally around the tri-lobed Drive Shaft (Figure 12), which is a pretty common type of roller clutch used in many off-the-shelf design configurations. The Input Gear surrounds a set of three Rollers in Clutch #1 and the Output Gear surrounds another set of three Rollers in Clutch #2 (Figure 13).

As the surrounding Gear (either Input Gear or Output Gear) rotates in one direction, it forces the Rollers to roll up the triangular lobes—rising radially outward—until they are trapped between the Drive Shaft lobes and the Gear bore. The Rollers are wedged in place and friction transmits torque from the Gear, to the Rollers, and finally to the Drive Shaft (Figure 14).

When the surrounding Gear rotates in the opposite direction, the Rollers ride down the triangular lobes and fall radially inward, thus providing a very small amount of clearance between the Gear bore and the Rollers. This clearance allows the Gear bore to slide past the Rollers and therefore not transfer torque (Figure 15). The clearance must be very small and held accurately during manufacturing in order for the Gear bore to catch the Rollers when transmitting torque. In fact, we measured the Input and Output Gear bores and they are within 0.01mm (.0004”) of each other.
Both Clutches position the Rollers in the same location on the Drive Shaft lobes. This means that the Input and Output Gears both drive the shaft in the same direction. What ties all these items together is the Transmission, as explained in the next section.

**Direction Switch**

The Direction Switch assembly consists of a plastic housing and plastic thumb switch that can be moved between two positions (Figure 16). A metal pin protrudes from the thumb switch and fits into a barrel cam feature molded into the plastic Clutch Sleeve. When the thumb switch moves between the two positions it causes the Clutch Sleeve to rotate approximately 60°, and positions the Clutch Rollers on different lobes of the Drive Shaft (Figures 17 & 18).
Force Path

The force path from Handle to Drive Shaft changes, depending on which way the Handle turns. For the double drive feature to function, the user needs to hold the blue Trim Ring with one hand while rotating the Handle with the other hand. Holding the Trim Ring stationary allows the Transmission to transmit the rotary motion from the Input Gear to the Output Gear. If the Trim Ring is not held then the screwdriver acts as a regular ratcheting screwdriver where it transmits torque in one direction and freewheels in the opposite direction.

When the Direction Switch is in position #1, the Clutch Sleeve is at 0°. Both Clutches will drive the shaft clockwise (as viewed from the bit end of the Drive Shaft). When the Handle drives clockwise, the Rollers in Clutch #1 engage the Drive Shaft and the Drive Shaft turns clockwise too (Figure 19).

Clockwise rotating Handle force path:
Input Gear → Clutch #1 rollers → Drive Shaft

As the Input Gear turns clockwise, the Transmission forces the Output Gear to turn in the opposite direction (counterclockwise). Because the Clutch Sleeve is at 0° and the Clutch Rollers are positioned so that they will only drive the shaft clockwise, the Output Gear slips over the Clutch #2 Rollers and transmits no torque to the Drive Shaft.
When the Handle turns counterclockwise, the Input Gear now slips over the Clutch #1 Rollers and transmits no torque to the Drive Shaft. The Transmission makes the Output Gear turn in the opposite direction (clockwise) and therefore engages Clutch #2 to turn the Drive Shaft in the clockwise direction (Figure 20).

**Counterclockwise rotating Handle force path:**  
Input Gear → Transmission → Output Gear → Clutch #2 rollers → Drive Shaft

When the Direction Switch is moved to position #2, the Clutch Sleeve is shifted 60°. This 60° shift moves the Clutch Rollers toward an adjacent Drive Shaft lobe. Both Clutches will now drive the shaft counterclockwise (as viewed from the bit end of the Drive Shaft). The operating mode is the same as before, but the Clutches now turn the Drive Shaft in the counterclockwise direction.
Conclusions

Like many product teardowns, this one yielded many interesting mechanisms. Each subsystem is fairly simple by itself and yet the combination of these elements makes an elegant product. There is quite a bit going on internally with the Transmission and dual Clutches to make the Double Drive mechanism work.

Most of the cost will be in the cast steel component tooling and manufacture. The key to quick payback is to limit the post-machining required for part functionality. The Input and Output Gear bores appeared to be the only items that received such machining, in order for the Clutches to function properly. Backlash between gears is likely not an issue for a hand-operated product.