Background

Approximately five years ago I made plans to leave the northern Virginia suburbs, rich in their C&Rs[1], and head to the country where I could erect a tower. While I would have liked to purchase a tower new, the freight costs from the US Towers locations of Kansas City, Missouri or California were oppressive to me. I began, in earnest, to watch the qth.com and eham.net websites for used towers within a reasonable driving distance. This culminated in my purchase of a used, approximately twelve year old US Towers TX-472.

Initially I shrugged off the idea of manually cranking this tower up and down, thinking this would be good exercise, and "why the concern over a little work out". Now five years older, hopefully a little wiser, currently enjoying no rotator cuff difficulties, and having acquired considerable experience cranking my tower up and down, I want to motorize the process. As most hams familiar with the US Towers product line will tell you, the company will not sell you an after-market raising and lowering system unless you return your tower to their factory. This costly option borders on ridiculous in my mind for the two-fold reason of double freight costs. Having studied a newer, positive pull down US Towers HDX-555 I just acquired, I understand why the tower must be returned to the factory; the modifications are out of reach of most amateurs. Implementation of a similar system would require I tip my tower over for the retrofit. I theorize, however, that the non positive pull down winch would be post-market installable by many, but as already stated, it is not for sale.

In the following pages I outline my solution to the problem. Due to the age of my tower there are differences between it and the newer TX-472s so a "copy and paste" of my implementation will require modification, unless of course your tower is of the same vintage as mine.

K0ZR Solution - Introduction

The remainder of this report details my solution. The design centers around the use of a Dayton 608A gear motor. The motor is coupled via a size 40 chain to a Fulton FK2550 manual winch. This winch is an upgraded, 2500 lb capacity winch, replacing the OEM 1500 pound winch normally shipped with the tower. This is an important point which will be elaborated on later. Steel fabrication and welding are required for this project. At the time of purchase (~ 2011) the Dayton gear motor cost ~ $ 750 so this is not a cheap solution.

Caution, Caution, Caution

While this all sounds simple, it is not due to the torques and forces at play in this implementation. With the weight of the tower and over 200 lbs of antennas, rotator, and mast at the top, approximately 25 pounds of radial force at the end of the 11" winch handle is required. This is replaced by torque applied only about 1 ½ inches from the winch drive shaft through a chain sprocket. Doing some simple torque arithmetic shows that the 25 pound force is now on the order of 185 pounds. Without the final reinforcement of the drive shaft (described later), unacceptable compliance of the 2 ½" by ½" steel plate and the channel iron it is mounted to occurs. You must be careful in a project like this.

[1] Covenants and Restrictions

The Details

Gear Motor

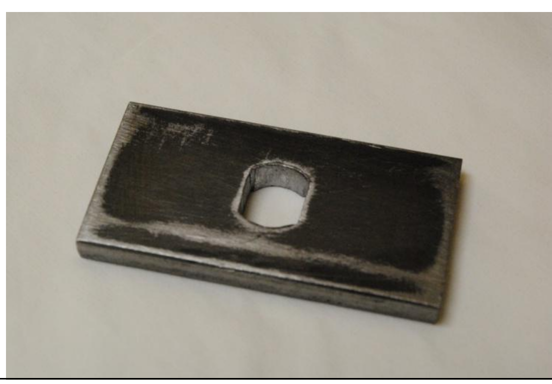
The faceplate specifications for the Dayton 608A gear motor are shown in the two images below for reference.

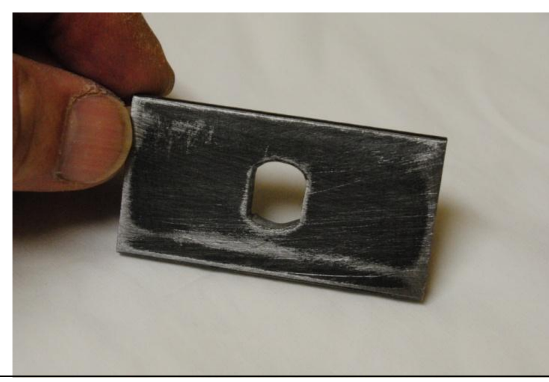
One can readily see that the motor is ½ HP and careful attention must be paid to its wiring. The motor is controlled by a phase reversal switch (~ $75) which must be properly wired or you will not have favorable results. The details of the wiring are on the "Marathon Electric" faceplate above. While this gear motor is suitable for mounting outdoors, I plan to place some type of "roof" over the assembly to afford some additional protection from the elements.

The criteria leading to the selection of this Dayton unit are the following: a) suitable for outdoor environment, b) delivered torque, c) suitable RPM range, and d) cost. As already mentioned, this unit is suitable for outdoor applications and does have a rather high service duty factor. The rated torque is 490 in-lbs and as mentioned several paragraphs earlier, a torque approaching 200 in-lbs is required. The 490 in-lbs figure provided sufficient margin at the time of ordering given the infancy of my design at that time. The highest RPM of the motor is 1665 RPM and with its inherent 28:1 gear reduction factor, leads to a rate of rotation of 60 RPM. Experience may reveal this is too fast, however this can be ameliorated by a different selection for one of the chain-drive sprockets. My own experience showed that a cranking rate of approximately 50 turns per minute was not unreasonable.

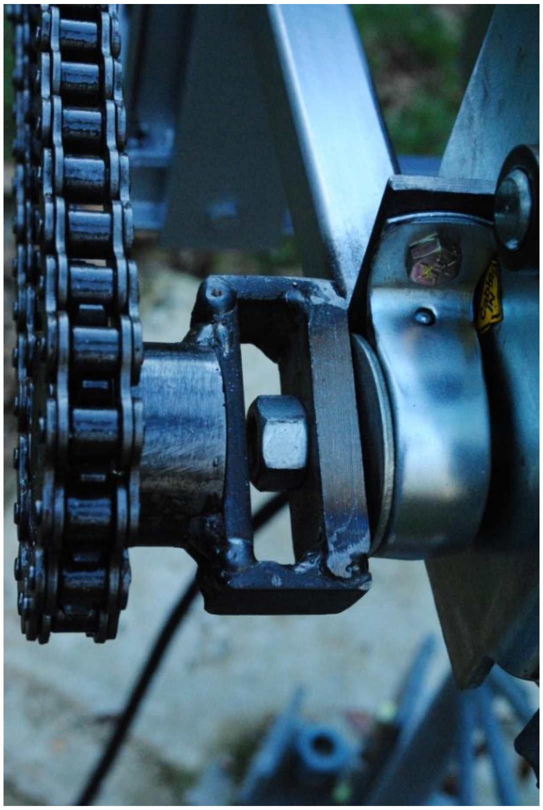
Weakest Part of the Design

The weakest part of the overall design is depicted in the figure below. This is a 1" by ¼" steel plate which interfaces with the shaft of the FK2550 winch in place of the crank handle. The hole must not only be centered, but has the added difficulty of a somewhat unusual shape. The steel used for this is <u>not</u> tool steel, so it is softer and likely to "open-up" unacceptably with use. The piece in the referenced figures was fashioned manually using a drill and multiple files. It is challenging to get a tight fit. With my design now proven out, I will likely approach a local fabricator about making a replacement for this using the much harder tool steel.





The picture below, while getting a little ahead of the story, illustrates the manner in which the steel plate is welded into an assembly for the winch shaft. Seen here is a 3 1/2 ", 40 chain sprocket welded to the small steel rectangle. The "open space" is required to attach the nut to the winch axle.



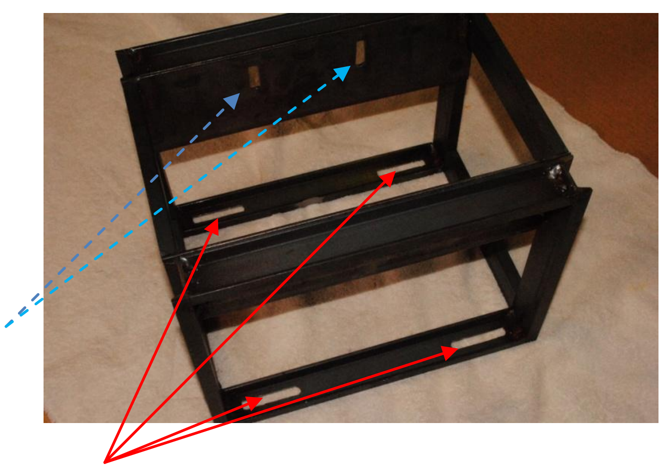
The sprockets used in this project are available at Tractor Supply or similar hardware store. They are designed to be used in a keyed configuration or suitable for welding as illustrated to the left. Unfortunately the winch shaft is not "keyed" in a manner accommodating these sprockets.

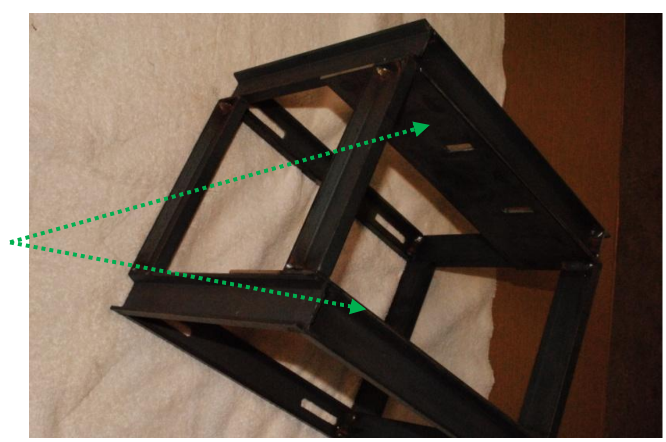
Proceeding from the left we see the 40 chain and its sprocket, welded to the small rectangular steel assembly forming the interface to the winch axle. Between this and the winch is a ¾" hole washer, followed by a thrust bearing mounted in its holding assembly. This thrust bearing is *absolutely imperative*. As later photographs will show, it is attached at only one end, to the cage holding the gear motor. As seen, there is just enough room to squeeze all of these things onto the shaft of the winch. Additional research would likely produce a thinner profile thrust bearing making this part of the design less critical.

Recognizing this as the weak part of the design, I placed inquiries with several winch vendors regarding the availability of "interface plates" or assemblies suitable for this design. To date no sources have been identified.

Home for the Gear Motor

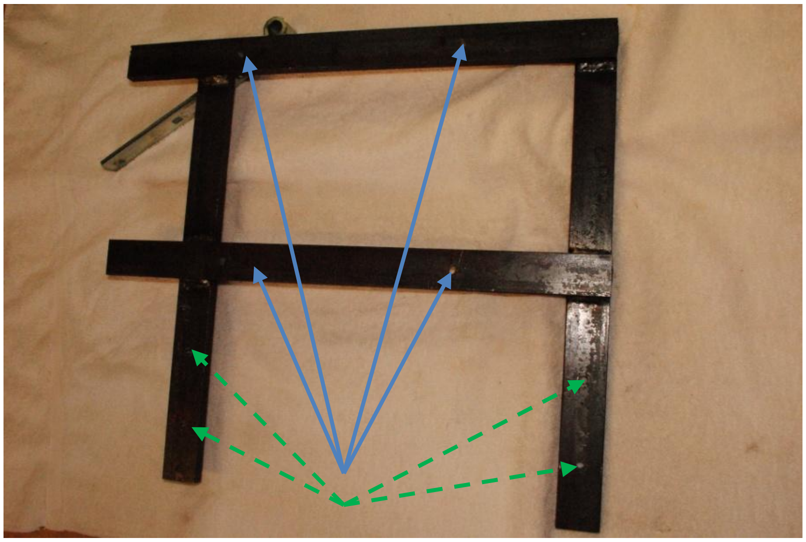
Some provision is necessary to hold the gear motor in a favorable position for interfacing with the winch. My solution to this requirement is shown below in two pictures take at different angles for further illustration.





Shown by the dashed arrows in the figure above (in blue if you are seeing this in color) are two rectangular holes for mounting of the gear motor. This steel plate is replicated on the bottom (difficult to see in view) with another set of holes for mounting the motor (the motor mount has four holes). The two plates are identified in the right figure, above, by the green dotted arrows. The holes are slotted to allow the gear motor to be shifted in +/- y directions, thus allowing alignment with the sprocket on the winch axle. This is necessary to alleviate any binding of the chain (obviously not good). The four red arrows (solid lines) on the left figure, above, are the slots to allow attachment and movement of the steel frame in the +/- x directions. These accommodations are mandatory in order to attach the chain to the sprockets before drawing out the slack in the chain. A taut chain is another mandatory feature of this design.

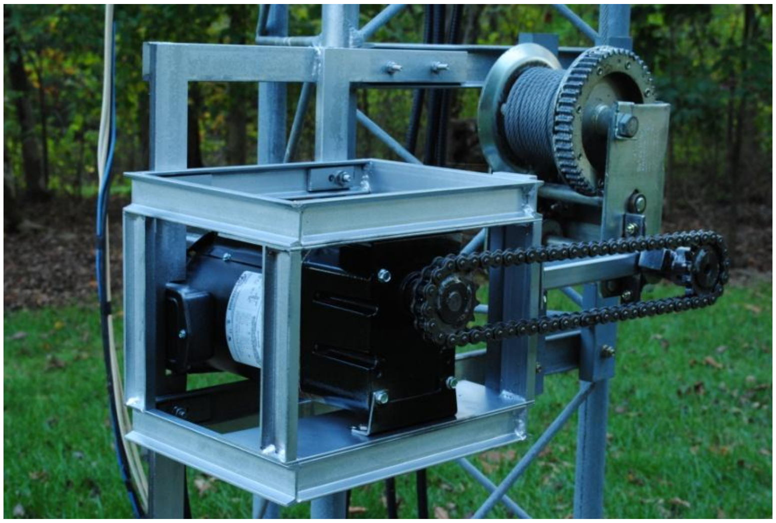
Mounting to the Tower



Mounting to the tower is accomplished with the assembly to the left. Each member is 2" x ½" steel plate. The blue arrows (solid lines) identify the holes used to attach the cage assembly just discussed. The green dotted lines are the holes used to attach to the tower.

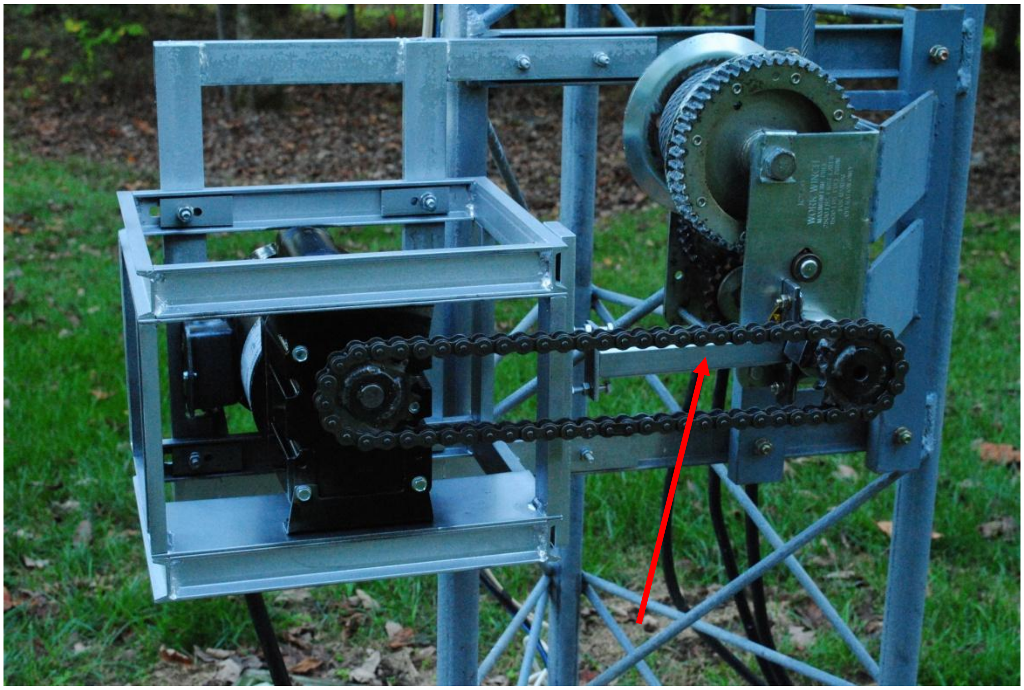
On my tower, two, 2 ½" channel iron are welded across the face of the tower specifically for mounting the winch. The 2" plate steel used here fits nicely in that channel making a very tight fit. In later generation US Towers, the tower cross members are formed using a continuous steel rod filament thus precluding this mounting approach. In this scenario it may be the case that another steel plate spanning the face of the tower will need to be welded to the tower legs for mounting of the gear motor (two points of attachment).

Completed Assembly

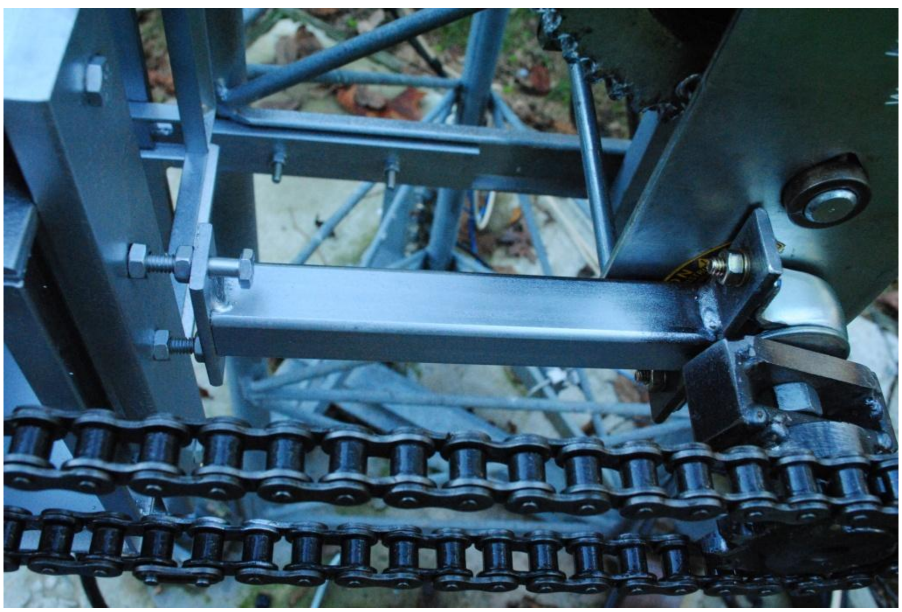


The remaining details of the assembly will be evident in the accompanying pictures.

To the left, the completed gear motor – winch assembly is shown. Things of note include: a) use of small ¼" thick steel plates in the channel iron of the cage for rigid attachment; b) taut chain; c) manner of attachment to the tower.



The picture to the left reveals further details of the construction. Of particular note is the steel member between the winch axle thrust bearing and the attachment to the right side of the gear motor cage. This is identified by the red arrow in the figure. This member greatly restricts any oscillatory movement to the left and right between the gear motor and the winch. It is *mandatory* or the chain may "eat itself". Without this added reinforcement the 2" x ½" steel plate members were complying to the degree that the top and bottom of the chain run would almost collide. Structurally such an oscillation cannot be tolerated as well, if for no other reason than fatigue to the welds, etc.



To the left is a close-up of this important restraining member. The left side is somewhat floating, with force in +/- x directions being provided by the positions of the nuts on the two grade 8 bolts. If detached on the left, the assembly will just free-rotate on the winch shaft bearing to a vertical position. All the force is in the +/- x directions, provided everything is lined up ☺.

Closing Commentary

Unless you are somewhat seasoned in this type of work, this may not be a project you should attempt. You run the risk of not only hurting yourself but also damaging your tower, antennas, etc. In forming this assembly I used a steel bandsaw cutter, Miller MIG welder, drill press, and lots of manual filing and grinding.

I replaced the OEM mount for the original winch with a much stronger and wider mount for the Fulton FK2550. This caused dimensions to grow somewhat because the FK2550 is considerably larger than the standard issue FK1550.

The down-side of using the FK1550 is its smaller gear reduction ratio. Accompanying this change will be an increase in the required torque from any mechanized raising and lowering option. This is an unfavorable consequence leading to a possibly shortened life of the gear motor and adding further strength requirements to the overall assembly. In selecting the gear motor one must balance available torque and RPM.

At several times I have considered replacing the Fulton FK2550 winch with a worm gear winch. With such a winch no consumable friction pads are used and there is little to no chance of movement up or down without external forces being applied to the winch shaft. Based upon photographs I have seen to date, there may be insufficient clearance to mount a winch axle thrust bearing in the worm gear winches. More research is necessary.

Areas for improvement:

1. Machine aforementioned critical assembly (winch interface) out of tool steel (in progress)
2. Enlarge the 2” x ½” steel frame and gear motor cage in the left-to-right dimensions, thus providing more clearance in the +/- x directions
3. Mount the 2” x ½” assembly to the tower with larger bolts (next weekend)
4. Provide some weather resistant features to the gear motor housing, such as a small roof and extension over most of the chain (two weekends later)
5. Use larger (i.e. 5/16”) bolts to establish the tension between the gear motor cage and the shaft thrust bearing on the winch.