ELECTRIFIED FLADRY for

DETERRENCE OF GRAY WOLVES (*Canis Lupus*)

An Evolving Manual of Best Practices

By

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PEOPLE AND CARNIVORES

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Introduction

This manual is for anyone installing fladry or considering its use as a proactive carnivore conflict prevention tool. The original manual was written by Steve Primm and Bryce Andrews of People and Carnivores, a nonprofit dedicated to preventing human-carnivore conflicts, and Amy Robinson of the Sun Ranch Institute. Through a decade of deploying fladry, including stretches more than four miles in length, we have garnered many important lessons. We are certain that other fladry practitioners have made similar discoveries and have developed useful techniques. In the following pages, we have done our best to give a concise summary of the possibilities, challenges, and best practices associated with using fladry in the field.

Background

There are many tools for reducing wolf predation on livestock (Shivik 2004). Among these, fladry shows great promise in excluding wolves from pastures. Anecdotal evidence from field trials shows that fladry may be an ineffective deterrent for grizzly bears, mountain lions, and other species. As such, this manual refers to fladry as a tool for wolf deterrence since it has been tested and used for years for this purpose.

Fladry consists of a line of cordage from which flags are suspended. Field experiments demonstrate that properly deployed fladry can be effective for as long as 60 days (Musiani et al. 2003). Electrified fladry—fladry combined with sufficient electrical current—is even more effective when properly deployed. Research indicates that electrified fladry (aka “turbo fladry”) has a longer duration of effectiveness (Lance 2009).

While electrified fladry has the potential to be highly effective in excluding wolves from pastures, adoption of this tool remains limited. There are several reasons for this: high capital costs (approximately $2,600 per mile for fladry, excluding labor, $600 for energizer with battery, and $400 for posts); limited availability of fladry; and skepticism about effectiveness.

Fladry can also be difficult to deploy without proper equipment and training. Because the flags create voltage leaks when they touch other objects, a powerful fence charger is required to keep sufficient voltage flowing through electrified fladry. Topography and other particulars of the site must also be considered, as the flags can become tangled in vegetation and fences making them ineffective deterrents.

Despite the tool’s steep learning curve, fladry can be an effective and efficient strategy for proactively addressing potential wolf conflicts. Significant strides have been made in the past decade in the application, installation, and breakdown of fladry systems. When fladry was a relatively new technology, deployment was extremely labor intensive. Lance (2009) documented labor inputs of roughly 32 person-hours per kilometer of fladry, or approximately 50 person-hours per mile. As a mile of fladry is required to surround a 40-acre pasture—a size typically used for calving—the labor cost has historically driven ranchers to abandon the tool. Today, however, fladry can be deployed at a rate of 7 person-hours per mile with appropriate technology and a trained crew and can be uninstalled even faster.

Once fladry has been erected, it is essential to keep it effectively deployed. Wind, precipitation, and ungulates can cause fladry to sag, collapse, or become dismantled. While there are many similarities between a conventional polywire fence and electrified fladry, the weight and wind resistance of the flags themselves add a new dimension. If fladry is to be effective, it must be checked and maintained regularly. Such maintenance—which typically amounts to 1 person-hour per week for a fladry fence in good condition—can be integrated into the daily ranching routine.

A fladry enclosure often follows the contours of an existing pasture. For user convenience, the fladry line must duplicate every gate in an existing permanent pasture fence. Where the electrified fladry line crosses existing fence lines, care must be taken to keep the wires properly insulated to avoid voltage shorts.

While there are challenges to using fladry, there are many anecdotal accounts of its successful use, as well as strong evidence gathered from field trials. We have utilized fladry on many projects with no losses, and have found the tool particularly well suited for use in calving pastures or other small, high-risk grazing units.

How to Install Fladry

In this section, we provide instruction and photos related to the deployment and maintenance of fladry. As we mentioned in the introduction, fladry's effectiveness depends on efficient and proper installation.

A. Spooling fladry

After multiple deployments, we have taken a hard look at what makes fladry

Figure 1: Hand coiling fladry is extremely inefficient.

deployment so potentially inefficient. With numerous experienced workers, we repeatedly found the biggest time sink was in dealing with hand-coiled fladry. Even when neatly coiled, it is unwieldy and prone to tangling. Also, ¼ mile coil of fladry (1320 feet) is fairly long, somewhat heavy, and a handful even for people with large hands. Thus, workers inevitably set the coils down or try to hang them on fences when carrying them in the field —another opportunity for tangling.

Figure 2: Fladry spooler 2.0 in action.

Most professional graziers insist on using spools or reels for handling temporary electric fence wire in the pasture because tangles waste time and make fence construction unpredictable and inefficient. Adding flags to the polywire makes the tangling problem exponentially worse. Thus, we cannot stress enough that fladry needs to be spooled up. Fladry on a spool has greatly improved our efficiency, as well as making fladry easier to store.

Other users have noted the potential efficiency gains of spooling fladry, and have developed their own methods and equipment. Our fladry spooler is a simple machine with minimal moving parts, and can be constructed from readily available parts with no custom machining required. Complete details and a parts list are available in Appendix A. Our larger spools will hold more than 1½ miles of fladry, depending on how tightly it is wound up. We have found that 1½ miles of fladry makes a very heavy spool, so we generally limit our quantities to between ½ and 1 mile per spool.

Figure 3: 1.5 miles of fladry on one spool.

Because of the bulk of the flags, fladry requires a far larger spool than does bare polywire. Therefore, when considering a spooling device, think big: 6 inch minimum bare spool diameter and 11 inch minimum spool width. While there are many excellent electric fence reels available, these are generally too small to hold more than a trivial amount of fladry.

B. Carrying and driving posts

As with any temporary electric fence, fladry needs to be attached to something to keep it at the correct height. The most popular and economical choice is $^{3}/_{8}$ inch x 4-foot fiberglass rod posts. Handling dozens of these posts in the field, while also wielding a hammer to drive them in the ground, can be challenging. One unique solution was suggested to us by a professional grazier in Wyoming: use an old golf bag. The fiberglass posts slide into the golf club slots. Workers can sling the bag across their torso, allowing them to carry roughly 40-50 posts hands-free. Having both hands free allows the worker to pull a post from the bag with one hand, position it, and then tap it into place with a hammer in the other hand. This dramatically shortens deployment time over carrying the posts in one's hands.

Figure 4: Golf bag filled with fladry posts; bag pockets can be used to store small parts.

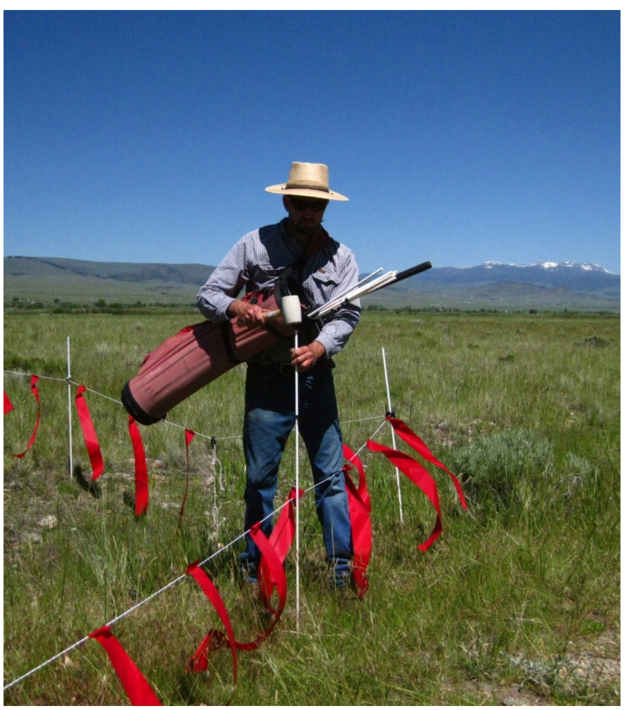

Figure 5: Using a golf bag for posts leaves hands free for positioning and hammering posts.

C. Attaching fladry to the posts

Fiberglass posts—spaced roughly 32 feet apart, or substantially closer than for bare polywire—need some sort of attachment point for joining fladry to post. After much trial and error, we have found **one product to be far superior**: **Premier Fence's Harp Clip**. The Harp Clip is durable, stays where you want it, and allows the fladry flags to slide through rather than snagging when tightening up the line. Clips made of wire springs snag the flags. Clips that look similar to the Premier Harp Clip have not performed well and tended to come off the posts.

The Harp Clip is also well-suited to the golf bag technique because the clips can be left on the posts with no risk of entangling with each other. This makes storage of large quantities of posts easier as well. The only difficulty with the Harp Clips is that they can be difficult to install since they are made of very strong plastic. Premier Fence has responded by making an inexpensive tool for snapping the clips onto the post.

Figure 6: Premier Fence Harp Clip.

D. Anchor posts for applying tension or making corners

The $^{3}/_{8}$-inch fiberglass posts are the mainstay of a fladry line; however, they are also very flexible and smooth. Thus, when trying to add tension to a segment of fladry so the line does not sag, we cannot rely on the $^{3}/_{8}$-inch posts by themselves.

These smaller posts will bend and will eventually pull out of the ground as we add tension to the fladry. Therefore, it is necessary to install heavier posts at regular intervals for adding tension to the line. We experimented with numerous ways of doing this and with different spacings and found that, on rolling terrain, it was necessary to have a heavier, less-flexible post approximately every 250 feet.

Figure 7: Steel T-post as an anchor for tensioning the fladry line in a fladry + polywire setup for dividing a cattle pasture. Note plastic insulators on post.

Steel T-posts are one option for heavy anchoring posts, as they are durable and reliable. They have drawbacks, however; they weigh a lot and require a post-pounding device to install, as well as a device for removing them from the ground at the end of the deployment. In addition, since they are steel, they require careful attention to insulation because if the electrified fladry line contacts the steel, it creates a "dead short," or a complete loss of voltage.

While we still use T-posts in some situations, we have found

Figure 8: Tensioning anchor, using a Dare-brand insulated clip and twine to connect the fladry line to a permanent post.

better alternatives for tension anchors. In situations where the fladry line parallels a permanent fence, we found that we could periodically tie the fladry line to the permanent posts using plastic insulator clips and twine. These anchors proved to be reliable, and the hardware was far more portable than steel T-posts and a pounder.

Our preferred method involves Dare-brand corner insulator clips and a length of twine, with fence staples connecting to a wooden post. The Dare clip (Part # BW-CP-10) proved to be very durable and very affordable at less than 10 cents each.

We have also begun using a variety of thicker/stronger fiberglass and composite posts for these purposes. Unlike steel T-posts, these posts require no insulators as they do not conduct electricity. Composite posts like the Powerflex G2 and PasturePro have performed the best—they are fairly flexible, nearly indestructible, and have enough roughness on their surface to help them stay in the ground. Smooth fiberglass posts may pull out of the ground under strain (however, this makes them easier to remove).

Figure 9: Powerflex composite post used to provide mid-line tension for fladry. Wire clip inserted through post keeps fladry at proper height; multiple half-hitches around the post vary the tension on the line.

Composite posts range up to 2 $^{3}/_{8}$ inches in diameter and are comparable in price to steel posts.

Half-inch diameter fiberglass posts are substantially stronger and stiffer than $^3/_8$-inch diameter and can be used to make a fladry segment more robust in challenging conditions.

For creating a 90-degree corner in a fladry line, however, it is still hard to beat a steel T-post. Again, it is imperative that the electrified fladry line not make any contact with the post. We have found that the Dare clip anchored to a T-post makes a strong, reliable, insulated connection. There are other insulators for T-posts, but we have found it preferable to have some space between the line and the steel.

Figure 10: Galvanized clip for half-inch fladry posts; this clip is very strong.

E. Maintaining consistent line height over rough terrain

Fladry flags should be kept slightly above the ground when possible to minimize voltage leaks from the flags. The line must not, however, be raised higher than about 28 to 30 inches. A line higher than roughly 29 inches may allow wolves to walk under the line without getting shocked.

On many pastures, the fladry line will have to contour over rough terrain, crossing ditches, ravines, and other features. Keeping the fladry line at a fairly consistent height in such places can be challenging. It is possible to use posts to keep the line at the desired height, but in extremely rough terrain the tension on the line may be enough to uproot most any posts besides T-posts. Compounding matters, many ravines and draws are extremely rocky, making it difficult to manually drive T-posts or composite posts into the ground.

Figure 11: Dare clip deadman.

The Dare corner insulator clip once again proved very useful in such situations. Using the Dare clip, a length of nylon cord (such as parachute cord), and a good-sized rock, we improvised a “deadman” for holding the line parallel to the terrain.

Again, this has the advantage of being highly portable and with no risk of shorts relative to steel posts.

F. Fladry gates

A necessary part of any fladry deployment, gates are fairly simple to construct; they just require a pair of fixed anchor posts, as described above, so that adequate tension can be maintained across the gate. It is possible for one end of the gate to be anchored to a permanent fence post near the gate, but it is inadvisable to put the gate or any other segment of the electrified fladry line within fladry-flag's length of the permanent fence due to flag entanglement or electrical short risk.

Figure 12: Fladry gate parallel to permanent gate. Both gates open from the right.

The gateway should be wider than the permanent gate it parallels (Figure 12). This will allow plenty of room for moving vehicles and livestock through the gate. The free end of the fladry gate should be on the same end as the permanent gate to facilitate easy use.

Figure 13: Gate handle connected to eye-bolt, attached to a Powerflex composite post.

Electric fence gate handles are required hardware for gate construction. Good quality handles cost about $4.00 and are far superior to the $2.00 varieties.

Cut the fladry line where a gate is required and tie the end to the eye on the end of the gate handle. To ensure a good electrical connection, wrap the polywire two or three turns around the gate handle eye, then tie it off with a bowline or other suitable knot. The gate handle's hook end (the free end) will then need to be connected to an anchor post that can withstand tension.

We suggest a minimum of $^{7}/_{8}$ inch diameter fiberglass or composite post such as the Powerflex 1.6-inch composite post, with a hole drilled through to accept an eye bolt (Figure 13). The gate handle's hook end then clips into the eye bolt. The fladry line continuing from the gate can then be tied into the eye bolt; again, make multiple turns around the metal to ensure good conductivity.

Figure 14: Gate handle connected to a wood post activator/insulator.

A gate connector, called a wood-post activator, is another good solution. This can be screwed into a permanent wood post. If using this method, the fladry gate must not be closely parallel to the permanent gate, but should intersect the fixed post at an angle that keeps most of the fladry line a good distance from the permanent fence. Otherwise, the flags will tangle in the permanent fence and/or the electrified fladry will short on the permanent fence, rendering it ineffective.

T-posts also work for gates, but require reliable insulation. We have used several insulator/connector devices that worked well on T-posts. It is also possible to use insulated fence wire wrapped around the T-post as a makeshift device for connecting gates.

G. Electrifying

Once the various posts and gateways have been installed, and the electrified fladry line has been attached to the posts and adequately tensioned to prevent sagging, it is time to add the electricity itself. This is fairly straightforward, and any good fence energizer will include an illustrated manual for proper installation.

It is important to select a good quality fence energizer for electrifying fladry. The flags themselves create significant voltage leaks, especially if they are in contact with vegetation or the ground. Thus, electrified fladry requires a significantly stronger energizer than an equivalent length of bare polywire.

The baseline strength of electric fence energizers is measured in **joules**. Some manufacturers report stored joules, while others report output or released joules. The most important number to focus on is **output joules** as a parameter of the energizer's ability to supply voltage over a wide range of situations.

Based on our monitoring of fladry voltages in a variety of settings, we believe that a good general guideline is that an energizer should have at least **one (1) joule of output per mile** of fladry. We found that an energizer with 3-output joules (Horizont Hotshock A50) with a fully charged 12-volt battery delivered consistent voltages of 4 to 5 kilovolts on more than 3 miles of electrified fladry. This was under challenging conditions, with the fladry in contact with tall sagebrush and other vegetation.

In addition to the guideline of 1 output joule/mile of fladry, we also recommend adding more ground rods to the energizer than the manufacturer specifies. In the case of the Hotshock A50, Horizont recommends 6 feet of ground rod; we used 3 ground rods, 3 feet each, for a total of 9 feet. High-quality rods are made of either copper or galvanized steel.

The Horizont Hotshock A50, as well as a few other energizers from Horizont and other manufacturers (available through Premier Fence, e.g.), are termed "wide impedance" energizers. Wide impedance energizers may not have as high a peak voltage as other energizers, but they deliver far better average voltage under adverse conditions. Such conditions are fairly common in the Intermountain West when dealing with wolves:

1. Dry, high mineral content soils that do not conduct electricity well.
2. Dry snow in cold temperatures serving as insulation from electrical shock.
3. Long fur insulating the animal against electric shock (particularly an issue in winter with wolves, especially when they may be standing on dry snow).

Figure 15: Horizont wide-impedance energizers with solar panels. The Hotshock B4 (left), with 0.35 output joules, is a compact unit that is suited for smaller runs of fladry around corrals or small pastures. The Hotshock A50 (right) is a heavy-duty unit that can adequately power more than 3 miles of electrified fladry; its 40-watt solar panel ensures a well-charged battery.

Since these factors are fairly routine when dealing with wolves, we suggest that fladry practitioners seriously consider using only wide impedance energizers.

Other points to keep in mind regarding electricity:

During spring and summer growing seasons, it may be impossible to keep the flags from touching vegetation because the grass is growing so fast. Line height should be adjusted as necessary.

When surrounding pastures with permanent fences, the fladry line is likely to cross over or through existing fence lines. Each of these is a potential short that must be insulated. Short runs of insulating tube can be made from rubber garden hose (the black heavy-duty hose), which can be slit lengthwise then taped on with electrical tape.

A good voltmeter is absolutely imperative for monitoring energizer performance and locating problems. Accurate voltmeters are available for less than $50; more sophisticated models that help find shorts are roughly $120.

Livestock Containment

Thus far we have focused on fladry as a wolf deterrent. Clearly, in circumstances where there is no permanent fence containing the livestock, ranchers and practitioners need to rely on the fladry fencing for this purpose.

We have found that standard electrified fladry was only marginally effective as a livestock fence. This was because flag lengths of 19 inches dictated a top wire height of no greater than 23 inches above grade (Davidson-Nelson and Gehring 2010). In our projects, we found that cattle would often step over a fence that low, which frequently led to brief entanglements that resulted in long stretches of fladry being torn down and rendered ineffective.

We experimented with longer flags that would allow the top electrified wire to be closer to the recommended cattle containment height of 30 to 32 inches. After discussion with experts and extensive research, we could find no compelling rationale for flags only 19 inches long. We think, however, that there is an upper limit on effective height for fladry: too high, and wolves would find it too easy to cross under the electrified wire without ever making contact.

Therefore, we believe that the optimal top wire height should correspond to wolf anatomical parameters—the wire height should be slightly below average shoulder height for a wolf, or about 29 to 30 inches. We base this on the idea that wolves that begin to lose their fear of fladry will first explore the novel object with their nose and mouth. Canids with a curious attitude often hold their head slightly below shoulder height as they explore novel objects.

Therefore, we believe 27 inches is the theoretical optimum flag length; this would allow deployment of the top wire at approximately 29 to 30 inches above grade without the flags making excessive ground contact (a significant voltage drain). Preliminary trials with cattle have shown that 29 inches is an effective wire height for containing adult cattle.

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APPENDIX A – Installation Summary (with Index)

To install fladry:

Spooler – Spool .5 to 1 mile of fladry on a spool so that it's not too heavy (larger spools can take 1.5 miles of fladry, but they are heavy). The spooler itself must be larger than what can be used with bare polywire. pp 3-5, and Appendix C (for spooler assembly)

Posts and carrying/driving posts – Use an old golf bag or other carrying bag that allows the worker to carry 40 to 50 fiberglass posts (3/8 inch x 4 feet) and be hands-free (to position posts and tap into place). p 5.

Anchor posts for tension and corners – The 3/8-inch fiberglass posts can pull out with tension, so we suggest adding heavier, less flexible posts approximately every 250 feet. Options include composite posts such as Pasture Pro's 1.5" x 5' line post, steel T-posts, stronger/thicker fiberglass posts, or tying the fladry to permanent fence/posts with non-conductive cord. pp 6-8.

Tension – It is best to stretch the fladry in segments of less than 1/4 mile, and to apply tension before clipping it to the posts. Pull hard to remove all slack from the line, then secure the fladry to the nearest heavy post or corner. pp 5-7.

Attaching fladry to posts – Fladry line needs to be clipped to the fiberglass posts (3/8 inch x 4 feet), which should be spaced roughly 32 feet apart (closer than for bare polywire). The best product for attaching fladry to a post is Premier Fence's Harp Clip. We also recommend using Premier's inexpensive tool for snapping the clips onto the posts. pp 5-6.

Adjusting and maintaining line height – The fladry line will need to contour over the terrain. Walk the line to ensure consistent height. Fladry flags must be kept from leaking voltage by touching the ground, vegetation, etc., and the line height must remain effective (23-30", depending on the length of your fladry, with flags hanging approximately 1-2" from the ground. We recommend 27" flags with a line height of 28-30"). Add extra posts where necessary, and consider using the Dare corner insulator clip to improvise a deadman to hold the line parallel to the terrain. pp 8-9.

Fladry gates – A necessary part of the installation, gates require a pair of fixed anchor posts. The gate should be wider than any permanent gate it may parallel. One end of the fladry gate can be anchored to a permanent fence. Also needed are a handle and gate connector. pp 9-10.

Electrifying – Select a high quality, strong fence energizer, as fladry flags generate voltage leaks. The most important number is output joules. We recommend at least one (1) joule of output per fladry mile. We also recommend adding more grounding rods to the energizer than manufacturer specs dictate. Copper or galvanized steel rods work well. pp 10-12.

<u>Livestock containment</u> – The line needs to be near the ideal cattle containment height of 30-32" but also correspond to the height of wolf heads and noses (the likely way they might explore the fence), about 30". We recommend a fladry flag length of about 27", with the top line height at 29-30". p 12.

<u>Testing</u> – Use a voltmeter to measure the voltage of the fence. 4,000-5,000 volts is an acceptable reading, but higher readings (up to 10,000 volts) are preferable. p 11.

<u>Communication</u> – Talk with the landowner and any immediate neighbors to **let them know that you have installed an electric fence**. Consider hanging a plastic warning sign on or near the fladry line to avoid accidents.

APPENDIX B – List of Tools and Equipment Needed

- Sufficient fladry to enclose the pasture
- Line, corner, and tensioning posts
- Fence energizer capable of delivering one output joule per mile of fladry
- Ground rods for energizer and lightning brake
- Insulated wire to connect charger to fence
- Uninsulated wire or braided aircraft cable to connect charger to ground field
- Lightning diverter or brake
- Fladry spooler
- Deadblow hammer or cap for driving fiberglass line posts
- Pounder for T-Posts and larger-diameter composite posts
- Sledgehammer for driving ground rods
- Utility knife for cutting and splicing wire
- Split bolts for electrical connections
- Nonconductive cord
- Spare harp clips
- Corner clips
- Pinlock plastic insulators
- Cotter pins for composite posts
- Drill and drillbits
- Screws
- Fence staples
- End strain insulators
- Dead end gate handles
- Pass through (conductive) gate handles
- Voltmeter/fault finder
- Leather or rubber-palmed gloves for handling fiberglass posts

APPENDIX C: Fladry Spooler Specifications

Figure A: Spooler 2.0, which included a level-winding device to evenly distribute the fladry on the spool. The level winder has been omitted from subsequent designs.

Our fladry spooler has gone through a few iterations, finally evolving into a simple machine that can be constructed with minimal welding and pre-fabricated parts. The basic design is for a hand-cranked machine that fits into the hitch receiver on a vehicle; the design can be readily modified to make the spooler freestanding or attachable to an ATV rack. To increase the spooler's versatility, we designed it to use easily interchangeable spools, as well as to use a variety of different spools to suit user needs.

Our original design aim was to make the spooler collapsible into four main parts. However, as the design grew simpler, we realize now that the spooler can be built to have just two major components: the frame, and a detachable axle (or spindle) for holding the spool. This keeps the spooler lightweight and with fewer parts to lose.

The spooler frame is made of steel tubing; we used 2"x2"x0.25" for the horizontal piece that inserts into the vehicle's hitch receiver. The angled arm piece is 2"x2"x0.188"; this lighter tubing saves weight, and allows “telescopic” assembly by accommodating 1.5”x1.5” tubing if the spooler is made to be collapsible. We set the arm at a 65° angle from horizontal.

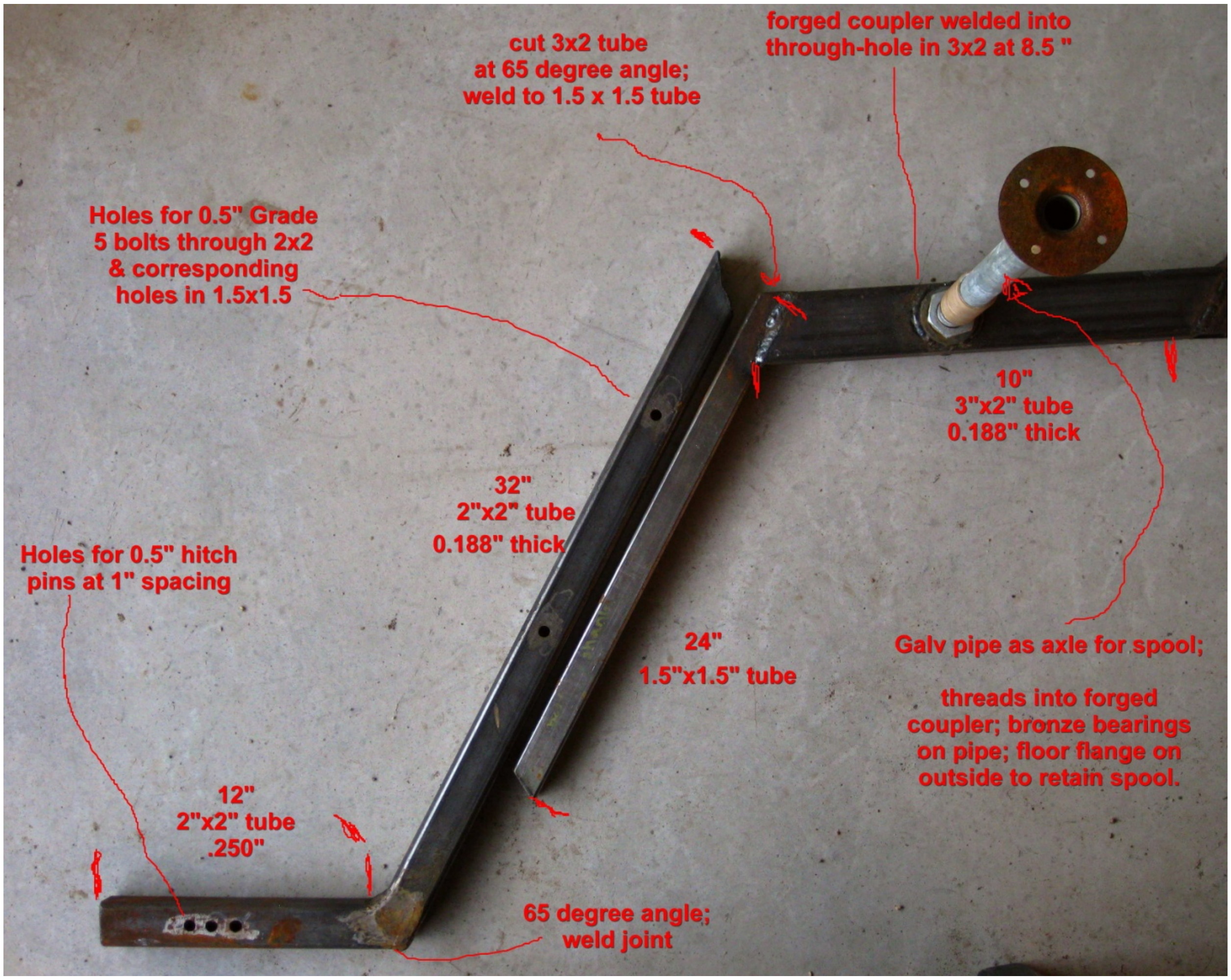


Figure B: Spooler specifications. The frame can be built in one piece instead of two, if desired.

The next piece is the 3”x2”x0.188” rectangular tube to support the spindle and spool. This material can be welded directly to the angled arm; or it can be welded to 1.5” square tubing if collapsibility is desired. We made this piece 10” long.

At 8.5”, we cut a through-hole into the 3”x2” tubing; this hole is to accommodate a pipe coupling. We used a forged pipe coupling for durability, and selected one threaded for 1.5” nominal pipe diameter. This size allows flexibility in choosing spools, since reducing bushings can be threaded into the coupling to accommodate smaller diameter pipes as spindles.

Figure C: Pipe coupling detail; coupling can be accessed from either side of frame for versatility.

The pipe coupling can be accessed from either side of the frame. This allows the user to put the spindle on either side, or to run two spools at once if necessary.

Spindles or axles can be made from whatever shaft material the user desires. However, we found that pre-cut, pre-threaded galvanized pipe made suitable spindles with sufficient strength, even under demanding loads over rough terrain. Threaded on both ends, the pipes easily threaded into the coupling on the spooler frame, and allowed use of a floor flange to keep the spool on the spindle in the field.

Figure D: Top view of pipe coupling welded into 3x2 tube; note reducing bushing on right receiving 1" pipe as spindle.

We found that McMaster-Carr polyethylene spools were affordable, durable, and lightweight. The size that has worked best for us was a 17” wide by 6” diameter spool core, with 24” flanges. This spool was large enough for over a mile of fladry if wound tightly.

Figure E: Polyethylene spool from McMaster-Carr; note detachable handle on flange.

The diameter of the hole on the spool core is 1.5”, which is larger than the outside diameter of 1” nominal pipe and smaller than the outside diameter of 1.5” nominal pipe. Thus, it may be a good idea to use a bushing of some sort on the pipe spindle. Bushings make the spool rotate far smoother and easier, and also minimize wear on the spool.

We used bronze bushings (sleeve bearings) from McMaster-Carr. There was no size available to precisely fit both the spindle and the spool. McMaster-Carr part # 6381K271 was a close fit, requiring minor reaming to fit the bushing onto the pipe. Users may find this bearing may require a slight reduction in outside diameter to fit the spool, but the polyethylene is flexible enough to slide onto the bearing with no modification in most cases. Bushings can be fixed in place on the spindle with a small welded bead or adhesives.

Figure F: 1" nominal pipe spindle, with bronze bushings for smooth spool rotation. Three bushings to accommodate different size spools.

The spools need handles for the user to wind up fladry. McMaster-Carr has handle assemblies that work well. We chose rotating plastic handles that can be bolted to and easily removed from the spool flanges.

Figure G: Removable spool handle attached to flange.

This eliminates the need to have a handle for every spool, and allows spools to be easily stacked for storage.

The handle has a threaded stud; we used a coupling nut and a wide-head bolt to attach the handle to the spool flange. A reinforcing spacer of metal or plastic on the inside of the flange is optional, but should increase flange durability.

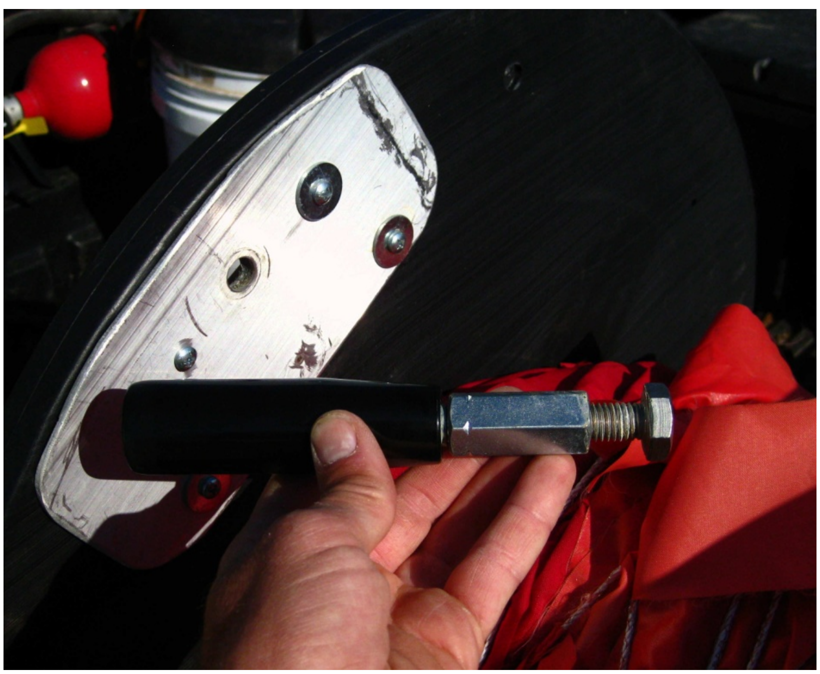
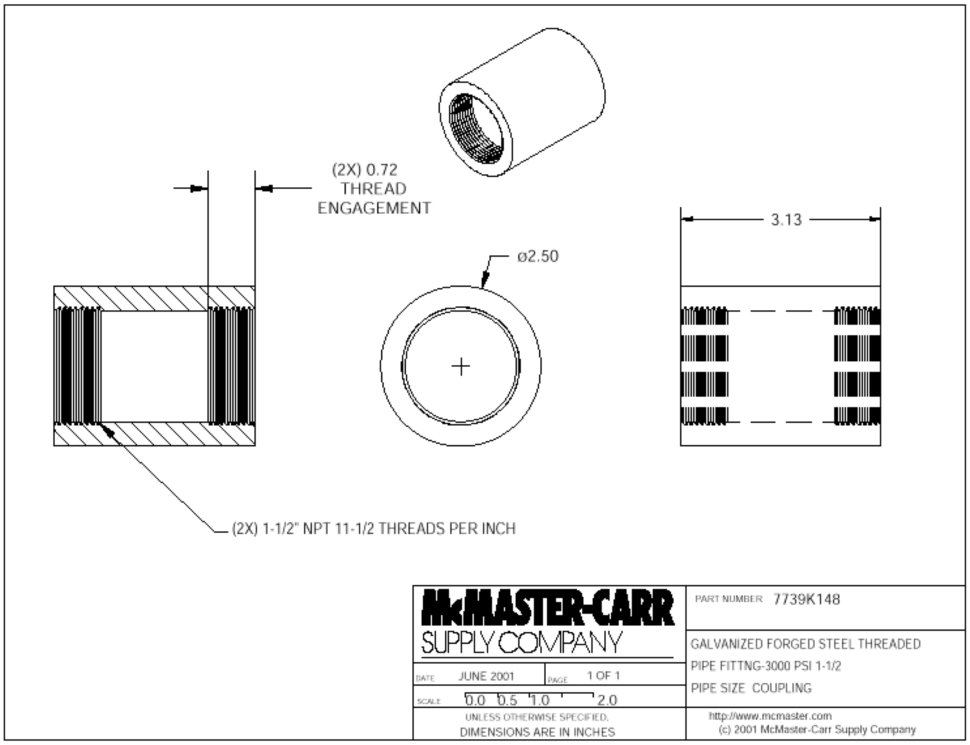


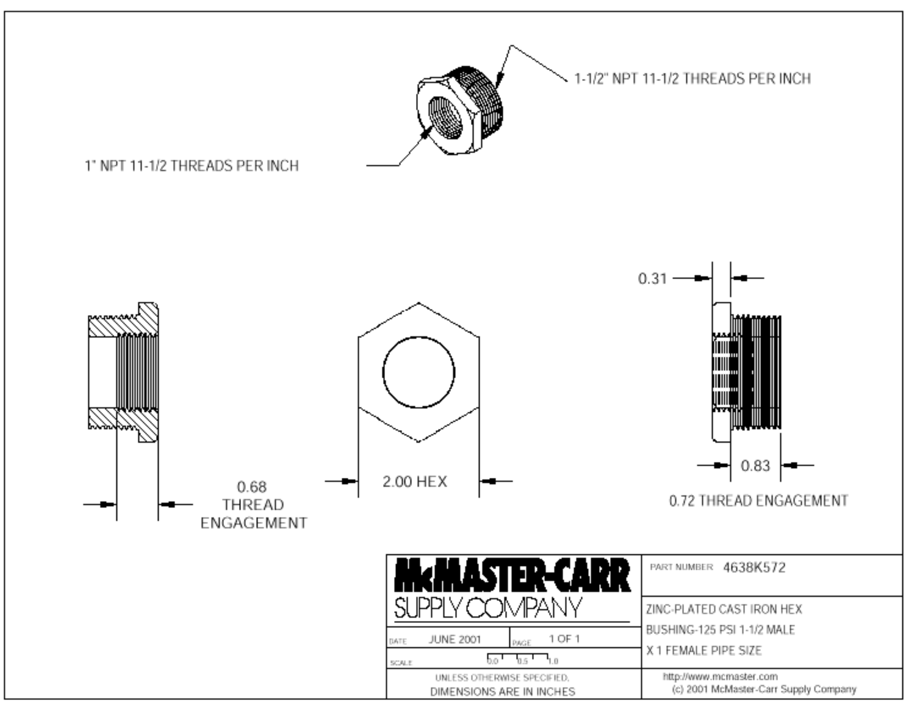
Figure H: Handle removed from spool; note coupling nut & bolt.

Parts:

1) Forged pipe coupling, McMaster-Carr part number 7739K148



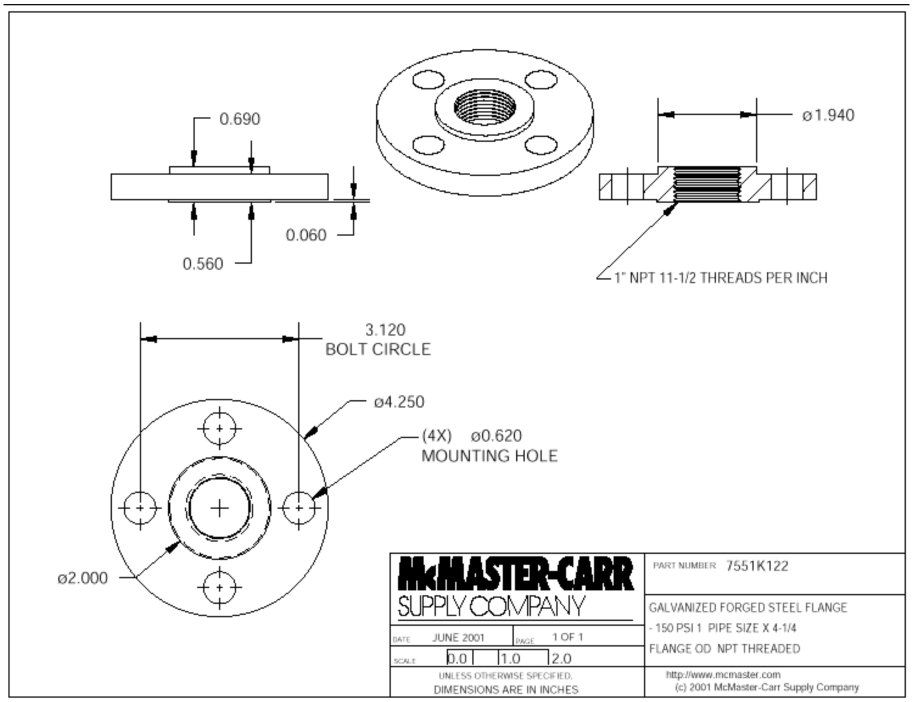
2) Reducing bushing, McMaster-Carr part number 4638K572; also widely available at hardware and plumbing stores.



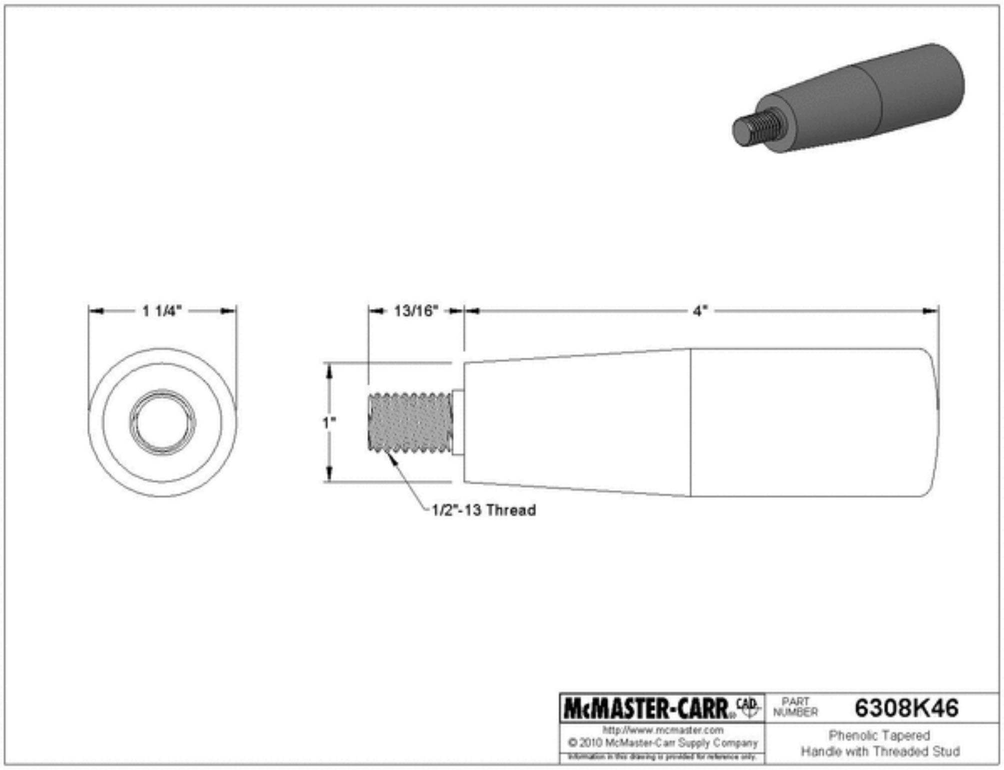
3) Bronze (alloy 932; cleaner than Oillite) bushings, McMaster-Carr part number 6381K271

Outside diameter: 1 5/8”
Inside diameter: 1 5/16”
Length: 2.5”

4) Floor flange; this item should be purchased at hardware or plumbing store.

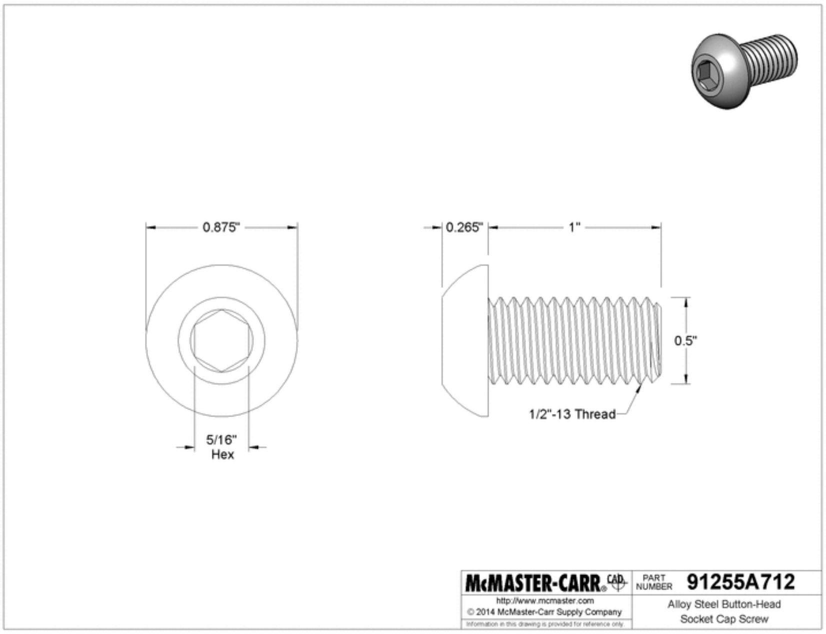


5) Tapered, rotating handle, McMaster-Carr part number 6308K46



6) Coupling nut 1.75” length, for handle; 1/2"-13 thread; McMaster-Carr part number 90977A195.

7) Bolt 1” length, ½”-13 thread; for attaching coupling nut/handle assembly through spool flange; McMaster Carr part number 91255A712 button head socket-cap bolt. This bolt has a low-profile head so it doesn’t snag fladry. Uses a 5/16” Allen wrench to attach or remove the handle.



8) Components for Polyethylene spools
    a. 17” spool core, McMaster-Carr part number 38305T12
    b. 24” spool flanges, McMaster-Carr part number 38305T23