The UVM Mobile Hop Harvester
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INTRODUCTION

The development of the small-scale, portable hop harvester was a project of University of Vermont Extension, Vermont Agency of Agriculture and Massachusetts Department of Agricultural Resources through the USDA Specialty Crops Block Grants Program. The support of these organizations is greatly appreciated.

The intent of this project was to demonstrate the feasibility of a portable hop harvester with sufficient capacity to serve a 1 acre hop yard per day. A machine like this one is needed since relatively few hop growers in the northeast can justify the expense of a larger, stationary harvester given the limited scale of their hop production. Additionally, this project intended from the start to make all design documents available to the public for review, replication and improvement of the machine by other users.

A team of hop growers, brewers, and UVM Extension faculty and staff teamed with an engineer and a fabricator to design and develop a functional prototype of a mobile hop harvester. Two general concepts were considered; a machine that stripped vertically hung bines and a machine that stripped horizontally pulled bines. The team decided on the horizontal machine since it lent itself more to being portable (lower height). Power supply was another consideration, with the main options being electrical or hydraulic. The overall power demand estimate and need for speed control suggested that if electrical power was selected, three-phase service would be required. Combined with the fact that most of the hop yards in the group are somewhat remote and the fact that most growers would have a reasonably sized tractor with a PTO, the group chose hydraulic power.

The design requirements (noted below) were developed among the design team, and the design concept was detailed by the team's engineer. Fabrication of the prototype was largely completed by Triangle Metal Fab, Inc. in Milton, VT. Some final assembly and modification was carried out on-site at Four Star Farm (Northfield, MA) and at Borderview Farm (Alburgh, VT). The work by both of these farms in making final adjustments and, in some cases, major alterations is greatly appreciated.

Finally, based on the first year of operation, the team has learned a great deal. Our lessons learned are provided at the end of this document. Not all improvements have been represented on the drawings and other description in this document. Readers are encouraged to be in touch with the UVM Extension NW Crops and Soils Team for updates and revisions (web: http://www.uvm.edu/extension/cropsoil/uvm-extension-crops-and-soils-team, phone: 802-524-6501, email: whatshoppening@uvm.edu.)

DESIGN REQUIREMENTS

The mobile hop harvester was designed to perform according to the following specifications:

Capacity	2 bine/min 8 hr/acre 10,000 lbs/day wet {2,000 lbs/day dry}
Portability	over road with standard tow hitch & full size pickup truck
Safety	similar to standard farm equipment training and personal responsibility required
Power	PTO / direct hydraulic
Cone Damage	<5% by volume
Operation	team of two trained operators

MACHINE DESCRIPTION

TRAILER – The hop harvester was intended to be highly portable, yet provide sufficient capacity to pick bines from a one acre hop yard in an 8 hour period. An 18 foot equipment trailer with a standard 2-5/16” hitch was selected as the portable platform for the hop harvester. The trailer purchased for this project was a Kaufman 8000 lb GVWR, 18 ft wood floor utility trailer with dual 4000 lb axels and a 2000 lb swing up jack (www.kaufmantrailers.com, 866 455-7444). The open area of the trailer platform was 82 inches between fenders and 16 feet of flat deck surface plus 2 feet of “dovetail” on the rear.

Figure 1. Photo of the harvester during initial test, showing main sections in place.

FRAME – The main structure of the hop harvester was constructed of 2”x2”x0.125” steel square tube. This material selection was intentionally conservative given the prototype nature of the initial build of the design. The design team wanted an extra strong frame to allow for future removal of frame members in case of interference or re-routing. This proved to be important as several frame members were later removed as fabrication and initial use proceeded. Additionally, the majority of the main framing assembly members are included to provide for mounting surface locations, and are most likely not structurally necessary. The heavier framing material is more costly and requires more welding (resulting in higher labor / fabrication costs). For this reason a slightly revised framing design is possible which uses 2”x2”x0.125” steel for main framing, but includes 1”x1”x0.125” steel for most of the inner members.

Figure 2. Main Frame assembled, viewed from the Bine Feed Input (front) side of the of the machine

SUBFRAME – The subframe of the hop harvester is comprised of Unistrut Metal Framing channel (www.unistrut.us, available through Fastenal, Grainger, and most Mechanical/HVAC supply companies). We used 1-5/8"x1-5/8"x12 gauge pre-painted channel. This material selection allowed for firmly connecting the subframe to the frame, while providing adjustability for machine parts fastened along the channel. For example all pillow block bearings on the machine are attached to Unistrut channel to allow for tensioning of belts, adjustment of dribble belt spacing and incline, and adjustment of stripping section opening.

BINE FEED – The bine feed pulls the loaded bines through the stripping section where hops and leaves are removed by the stripping fingers. The design concept for this feed mechanism uses ANSI 60 chain with chain attachment linkages (both available through McMaster-Carr, www.mcmaster.com, 609-689-3415, or other such suppliers) to attach a bine feed hook to the chain. The bine feed hook was purchased from Dauenhauer Manufacturing (www.dmfg.com, 707-546-0577). It had to be cut and re-welded to allow loading of the bines on the side of the machine to which the bine feed was installed. The bine hook allows for rapid loading and unloading of the bine without any moving parts, since it uses the weight of the bine and later tension of the feed / stripping section opposition to hold it on the hook. Spring-loaded bine clips or even small clamps have been successfully used by others and could be applied here. The bine feed is driven by a single White Drive Products RE750 hydraulic motor (P/N: 500750A3120AAAAA) with a speed control valve on the outlet to adjust feed rate. This motor was selected to provide high torque at low speed. The design team was not certain about the exact loading a bine would impose on the motor in the stripping section so the motor was selected with significant margin in sizing. Based on initial operation of the machine, a lower duty motor would probably suffice in this application.

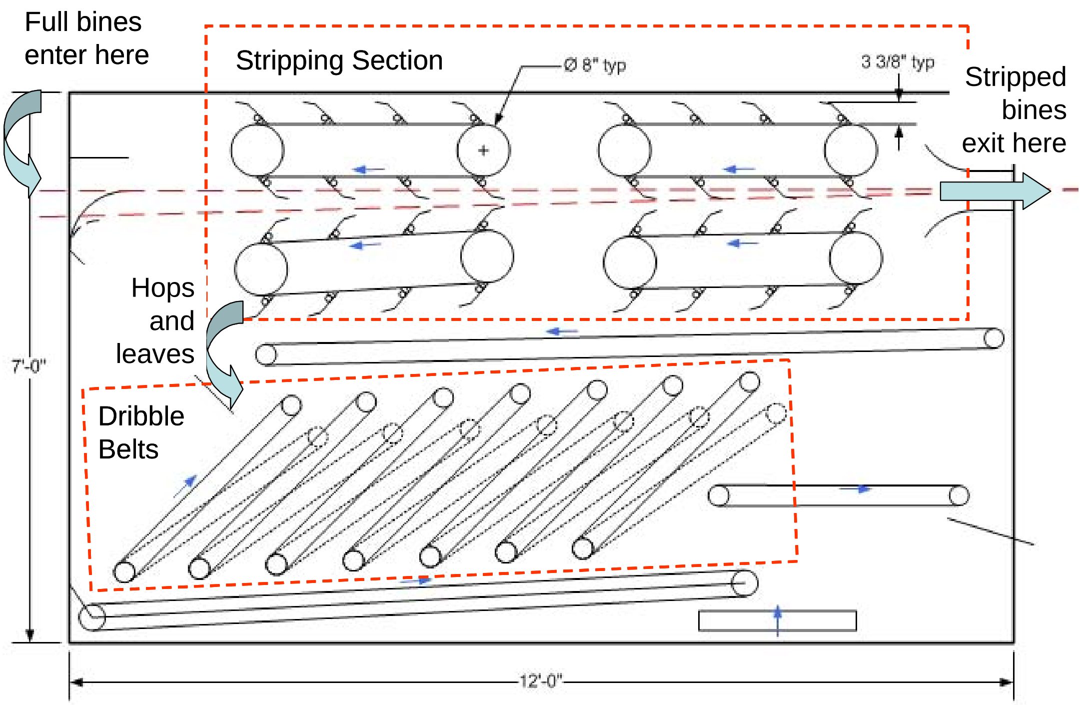


Figure 3. Cut-away view of the harvester showing basic operation.

Figure 4. A bine hook purchased from Dauenhauer Manufacturing Co, Inc. Due to space limitations in the bine feed area of the stripping section we had to trim the hook as shown by the dashed line. We also drilled a new hole for attachment to the bine feed chain using attachment links. Lastly, we had to reverse the bine hook finger locations since we were pulling the bines down the right side of the machine.

Figure 5. The bine feed inlet (front) of the machine. Showing the bine feed motor, chain, sprockets and mounting plate in the upper right corner of the picture.

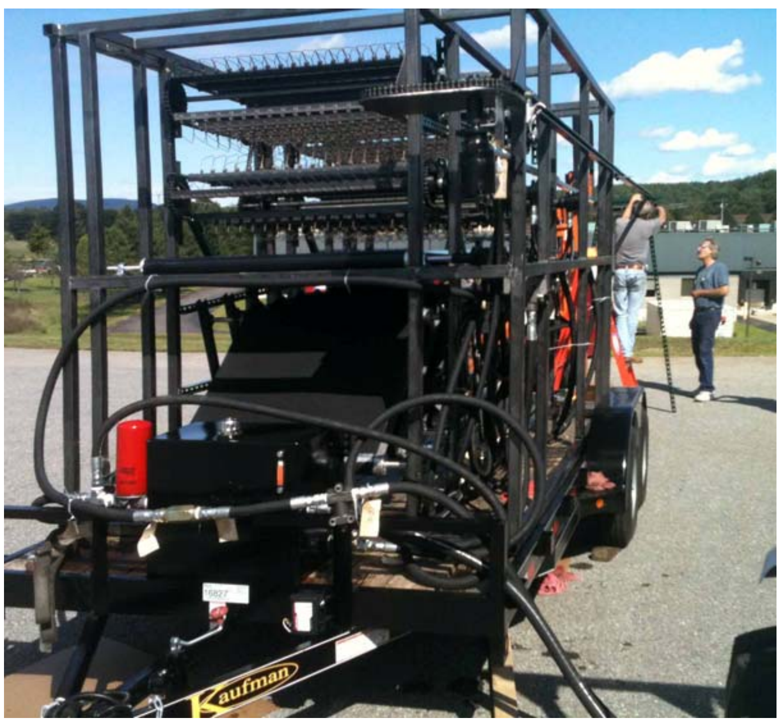


Figure 6. Harvester on the trailer with only stripping section and dribble belts installed. Bine feed extension is being assembled on far end of picture.

Figure 7. Bine feed motor, mount, and speed control valve on the front (feed inlet) side of the machine).

STRIPPING SECTION – The stripping section is comprised of opposed stripping fingers on 48” bars which are pulled against the bine as it is fed through the machine by the bine feed. These stripping fingers were purchased from Dauenhauer Manufacturing (www.dmfg.com, 707-546-0577) as sub-assemblies on angle iron bars. The bars are attached to the ANSI 60 drive chains using chain attachments noted above. In the current design, these fingers are installed on 8.75” centers along the drive chain so that the tip of the fingers line up with each other (in the direction of movement) and are directly opposite from one another (across the bine being stripped). There are numerous possible approaches to the layout of the stripping fingers which might make use of overlap, meshing, etc. This was our initial setup and has not required any significant adjustment in order to reliably strip the bines clean.

Figure 8. The far end of one half of the bine feed extension showing idling sprocket and mounting plate. Chain not attached in this photo.

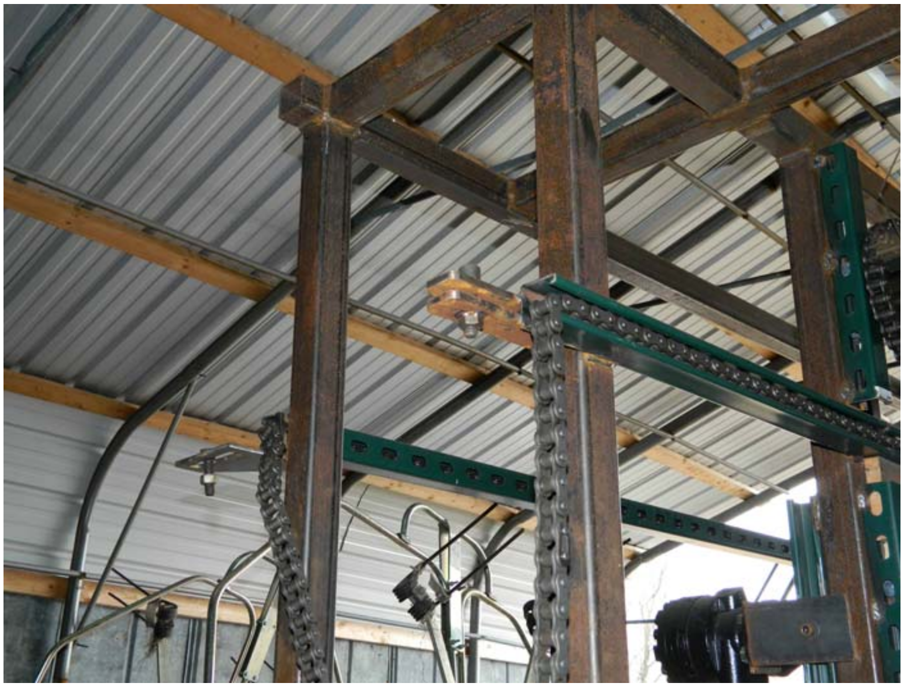


Figure 9. The bine feed section that remains attached to the frame when the machine is broken down for transport. This view shows how the chain is nested inside the Unistrut (although it is rotated about 90 degrees to allow chain to be held in a container for transport.

Figure 10. A single stripping finger.

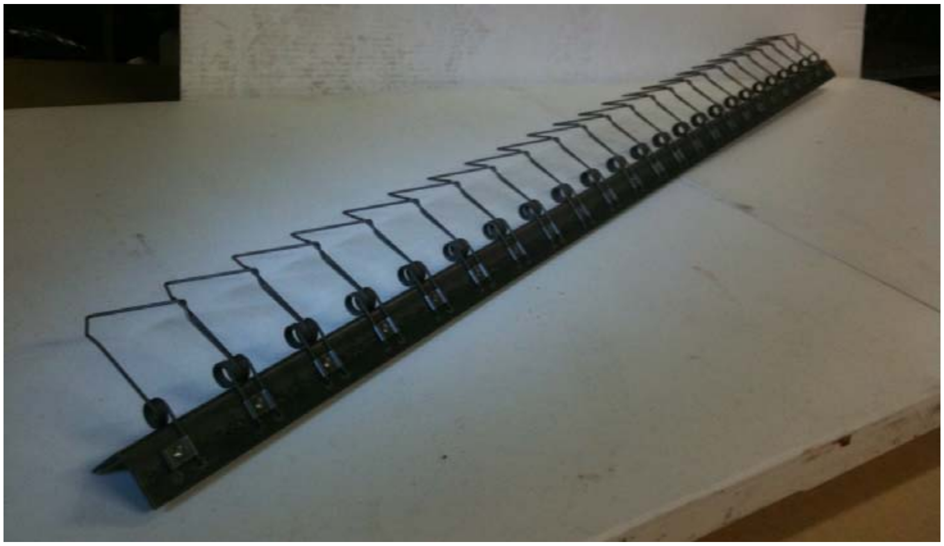


Figure 11. Stripping fingers mounted on a 48" bar, purchased as an assembly from Dauenhauer Manufacturing Co., Inc. The fingers / bars are attached to the stripping chains so that the tip of the finger leans slightly away from the incoming bine (i.e. away from the direction of stripping finger travel.)

The stripping sections are designed to be independently adjustable allowing a gradually more constrictive pathway as the bine is fed further through the machine. This allows for stripping of outer, lateral branches and outside cones in the a relatively wide open first section (4" between fingers) with the balance of stripping occurring in the second section which is generally set up with a smaller opening between opposing stripping fingers (e.g. 1"). The speed of the stripping section can be adjusted using a flow control valve attached to the common outlet of the two motors used in this section (White Drive Products RE160, P/N: 500160A3120AAAAA). We have not yet found a need to adjust the speed of the stripping sections individually, but it could be done with slightly different hydraulic layout. The motors in this section demand the highest proportion of hydraulic flow (14.8 gpm at rating) of the system.

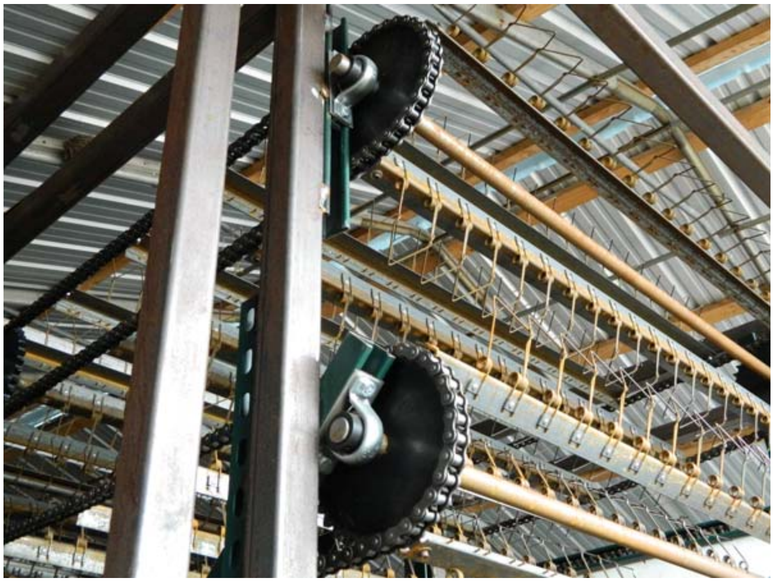


Figure 12. View of front stripping section showing installation of finger bars. Also note the use of Unistrut to provide adjustability of the stripping section (opening width).The bars are attached to the chain using standard chain "attachment" links that come with pre-drilled tabs for attaching items to the chain.

Figure 13. Reversing transmission is required to make the top stripping belt run in the same direction as the bottom.

STRIPPAGE CONVEYOR – The primary conveyor provides primary collection of "strippage" from the stripping section. This contains all leaves, branches and cones stripped from the bine above. This belt conveys the "strippage" forward along the machine to the start of the dribble belt section where cones are to be separated from trash. The belt used in the prototype machine is EconoPac120 rubber belting purchased from Spark Belting (www.sparksbelting.com, 800 451 4537) is 48" wide (face width) with a total length of 21' 9.42" for an approximate one way run of 10'. This belt is hung between two 3" rollers (aka a pulley and a tail) with a 1" diameter shaft. Standard pillow blocks (McMaster-Carr #5913K64) were used for bearings. The conveyor is driven by a single hydraulic motor (White Drive Products WP050, P/N: 155050A1110AAAAA). Due to initial schedule constraints, these pulleys and their shafts were constructed from aluminum (1/4" thick wall x 3" diameter tube) and with flat facing. As noted in the "Improvements" section, steel shafts and rollers would be preferred to avoid deflection of the shafts. Additionally, a v-groove in the rollers with accompanying v-belt guide on the underside of the belt would correct tracking issues encountered in our first year of use. Generally a run of 10' for every 1' of width is necessary to avoid tracking issues on belts. The dribble belts were ordered with these guides and performed well even with very short runs vs. width.

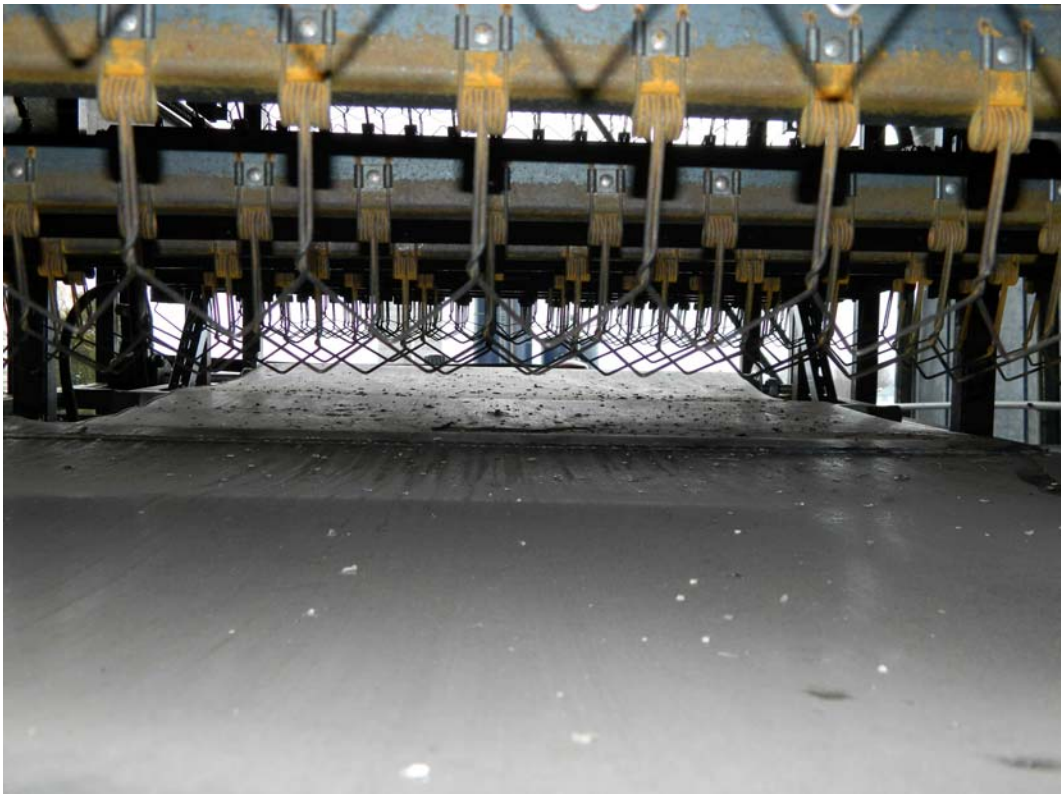


Figure 14. The view along the strippage belt (loosened for storage).

DRIBBLE BELTS – The dribble belts are rough surface rubber belts set at an incline and rolling uphill (on the top surface). These Ruff Tuff model 75 belts were purchased from Sparks Belting (see above) and are 36” wide with a total length of 6’ 9.42” for an approximate one way run of 3’. The rollers used for these belts had v-grooves (Type K8) machined into them which mates with a v-belt guide adhered to the underside of the belt material. They are also 3” diameter rollers with 1”diameter shafts supported by the same bearings as noted above. Note that stock material used for these rollers were thicker walled tube (1/2”) so that the v-groove could be machined into the surface. With the v-groove engaged the belt is held in place and does not walk along the rollers. We used a total of 5 dribble belts which are fed in series to result in a cumulative cleaning / sorting process. The first belt receives the “strippage” from the primary conveyor belt under the stripping section. The cones roll “downhill”, while the leaves and less round debris such as branches stick to the rough surface and are drawn uphill along with some of the cones that don’t roll down the first dribble belt. Whatever hasn’t rolled down the first belt is delivered to the second where another round of separation takes place. This continues over 5 belts with the “trash” being deposited over the top of the last dribble belt onto a trash conveyor while the cones that come off the bottom of each dribble belt are deposited onto a primary hop conveyor. In this design the angle, spacing, and speed of the dribble belts are adjustable to accommodate different varieties of hops and different stripping rates.

Figure 15. A side view of the machine showing the relation of the dribble belts to the stripping belts and how the dribble belt drive chain is connected between belts.

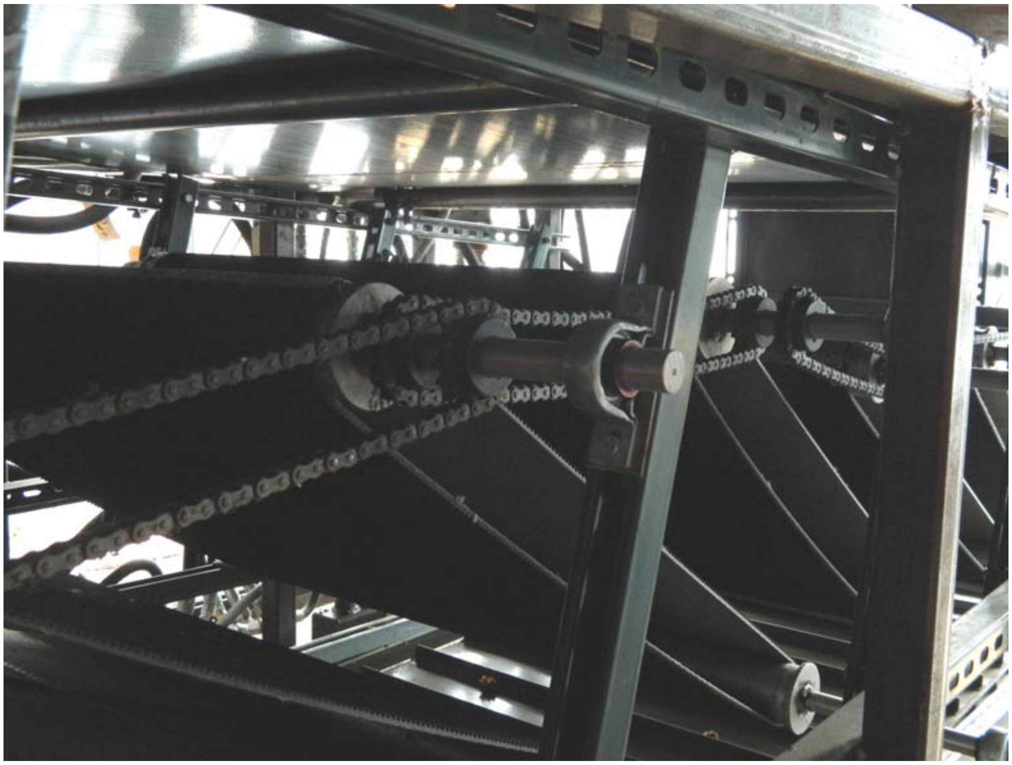


Figure 16. Dribble belts viewed from the non-drive side, showing the double sprocket chain transmission from the driven belt (front of machine, #1) to the others.

Figure 17. Dribble belts viewed from the drive side (motor is on the front / left belt at top). Adjustment of the belts is done by moving the pillow block bearings and angled vertical supports along the UniStrut sub-frame (green). Also visible (from left to right along the top) are the bine feed directional control valve (#303), the stripping assembly directional control valve (#203) and the stripping section speed control valve (#129).

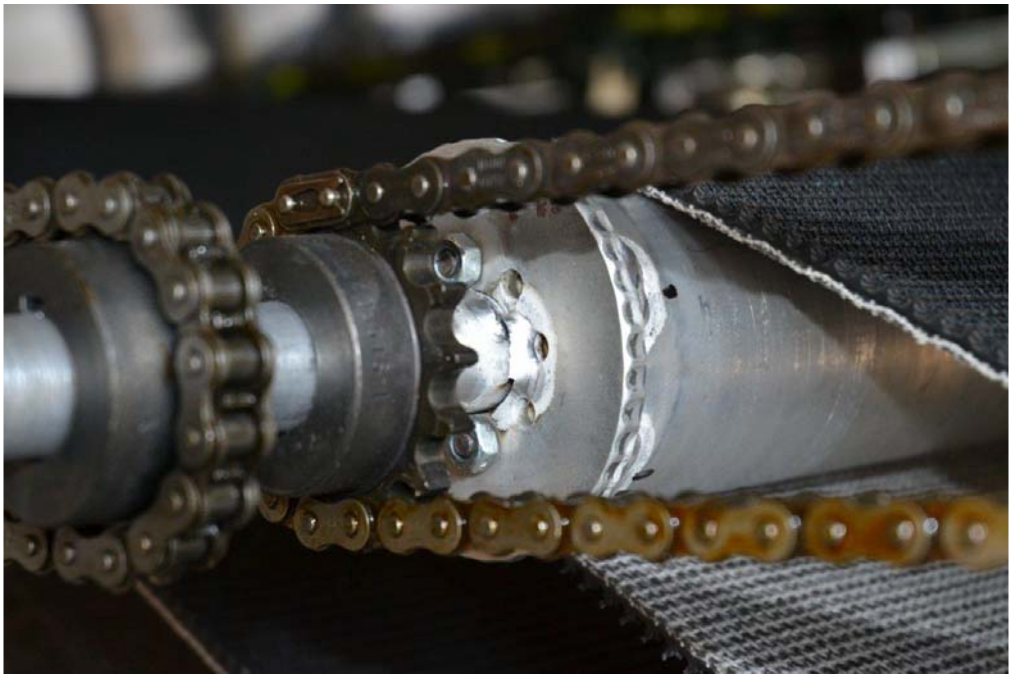


Figure 18. Double sprocket arrangement on opposite side of shaft from motor which was used to transmit drive power from belt #1 to all the other belts. The rough-top belt surface is also visible in this photo.

Figure 19. The dribble belts at work, viewed from the bine feed inlet (front) side of the machine. The cardboard in the photo was used to direct all strippage onto the dribble belts as panels and chutes had not yet been fabricated for that purpose. Primary and secondary hop conveyors are also visible in this photo, with "sorted" cones being delivered to the left of the photo.

PRIMARY & SECONDARY HOPS CONVEYOR – The primary hop conveyor moves hop cones dropped off the bottom of the dribble belts to the secondary hop conveyor which moves them off of the machine into a collection bin. The primary conveyor is 36" wide with a total length of 17' 9.42" for a total one-way run of 8.5' on 3" diameter rollers with 1" shafts. It is driven by a single hydraulic motor (White Drive Products WP050, P/N: 155050A1110AAAAA) and the shafts are supported by the same bearings as noted above. The secondary conveyor is 24" wide with a total length of 9' 11.41" for a one-way run of 4' 7". These belts (EconoPac 120 from Sparks Belting) were specified with 1" lateral PVC cleats at 12" centers because in the initial design they were intended to be inclined to clear the wheel fenders of the trailer. The cleats were intended to prevent rolling of the hop cones when inclined. A field adjustment to the layout re-routed the conveyors toward the front of the trailer and avoided the need for the incline. Belts without cleats could be used based on the current configuration. Similar to the strippage conveyor, the rollers used in the prototype for these two hop conveyors were fabricated from aluminum shafts and tube and were made as flat face rollers. Due to tracking issues encountered during initial operation, the team feels a v-groove would be beneficial. Also the material of construction should be steel, not aluminum. Omni Metalcraft (www.omni.com, 989-358-7000) offers standard rollers (drive and tail) for use with conveyor belts. They also offer these rollers with v-grooves already in place.

TRASH CONVEYOR – The trash conveyor receives leaves and branches that come over the top of the last dribble belt and conveys them off of the machine. It was also specified to be cleated with 1" PVC lateral cleats at 12" centers as some incline was anticipated, but later found to be unnecessary. This belt is 36" wide with an overall length of 6' 9.42" and a one way run of 3'. It is hung on 3" diameter rollers with 1" diameter shafts supported by the same bearings as noted above.

Figure 20. Trash conveyor viewed from back end of the machine. When operating it brings leaves and twigs from the last dribble belt out the back of the machine. As noted above, the belt does not need to be cleated.

Figure 21. All long conveyors (strippage, primary hop, secondary hop, and trash conveyors) required a tensioning adjustment. This was accomplished in the prototype using a long eye bolt fastened to the corresponding pillow block bearing using the existing bolt and UniStrut lock nut.

HYDRAULIC POWER SYSTEM – The design team for the harvester debated what power source to use for this system narrowed the selection to either electric power or hydraulic power (with tractor PTO input). It was decided that most of the locations where this machine would be used would have a medium sized tractor with PTO output, while most would not have readily accessible high voltage or 3-phase power. Additionally, there was a concern about electric power reducing the portability of the machine. Using tractor PTO as input, the machine could be setup near the hop yard for minimal transport of bines. The team decided on PTO driven hydraulics.

At the heart of the hydraulic system is a PTO hydraulic pump that provides the pressure and flow for the system. A Prince Hydraulic pump (HC-P-K11) was used which provides 40 gpm at 1500 psi with 43.4 HP input. The sizing of this pump was based on the aggregate flow estimated through each hydraulic motor in the system at the expected RPM and torque during operation. This is summarized in the motor list. A 25 gallon reservoir was selected and installed upstream of the pump to provide expansion volume and a buffer for flow changes. The reservoir also serves to reject some heat that builds up in the hydraulic system. A radiator was not initially included in the system, but is expected to be installed in prior to the next harvest season in order to better maintain a safe operating oil temperature.

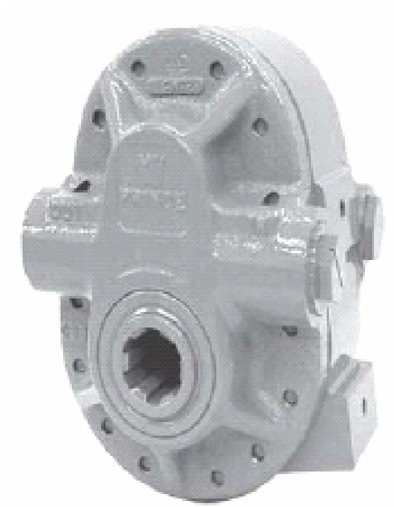


Figure 22. Prince HC-P-K11 PTO pump used on the harvester.

Figure 23. Flow control valve similar to those used on the outlet of individual motors in the prototype harvester (Valve #'s 311, 401, 501, 601, 701, & 801.)

Figure 24. The harvester with the PTO pump connected on a small tractor for initial testing.

Figure 25. A typical White Drive Products hydraulic motor.

Figure 26. Flow control valve used to set stripping assembly speed by controlling the split of flow between the stripper motors and all other motors. (Valve #129)

Figure 27. A single spool two position valve used as an emergency stop switch for the machine (Valve #'s 117 & 123). Two are included on the machine at opposite corners. When pushed in, they shunt all hydraulic flow directly from the pump to the reservoir, depowering the motors. Either of the two valves will do this. They valve spool needs to be pulled out in order to run the motors again.

Figure 28. Three control valves. The nearest is the bine feed directional control valve (a three position, single spool control valve, Valve #303). A second of the same type is the next valve to the right and is used to control the stripper section direction (Valve #203). On the far right side of the picture is the stripper speed control valve mounted upside down (Valve #129). See Bill of Materials and Hydraulic Schematic for more information.

INITIAL PEROFRMANCE REVIEW
& AREAS FOR IMPROVEMENT

The harvester was first used shortly after the initial build in August and September of 2011. The L'Etoile family at Four Star Farms in Northfield, MA was able to process a maximum of 45 bines in one hour (2 year old bines) with reasonable separation of cones and leaves, and with minimal cone damage. Machine operation was possible with two people at the machine and a third supplying bines to the work area from the hop yard.

The following performance notes and areas for improvement are summarized by sub-system:

1. Trailer
    a. The 18 ft trailer fits the machine well.
    b. We may remove the wood planking to allow for easier cleanup.
2. Frame
    a. Likely overbuilt using 2"x2" stock steel. This material could be lighter and save initial cost
3. Bine Feed
    a. The long extension of the back of the machine may not be necessary. It was originally designed that way so that the tension on the bine was maintained even through the last of the stripping sections and so that the bine did not wrap around the stripping assemblies or the frame as it might if going around the frame using a shorter bine feed extension. Two factors make the team think this extension could be shortened: (1) the second stripping section is not doing a whole lot of stripping (see other lesson learned in that section), and (2) the bine feed operator has enough time to attach a new bine and guide the stripped bine out of the machine.
    b. The location of the bine feed in this prototype was along the right side of the stripping section (facing the inlet). This has a tendency to pull the bine toward the bine feed chain. There are two problems with this (1) all stripping of cones and leave occurs on one side of the machine causing inefficient stripping and imbalanced loading of the conveyor and (2) the bine can more easily be tangled in the stripping drive mechanisms, therefore not be adequately stripped. The first year operators tried installed guides on the front of the machine to direct the bine diagonally across the stripping sections with some success. Ultimately the inlet requires a "throat" that holds the trailing edge of the bine toward the left of the machine (facing the inlet). Alternatively, one of two stripping fingers could be removed from the center of the stripping bars and the bine feed could be sent down the center of the stripping section rather than the far right side.
    c. Only two bine hooks were installed in the first year of operation. Capacity of the machine can be increased by adding additional bine hooks.
4. Stripping Section
    a. Overall the stripping section performs well as designed. Our first year operators found that a front stripping section opening (finger to finger distance) from 4" at the inlet to 2" at the outlet worked well and stripped the vast majority of the leaves and cones from the bine. The second stripping assembly may not be necessary at all. In our initial operation the bines were "picked clean" by the first section before entering the second section.
    b. Adjustability of the stripping section was found to be valuable. Having the ability to adjust both the opening and the speed of the stripping sections was useful in achieving optimal net yields.
    c. Deflection paneling and directional chutes need to be added to the prototype to ensure all cones and leaves are sent to the primary conveyor and ultimately to the dribble belts for sorting. A combination of cardboard and plywood was used in the first year of operation to better understand where they would be most beneficial:
        i. Semi vertical panel from the bin inlet down toward the primary conveyor
        ii. Vertical panel from the top of the machine to the bine inlet at the bine inlet
        iii. Vertical panels with angled bottoms on the side of the stripping section to direct strippage from the stripping section to the strippage conveyor.
5. Strippage Conveyor
    a. The greatest challenge with the strippage conveyor was tracking of the belt. It was installed without a V-belt/groove, and really should have one. Alternative tracking mechanisms are also possible.

   b. Additionally, this belt was installed with only a drive and tail pulley. Given the span of the belt one or two mid-span rollers would help distribute the belt weight better.
   c. As noted above, ready made steel drive and tail pulleys with steel shafts with V-grooves are available and should be considered over self-made aluminum pulleys with aluminum shafts as used in the prototype.
6. Dribble Belts
   a. The Sparks RuffTuff belting proves well suited for this purpose at the inclines and speeds the machine is designed for.
   b. The V-belt on these belts prevented any tracking issues.
   c. Adjustability of the dribble belts is critical. We made adjustments to both spacing, angle and speed over the course of the first harvesting season.
   d. There are no hard and fast rules for proper adjustment, and some operators found adjustment was required as the day went by and the moisture content of the cones or the variety being harvested changed.
7. Primary and Secondary Hop Conveyors
   a. PVC cleats are unnecessary since the belts were able to be installed with minimal to no incline.
   b. Tracking issues suggest installing V-belt/groove with these belts/pulleys as well.
   c. Steel drive and tail pulleys should be used as noted above.
   d. The secondary hop conveyor was initially intended to bring hops up and over the fender of the trailer. Space constraints limited our ability to do that, so it was move to the front of the machine and installed horizontally. This required reversing direction of the primary hop conveyor.
8. Trash Conveyor
   a. PVC cleats are unnecessary since the belts were able to be installed with minimal to no incline.
   b. Tracking issues suggest installing V-belt/groove with these belts/pulleys as well.
   c. Steel drive and tail pulleys should be used as noted above.
9. Hydraulic System
   a. Speed controls as designed worked well
   b. PTO pump worked well
   c. The bine feed and stripping motors are possibly oversized. They were intentionally over-sized because the team was not sure how strong the bines would be, and wanted to ensure stripping capacity.
   d. There is probably a better location for the hydraulic reservoir than directly over the secondary hop conveyor. When the reservoir was installed, the secondary conveyor was supposed to be installed in a different location.
   e. An oil cooler needs to be included in the system. One limitation to harvesting capacity in the first year was that the hydraulic system got too hot. The cooler needs a rejection rate of approximately 21,000 BTU/hr based on the estimate summarized in the motor list.

BILL OF MATERIALS

Section	Part	Part #	Qty	Unit	Supplier	Supplier Part Description	Supplier Part #
Trailer		**010**			**Kauffman Trailer**	**8'x18' Heavy Duty Equipment Trailer**	**N/A**
Frame		**020**					
	Super Frame	020-1	249	ft	American Steel	2"x2"x0.125" Steel Square Stock	
	Sub Frame	020-2	124	ft	McMaster-Carr	Slotted UniStrut Channel - 10 ft length 1-5/8x1-5/8", primed	3310T126
	Interior Cover Panels	020-3	396	ft2	Tri-Angle Metal Fab	18g sheet	
	Exterior Cover Panels	020-4	252	ft2	Tri-Angle Metal Fab	16g sheet	
Stripping Assemblies		**030**					
	Chains	030-1	80	ft	McMaster-Carr	ANSI 60 Roller Chain, Single Strand, Standard	6261K176
	Finger Bars	030-2	48	each	Dauenhauer Mfg Co.	48" bar with fingers	N/A
	Bearing Block	030-4	8	each	McMaster-Carr	Stamped Steel Mounted Ball Bearing-ABEC-1 for 1" shaft	5913K64
	Shaft - Drive	030-6	2	each	McMaster-Carr	Steel Shaft - 1" OD x 65" L	8920K23 (cut)
	Shaft - Tail	030-7	6	each	McMaster-Carr	Steel Shaft - 1" OD x 55" L	8920K23 (cut)
	Sprocket	030-8	20	each	McMaster-Carr	Steel Finished Bore ANSI 60 Roller Chain Sprocket - 8.07" OD	6236K422
	Drive Motor	030-9	2	each	White Motor Products	RE 160 - 9.9 in3/rev	500160A3120AAAAA
	Bearing (idler/reverser)	030-10	2	each	McMaster-Carr	Nylon Flanged Sleeve Bearing (intended for 1" OD shaft)	6389K435
	Sprocket (idler/reverser)	030-11	2	each	McMaster-Carr	Steel Finished Bore ANSI 60 Roller Chain Sprocket - 3.98" OD	6280K186
Strippage Conveyer		**040**					
	Belt	040-1	1	each	Sparks Belting Co.	EconoPac 120 36" wide x 20' 9.420" long	FG-99519
	Drive Pulley	040-2	1	each	Omni Metalcraft Corp	To order. See Vendor Quote attached.	N/A
	Tail Pulley	040-3	2	each	Omni Metalcraft Corp	To order. See Vendor Quote attached. 2 needed for mid-span support of belt	N/A
	Bearing Block	040-4	6	each	McMaster-Carr	Stamped Steel Mounted Ball Bearing-ABEC-1 for 1" shaft	5913K64
	Drive Motor (direct drive)	040-5	1	each	White Motor Products	WP 50 - 3.0 in3/rev	155050A1101AAAAA
Deflection Sheets		**050**					
	Inlet Throat	050-1	10	ft2		18g sheet to fit	
	Exit Throat	050-2	10	ft2		18g sheet to fit	
	Strippage Deflection Sheet	050-3	15	ft2		18g sheet to fit	
	Strippage Collection Sheets	050-4	32	ft2		18g sheet to fit	
Dribble Belts		**060**					
	Belt	060-1	5	each	Sparks Belting Co.	RuffTuff 75 36" wide x 6' 9.42" inch long with K8 V-belt	FG-99522
	Drive Pulley	060-2	5	each	Omni Metalcraft Corp	To order. See Vendor Quote attached.	N/A
	Tail Pulley	060-3	5	each	Omni Metalcraft Corp	To order. See Vendor Quote attached.	N/A
	Bearing Block	060-4	20	each	McMaster-Carr	Stamped Steel Mounted Ball Bearing-ABEC-1 for 1" shaft	5913K64
	Sprocket	060-6	7	each	McMaster-Carr	Steel Finished Bore ANSI 60 Roller Chain Sprocket - 8.07" OD	6236K422
	Drive Motor	060-7	1	each	White Motor Products	WP 50 - 3.0 in3/rev	155050A1101AAAAA
	Drive Chain	060-8	20	ft	McMaster-Carr	ANSI 40 Roller Chain, Single Strand, 304SS Hollow Pin	like 7272K311

BILL OF MATERIALS (cont.)

Section	Part	Part #	Qty	Unit	Supplier	Supplier Part Description	Supplier Part #
Hop Conveyer		**070**					
	Primary Hop Conveyer	070-1					
	Belt	070-1-001	1	each	Sparks Belting Co.	EconoPac 120 36" wide x 17' 9.420" long	FG-108177
	Drive Pulley	070-1-002	1	each	Omni Metalcraft Corp	To order. See Vendor Quote attached.	N/A
	Tail Pulley	070-1-003	1	each	Omni Metalcraft Corp	To order. See Vendor Quote attached.	N/A
	Bearing Block	070-1-004	4	each	McMaster-Carr	Stamped Steel Mounted Ball Bearing-ABEC-1 for 1" shaft	5913K64 or similar
	Drive Motor	070-1-005	1	each	White Motor Products	WP 50 - 3.0 in3/rev	155050A1101AAAAA
	Secondary Hop Conveyer	070-2					
	Belt	070-2-001	1	each	Sparks Belting Co.	EconoPac 120 24" wide x 9' 11.410" long	FG-108178
	Drive Pulley	070-2-002	1	each	Omni Metalcraft Corp	To order. See Vendor Quote attached.	N/A
	Tail Pulley	070-2-003	1	each	Omni Metalcraft Corp	To order. See Vendor Quote attached.	N/A
	Bearing Block	070-2-004	4	each	McMaster-Carr	Stamped Steel Mounted Ball Bearing-ABEC-1 for 1" shaft	5913K64 or similar
	Drive Motor	070-2-005	1	each	White Motor Products	WP 50 - 3.0 in3/rev	155050A1101AAAAA
Trash Conveyer		**080**					
	Belt	080-1	6	ft	Sparks Belting Co.	EconoPac 120 36" wide x 6' 9.420" long	FG-108179
	Drive Pulley	080-2	1	each	Omni Metalcraft Corp	To order. See Vendor Quote attached.	N/A
	Tail Pulley	080-3	1	each	Omni Metalcraft Corp	To order. See Vendor Quote attached.	N/A
	Bearing Block	080-4	4	each	McMaster-Carr	Stamped Steel Mounted Ball Bearing-ABEC-1 for 1" shaft	5913K64 or similar
	Drive Motor	080-5	1	each	White Motor Products	WP 50 - 3.0 in3/rev	155050A1101AAAAA
Bine Feed		**090**					
	Chain	090-1	40	ft	McMaster-Carr	ANSI 60 Roller Chain, Single Strand, Standard	6261K176
	Chain Add-on Links	090-2	6	each	McMaster-Carr	SK1 Roller Chain Attachment Link	7321K47
	Bine Hook	090-3	6	each	Dauenhauer Mfg Co.	Pin style hooks	N/A
	Bearing Block	090-4	2	each	McMaster-Carr	Nylon Flanged Sleeve Bearing (intended for 1" OD shaft)	6389K435
	Sprocket	090-5	4	each	McMaster-Carr	Steel Finished Bore ANSI 60 Roller Chain Sprocket - 8.07" OD	6236K422 or similar
	Strut Channel	090-6	40	ft	McMaster-Carr	Slotted UniStrut Channel - 10 ft length 1-5/8x1-5/8", primed	3310T126
	Drive Motor	090-7	1	each	White Motor Products	RE 750 - 45.6 in3/rev	500750A3120AAAAA
Hydraulic Supply		**110**					
	Pump	110-1	1	each	Prince Hydraulic	Prince - PTO Pump - Rear Port	HC-P-K11
	Lines	110-2-(#)			Charlebois Truck Parts	See Hose List attached for numbers and specs	
	Speed Control Valves (Motor Oultet Mount)	110-3	7	each	Hydstar / Northern Tool	Inline dial type flow control valve (throttle valve) - 1/2 NPT ports typical	2057
	Flow Control Valve (Stripper Speed / Split)	110-4	2	each	Prince Hydraulic	Pressure Compensating Variable Flow Control Valve (0-16 gpm)	RD-1975-16
	50/50 Flow Divider Stripper Section	110-5	1	each	Prince Hydraulic	Prince - Proportional Flow Divider	RD-200
	Directional Control Valve (Bine Feed and Strippers)	110-6	2	each	Prince Hydraulic	Prince - Single 4 way Spool, 3 position detent, 20 GPM rated	RD-2575-T4-EDA1
	Emergency Stop Solenoid Valves	110-7	2	each	Brand	Brand - Manual Selector Valve "MS"	MS-16SAE
	Pressure Gauges	110-8	1	each		Hydraulic Pressure Gauge (0-3000 psi, liquid filled, 4-1/4" dial)	3715K713
	Pressure Relief Valve	110-9	1	each	Cross	Cross - Pressure Relief Valve - 40 GPM at 2500 PSI	VRV1
	Check Valve	110-10	1	each	Hydac	Hydac - Check Valve - SAE-16 (1"NPT)	RD-20
	Resevoir	110-11	1	each	Northern Tool	Buyers - Hydraulic Reservoir 25 gallon	40541
	Filter	110-12	1	each	Baldwin	Base 1-1/4" NPT to 1-1/4" NPT / Filter 5" Hydraulic	OB8771 / BT389
	Supply Manifold	110-13	1	each	Charlebois Truck Parts	Pressure rated with Ports to match hose (can be done with a chain of tees adapters)	
	Return Manifold	110-14	1	each	Charlebois Truck Parts	Pressure rated with Ports to match hose (can be done with a chain of tees adapters)	

PULLEY AND BELT QUOTES

Chris Callahan

To: customerservice@sparksbelting.com

Subject: RE: Here is your quote from Sparks Belting - Quote #42180

-----Original Message-----
From: customerservice@sparksbelting.com [mailto:customerservice@sparksbelting.com]
Sent: Wednesday, March 07, 2012 3:30 PM
To: chris@callahan.eng.pro
Subject: Here is your quote from Sparks Belting - Quote #42180

Sparks Belting Co, Inc.

Grand Rapids, MI	Chicago, IL	Seattle, WA	Denver, CO
Cleveland, OH	Los Angeles, CA	Charlotte, NC	
Fairfield, NJ	York, PA	Monterry, MX	

Visit us on the web at www.sparksbelting.com
Phone: 800-451-4537 Fax: 800-338-2358
Email: customerservice@sparksbelting.com

***If you cannot read this email please email Sparks Customer Service at customerservice@sparksbelting.com ***

Sparks Sales Quote Acknowledgement

Date of Quote: 03-07-12
Expiration Date: 04-06-12
Revision Level: 0 0 0 0 0 0 0 0 0
Requested By: CHRIS CALLAHAN
Email: chris@callahan.eng.pro

```
Bill To:
Callahan Engineering, PLLC
PO Box 155
19 Spring St.


Phone: 518-677-5275    Fax: 518-677-5275

Ship To:
Callahan Engineering, PLLC
PO Box 155
19 Spring St.
Cambridge, NY 12816
United States of America

Ln Item                                  Lead Time
No Number                               (in days)     UM       QTY   Unit
Price  Ext Price
  1 FG-99519|10                            7          EA     1.000
467.705      467.71
    CUST PN #1 STRIPPAGE CONV.
    ECONO PAC 120
    01-029|10
    36.000" wide X 20' 9.420" long
    Laced
    Customer Part Number = Not Supplied
    Alligator Staple Lace No Fab
    1 V-Guides of Z Section (K8), PVC Regular
```

Center on Pulley Side

2	FG-108176|10 CUST PN #1 STRIPPAGE CONV. ECONO PAC 120 01-029|10 48.000" wide X 20' 9.420" long Laced Customer Part Number = Not Supplied Alligator Staple Lace No Fab 1 V-Guides of Z Section (K8), PVC Regular Center on Pulley Side	7	EA	1.000	592.200	592.20
3	FG-99522|10 CUST PN DRIBBLE BELTS #2-#6 RUFF TUFF 75 01-011|10 36.000" wide X 6' 9.420" long Laced Customer Part Number = Not Supplied Alligator Staple Lace Recessed 1 V-Guides of Z Section (K8), PVC Regular Center on Pulley Side	7	EA	1.000	303.737	303.74
4	FG-108177|10 CUST PN #7 PRIMARY HOPPER ECONO PAC 120 01-029|10 36.000" wide X 17' 9.420" long Laced Customer Part Number = Not Supplied Alligator Staple Lace No Fab 1 V-Guides of Z Section (K8), PVC Regular Center on Pulley Side	7	EA	1.000	421.309	421.31
5	FG-108178|10 CUST PN #8 SECONDARY HOPPER ECONO PAC 120 01-029|10 24.000" wide X 9' 11.410" long Laced Customer Part Number = Not Supplied Alligator Staple Lace No Fab 1 V-Guides of Z Section (K8), PVC Regular Center on Pulley Side	7	EA	1.000	217.266	217.27
6	FG-108179|10 CUST PN #9 TRASH CONV. ECONO PAC 120 01-029|10 36.000" wide X 6' 9.420" long Laced Customer Part Number = Not Supplied Alligator Staple Lace No Fab 1 V-Guides of Z Section (K8), PVC Regular Center on Pulley Side	7	EA	1.000	251.202	251.20

Freight Terms: Prepaid & Add
Ship Via:BEST WAY
Payment Terms
Delivery dates relative to quote acceptance date

Sales Rep: T07 Charles Storer

Quotation

P.O. Box 352, Alpena, MI 49707 – Phone: (989) 358-7000 – www.omni.com

To:	Callahan Engineering PO Box 155 Cambridge, NY 12816	Quote: Date: Quoted By:	**778891 [Rev.: A]** April 13, 2012 Susan McHarg
Attn: Voice: Fax:	Mr. Chris Callahan (518) 677-5275	Direct Dial: Fax: Email:	(989) 358-7066 (989) 358-7020 susan@omni.com

Item	Quantity	Description	Your Cost
1)	1	STRIPPAGE DRIVE PULLEY - 50" FACE LENGTH - CROWNED AND LAGGED 1/4" BLACK 60 DURO SBR VULCANIZED - 3.5" FINISH DIA. - 3" DIA X 11 GA TUBE - K8 V-GROOVE IN CENTER - 1" BORE TYPE2 KEYED HUBS W/SET SCREWS - PRIME ENDS ONLY - AXLE 1" DIA 1045 COLD ROLLED X 65" LONG 2 HUB KEYWAY AND 1 DRIVE KEYWAY - 42 LB WT.	$ 252.30/EA
2)	1	STRIPPAGE TAIL PULLEY - 50" FACE LENGTH - LESS CROWN AND LAGGING - 3.5" DIA X 1/4" WALL TUBE - K8 V-GROOVE IN CENTER - 1.4375" BORE TYPE2 KEYED HUBS W/SET SCREWS - PRIME ENDS ONLY - AXLE 1.4375" DIA 1045 COLD ROLLED X 55" LONG 2 HUB KEYWAY ENDS TURNED DOWN TO 1" DIA OUTSIDE HUBS - 67 LB WT.	$ 338.08/EA
3)	6	DRIBBLE DRIVE PULLEY - 38" FACE LENGTH - CROWNED AND LAGGED 1/4" BLACK 60 DURO SBR VULCANIZED - 3.5" FINISH DIA. - 3" DIA. X 11 GA TUBE - K8 V-GROOVE IN CENTER - 1" BORE TYPE2 KEYED HUBS W/SET SCREWS - PRIME ENDS ONLY - AXLE 1" DIA 1045 COLD ROLLED X 65" LONG 2 HUB KEYWAY AND 1 DRIVE KEYWAY - 37 LB WT.	$ 233.20/EA
4)	6	DRIBBLE TAIL PULLEY - 38" FACE LENGTH - LESS CROWN AND LAGGING - 3" DIA X 11 GA TUBE - K8 V-GROOVE IN CENTER	$ 127.25/EA

- 1" BORE TYPE2 KEYED HUBS W/SET SCREWS
- PRIME ENDS ONLY
- AXLE 1" DIA 1045 COLD ROLLED X 55" LONG 2 HUB KEYWAY
- 30 LB WT.

5)	1	SECONDARY HOP DRIVE PULLEY - 26" FACE LENGTH - CROWNED AND LAGGED 1/4" BLACK 60 DURO SBR VULCANIZED - 3.5" FINISH DIA. - 3" DIA. X 11 GA TUBE - K8 V-GROOVE IN CENTER - 1" BORE TYPE2 KEYED HUBS W/SET SCREWS - PRIME ENDS ONLY - AXLE 1" DIA 1045 COLD ROLLED X 37" LONG 2 HUB KEYWAY AND 1 DRIVE KEYWAY - 26 LB WT.	$ 198.67/EA
6)	1	SECONDARY HOP TAIL PULLEY - 26" FACE LENGTH - LESS CROWN AND LAGGING - 3" DIA X 11 GA TUBE - K8 V-GROOVE IN CENTER - 1" BORE TYPE2 KEYED HUBS W/SET SCREWS - PRIME ENDS ONLY - AXLE 1" DIA 1045 COLD ROLLED X 28.75" 2 HUB KEYWAY - 20 LB WT.	$ 108.95/EA
7)	1	PRIMARY HOP DRIVE PULLEY - 38" FACE LENGTH - CROWNED AND LAGGED 1/4" BLACK 60 DURO SBR VULCANIZED - 3.5" FINISH DIA. - 3" DIA. X 11 GA TUBE - K8 V-GROOVE IN CENTER - 1" BORE TYPE2 KEYED HUBS W/SET SCREWS - PRIME ENDS ONLY - AXLE 1" DIA 1045 COLD ROLLED X 65" 2 HUB KEYWAY AND 1 DRIVE KEYWAY - 37 LB WT.	$ 233.20/EA
8)	1	PRIMARY HOP TAIL PULLEY - 38" FACE LENGTH - LESS CROWN AND LAGGING - 3" DIA X 11 GA TUBE - K8 V-GROOVE IN CENTER - 1" BORE TYPE2 KEYED HUBS W/SET SCREWS - PRIME ENDS ONLY - AXLE 1" DIA 1045 COLD ROLLED X 55" 2 HUB KEYWAY - 30 LB WT.	$ 127.25/EA
9)	1	TRASH DRIVE PULLEY - 36" FACE LENGTH - CROWNED AND LAGGED 1/4" BLACK 60 DURO SBR VULCANIZED - 3.5" FINISH DIA. - 3" DIA. X 11 GA TUBE - K8 V-GROOVE IN CENTER - 1" BORE TYPE2 KEYED HUBS W/SET	$ 229.35/EA

		SCREWS - PRIME ENDS ONLY - AXLE 1" DIA 1045 COLD ROLLED X 65" 2 HUB KEYWAY AND 1 DRIVE KEYWAY - 36 LB WT.	
10)	1	TRASH TAIL PULLEY - 36" FACE LENGTH - LESS CROWN AND LAGGING - 3" DIA X 11 GA TUBE - K8 V-GROOVE IN CENTER - 1" BORE TYPE2 KEYED HUBS W/SET SCREWS - PRIME ENDS ONLY - AXLE 1" DIA 1045 COLD ROLLED X 55" 2 HUB KEYWAY - 29 LB WT.	$ 126.35/EA
11)	1	NOTE: PRICING BASED ON TOTAL QTY PURCHASED AND BUILT AT THE SAME TIME - ITEMS ARE BUILT TO ORDER AND ARE NOT RETURNABLE	$ .00/EA
12)	1	CHRIS - THE STRIPPAGE TAIL PULLEY HAD A QUOTING ISSUE AND THAT IS WHY IT IS SLIGHTLY DIFFERENT THAN THE OTHER TAIL PULLEYS - I WILL CALL TO EXPLAIN - WE PUT DRIVE KEYWAY ON ALL DRIVE PULLEY SHAFTS - BEFORE PULLEYS CAN BE BUILT, WE NEED SPECIFIC INFO ON THE SHAFT EXTENSION LENGTH EACH END OF THE PULLEY TO LOCATE PULLEY ON THE SHAFT	$ .00/EA

SHIPMENT: 7 WRKING DAYS (1.5 WKS)

- Unless otherwise stated - All prices are F.O.B. Shipping Point, and firm for 30 days subject to material cost increases.
- Terms of payment are subject to credit review and approval.
- Quoted delivery is based on current inventory status and/or material availability; check delivery when placing order.
- Stenographic and clerical errors are subject to correction.
- All orders subject to Omni Metalcraft Corp. Standard Terms and Conditions of Sale.

MOTOR & PUMP LIST

Motor Name	Part Number	Nominal Drive Speed	Drive Diameter	Nominal RPM	Expected Load	Expected Torque	Shaft Power	Assumed % Efficiency	Heat Load	Shaft Diam	Shaft Stress	Material S_ut	FOS	in3/rev	Expected GPM
Bine Feed Drive	090-7	2 in/sec	8 inch	5	500 lbs	4000 in-lbs	167 ft-lbs/s	80%	45 watts	1 in	20 ksi	74 ksi	4	45.60	0.9
Stripper Drive 1	030-9	6 ft/sec	8 inch	172	500 lbs	4000 in-lbs	6000 ft-lbs/s	80%	1627 watts	1 in	20 ksi	74 ksi	4	9.90	7.4
Stripper Drive 2	030-9	6 ft/sec	8 inch	172	500 lbs	4000 in-lbs	6000 ft-lbs/s	80%	1627 watts	1 in	20 ksi	74 ksi	4	9.90	7.4
Strippage Conveyor Drive	040-5	1 ft/sec	3 inch	76	100 lbs	300 in-lbs	200 ft-lbs/s	80%	54 watts	1 in	2 ksi	74 ksi	48	3.00	1.0
Dribble Belt Drive	060-7	1 ft/sec	3 inch	76	100 lbs	300 in-lbs	200 ft-lbs/s	80%	54 watts	1 in	2 ksi	74 ksi	48	3.00	1.0
Primary Hop Conveyor Drive	070-1-005	1 ft/sec	3 inch	76	100 lbs	300 in-lbs	200 ft-lbs/s	80%	54 watts	1 in	2 ksi	74 ksi	48	3.00	1.0
Secondary Hop Conveyor Drive	070-2-005	1 ft/sec	3 inch	76	100 lbs	300 in-lbs	200 ft-lbs/s	80%	54 watts	1 in	2 ksi	74 ksi	48	3.00	1.0
Trash Drive	080-5	1 ft/sec	3 inch	76	100 lbs	300 in-lbs	200 ft-lbs/s	80%	54 watts	1 in	2 ksi	74 ksi	48	3.00	1.0
Total (at 1500 psi)									3571 watts						**20.6**
Pump Name	**Part Number**			**Nominal RPM**		**Expected Pressure**		**ETD**	**60**						**Expected GPM**
PTO Hydraulic Pump	110-1			**540**		1500									**21**
				1000		1500									**40**
								Heat Rejection Needed	5951	Watts					
									20306	BTU/hr					

HYDRUALIC CONTROL LIST

Speed Control Valves	Part Number	Valve Number	Mfr / Supplier	Mfr. Part Number	Description
Bine Feed Drive	110-3	311	Hydrastar / Northern Tool	2057	1/2 in. port inline flow control valve. Dial type.
Stripper Drive	110-4	129	Prince	RD-1975-16	3/4 in port Pressure Compensated Flow Control Valve (0-16 GPM)
Strippage Conveyor Drive	110-3	401	Hydrastar / Northern Tool	2057	1/2 in. port inline flow control valve. Dial type.
Dribble Belt Drive	110-3	501	Hydrastar / Northern Tool	2057	1/2 in. port inline flow control valve. Dial type.
Primary Hop Conveyor Drive	110-3	601	Hydrastar / Northern Tool	2057	1/2 in. port inline flow control valve. Dial type.
Secondary Hop Conveyor Drive	110-3	701	Hydrastar / Northern Tool	2057	1/2 in. port inline flow control valve. Dial type.
Trash Drive	110-3	801	Hydrastar / Northern Tool	2057	1/2 in. port inline flow control valve. Dial type.
Directional Control Valves					
Bine Feed	110-6	303	Prince	RD-2575-T4-EDA1 or similar	Single 4 way Spool, 3 position detent, 20 GPM rated
Stripper Drives	110-6	203	Prince	RD-2575-T4-EDA1 or similar	Single 4 way Spool, 3 position detent, 20 GPM rated
E-Stop Valves					
Main Supply from Pump - Bine Inlet	110-7	117	Brand	MS16SAE or similar	Single 4 way spool, 2 position detent, "Selector Valve"
Main Supply from Pump - Bine Outlet	110-7	123	Brand	MS16SAE or similar	Single 4 way spool, 2 position detent, "Selector Valve"
Flow Splitter					
Stripper Drive Flow Splitter (50/50)	110-5	N/A	Prince	RD-200	Proportional flow splitter, adjustable for field setting.

HOSE LIST

Hose #	Hose Diameter (inch)	Length (ft)	From	Inlet Connection	To	Outlet Connection	Est. Flow (GPM)	Notes
100	1.250	10	Tank Supply (out)	2" NPT	Pump In	#20 SAE Oring	21.1	
105	1.000	10	Pump Out	#20 SAE Oring	Pressure Relief Valve In	#16 JIC	21.1	40 GPM max
110	1.000	1	Pressure Relief Out (Non-Relieving)	#16 JIC	Check Valve In	#16 JIC	21.1	Junction / Tee possible
115	1.000	12	Check Valve Out	#16 JIC	E-Stop 1 In	#16 JIC	21.1	
120	1.000	20	E-Stop 1 Out	#16 JIC	E-Stop 2 In	#16 JIC	21.1	
125	1.000	20	E-Stop 2 Out	#16 JIC	Stripper FCV In	#16 JIC	21.1	
200	0.750	1	Stripper FCV Control Flow Out	#12 JIC	Stripper Reversing Valve In (Normal)	#12 JIC	14.8	
205	0.750	6	Stripper Reversing Valve Supply (Normal	#12 JIC	Stripper Motor 1 In	#12 SAE Oring	7.4	
210	0.750	6	Stripper Motor 1 In	#12 JIC	Stripper Motor 2 In	#12 SAE Oring	7.4	Junction / Tee possible
215	0.750	12	Stripper Motor 2 Out	#12 SAE Oring	Stripper Motor 1 Out	#12 SAE Oring	7.4	Junction / Tee possible
220	0.750	12	Stripper Motor 1 Out	#12 JIC	Stripper Reversing Valve Return (Normal	#12 JIC	7.4	
225	1.250	6	Stripper Reversing Valve Out (Normal)	#20 JIC	Return Manifold In	#20 JIC	14.8	Large hose for slow flow (to cool down)
300	0.750	6	Stripper FCV Exhaust Flow Out	#12 JIC	Supply Manifold In	#12 JIC	6.3	
305	0.750	3	Supply Manifold Out	#12 JIC	Bine Feed Motor Reversing Valve In (Nor	#12 JIC	1.3	
310	0.750	6	Bine Feed Motor Reversing Valve Supply	#12 JIC	Bine Feed Motor In	#12 SAE Oring	1.3	
315	0.750	6	Bine Feed Motor Out	#12 SAE Oring	Bine Feed Motor Reversing Valve Return	#12 JIC	1.3	
320	0.750	6	Bine Feed Motor Reversing Valve Out (N	#12 JIC	Return Manifold In	#12 JIC	1.3	
400	0.625	3	Supply Manifold Out	#10 JIC	Stripper Conveyor Motor In	#10 SAE Oring	1	
405	0.625	4	Stripper Conveyor Motor & FCV Out	#10 JIC	Return Manifold In	#10 JIC	1	
500	0.625	6	Supply Manifold Out	#10 JIC	Dribble Belt Motor In	#10 SAE Oring	1	
505	0.625	4	Dribble Belt Motor & FCV Out	#10 JIC	Return Manifold In	#10 JIC	1	
600	0.625	6	Supply Manifold Out	#10 JIC	Primary Hop Conveyor Motor In	#10 SAE Oring	1	
610	0.625	4	Primary Hop Conveyor Motor & FCV Out	#10 JIC	Return Manifold In	#10 JIC	1	
700	0.625	12	Supply Manifold Out	#10 JIC	Secondary Hop Conveyor Motor In	#10 SAE Oring	1	
710	0.625	6	Secondary Hop Conveyor Motor & FCV (	#10 JIC	Return Manifold In	#10 JIC	1	
800	0.625	6	Supply Manifold Out	#10 JIC	Trash Conveyor Motor In	#10 SAE Oring	1	
810	0.625	4	Trash Conveyor Motor & FCV Out	#10 JIC	Return Manifold In	#10 JIC	1	
900	1.000	12	Return Manifold Out	#16 JIC	Radiator (To be added)	#16 JIC	21.1	Large hose for slow flow (to cool down)
905	1.000	1	Radiator Out	#16 JIC	Filter In	#16 JIC	21.1	Junction / Tee possible
907	1.000	1	Filter Out	#16 JIC	Tank Return (in)	1.250" NPT	21.1	Junction / Tee possible
910	1.000	12	E-Stop 1 Bypass	#16 JIC	Tank Return (in)	1.250" NPT	21.1	40 GPM Max
920	1.000	14	E-Stop 2 Bypass	#16 JIC	Tank Return (in)	1.250" NPT	21.1	40 GPM Max

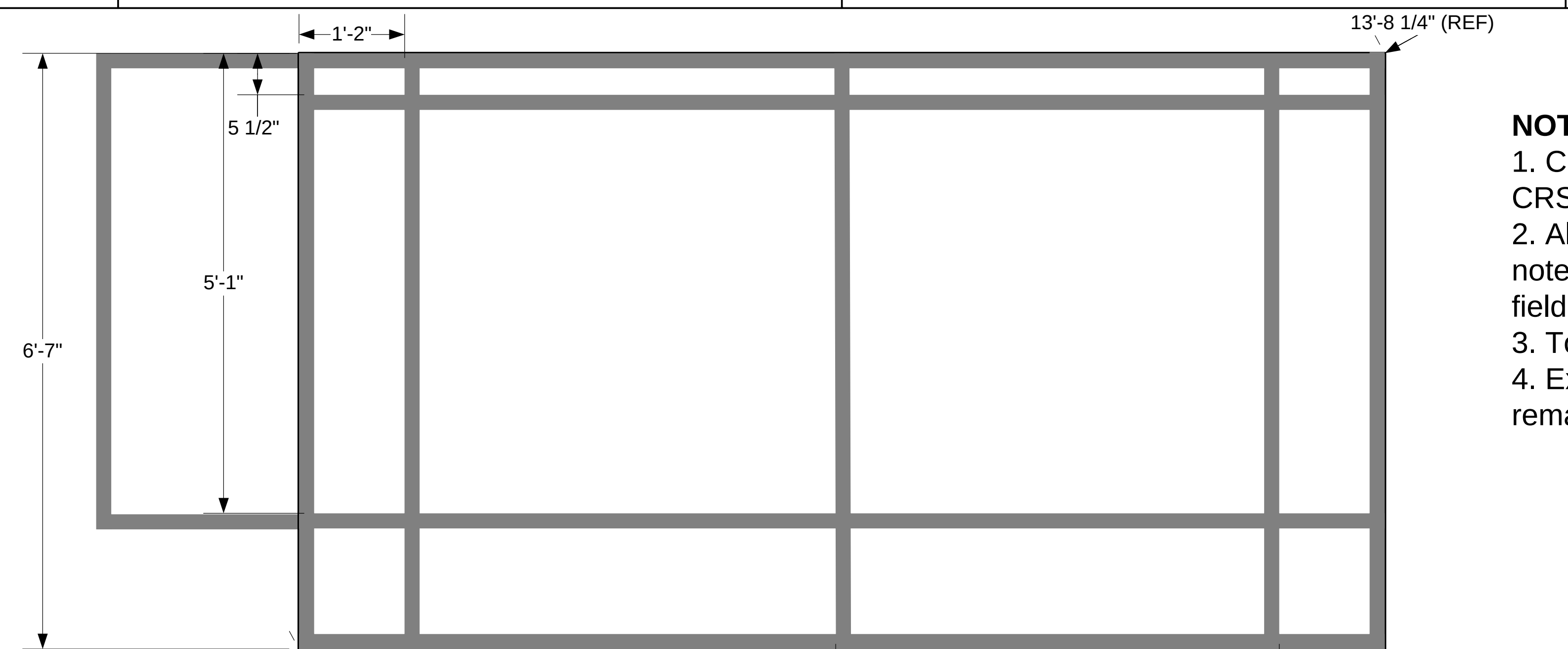
Totals	1.250	16 feet
	1.000	103 feet
	0.750	64 feet
	0.625	55 feet

DRAWINGS

** NOTE **
The drawings are intended for 11”x17” paper when printed at full scale. You may print them on 8.5”x11” paper by selecting “Fit” or “Shrink Oversized Pages” in the print menu. Remember, if printed on 8.5”x11” paper, the scale indicated on the drawings will not be accurate. A larger set may be desirable for ease of reading / use.

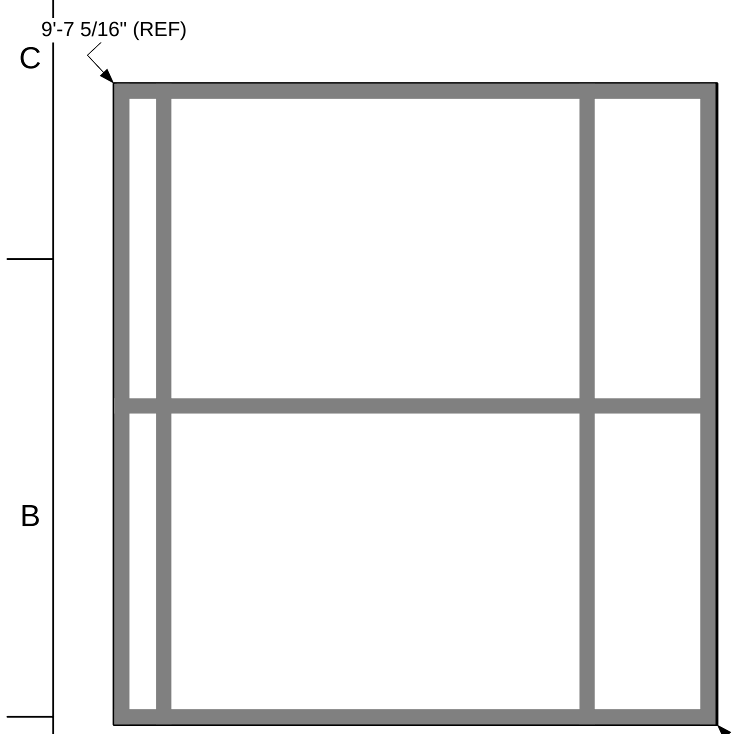
TOP

TYPICAL FRAME SECTION IN PLAN VIEW



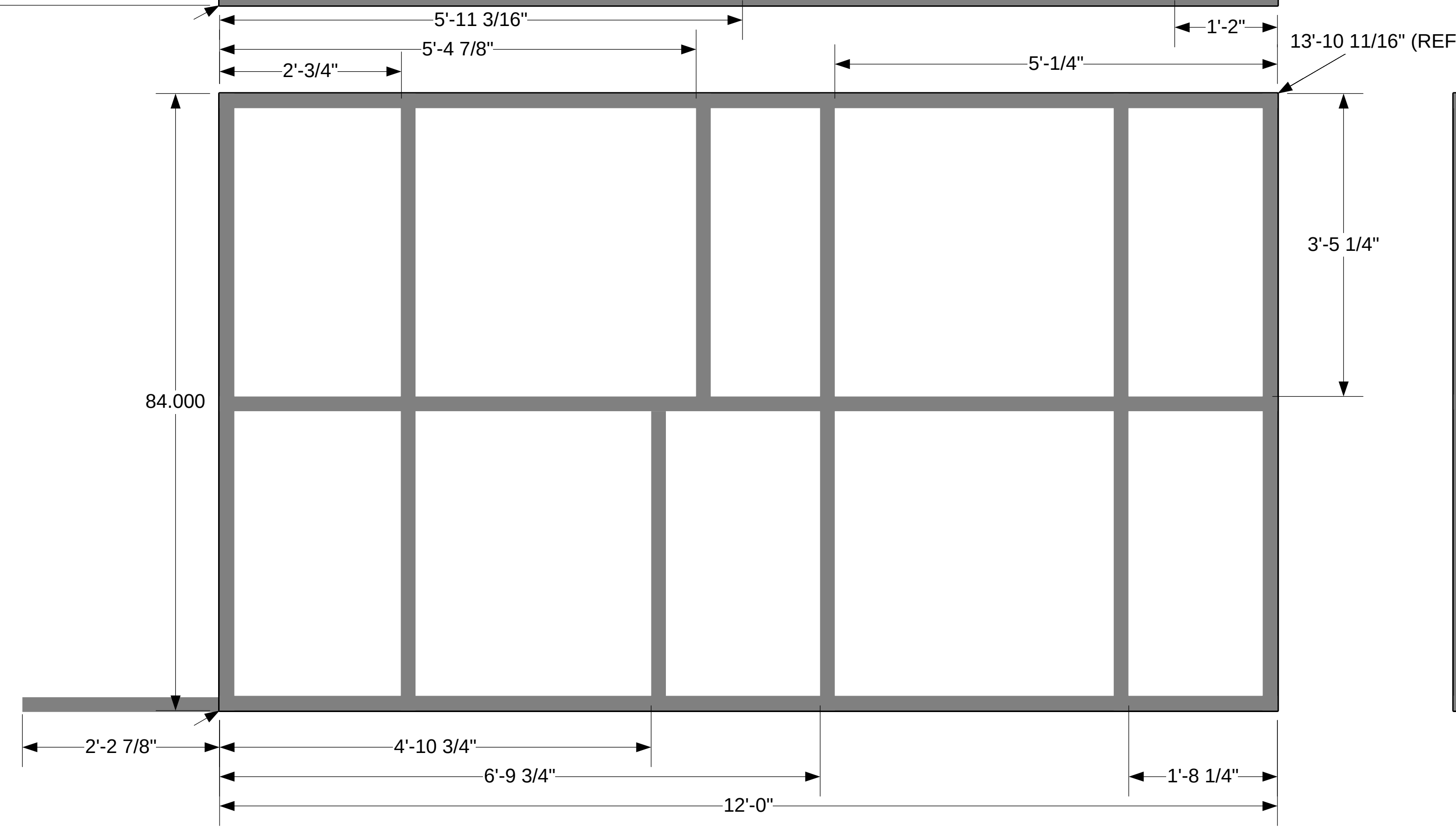
NOTES

1. Construction from 2"x2"x0.125" wall square stock CRS welded at joints and dressed with grinding.
2. All corners square (90 deg) unless otherwise noted. Diagonal dimensions provided for reference field verification of square.
3. Tolerances: Linear +/- .0625". Angular +/- 2 deg.
4. Exterior panels cut to size after completion of remaining assembly.



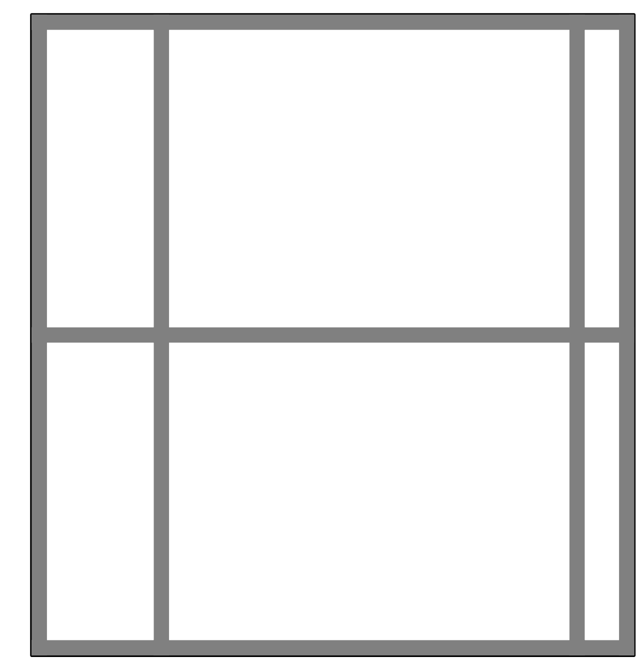
FEED SIDE

TYPICAL FRAME SECTION IN FEED DIRECTION



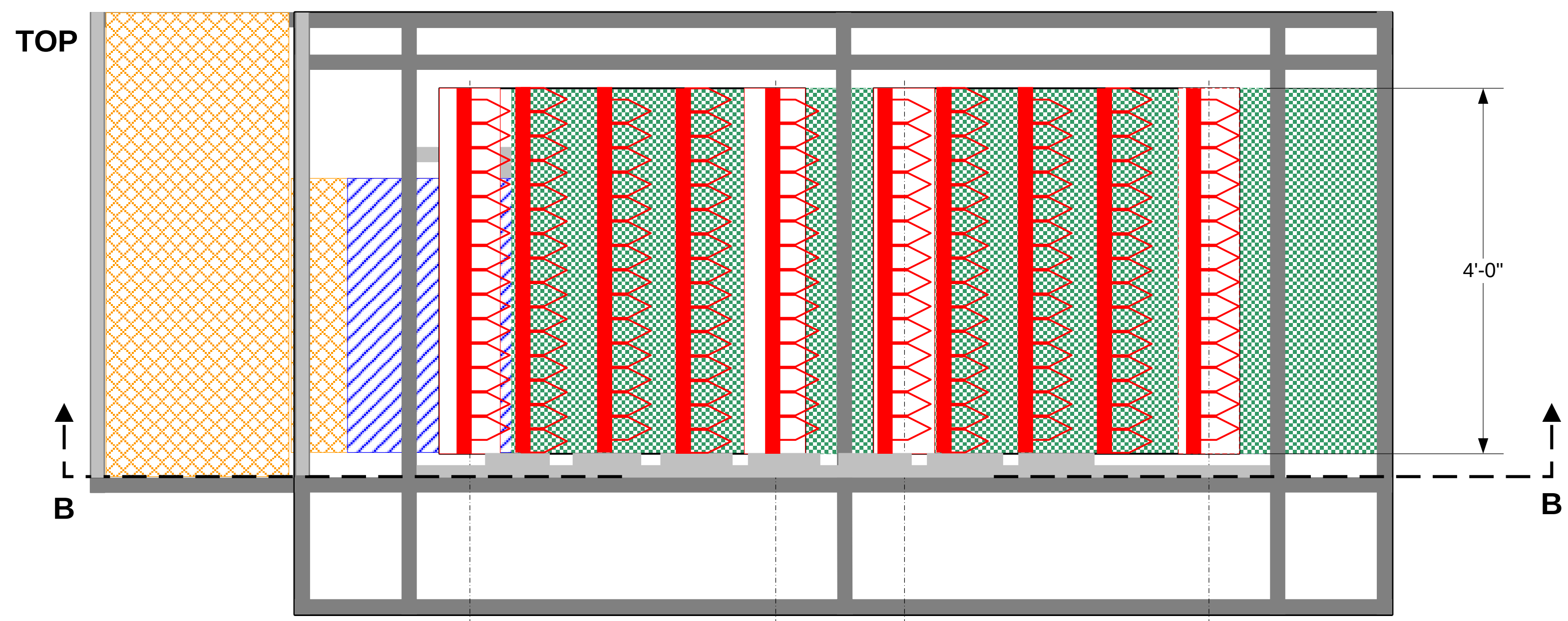
ELEVATION VIEW

TYPICAL FRAME SECTION ON EITHER SIDE OF STRIPPING BELTS and EXTERIOR FRAME SECTIONS IN THIS VIEW



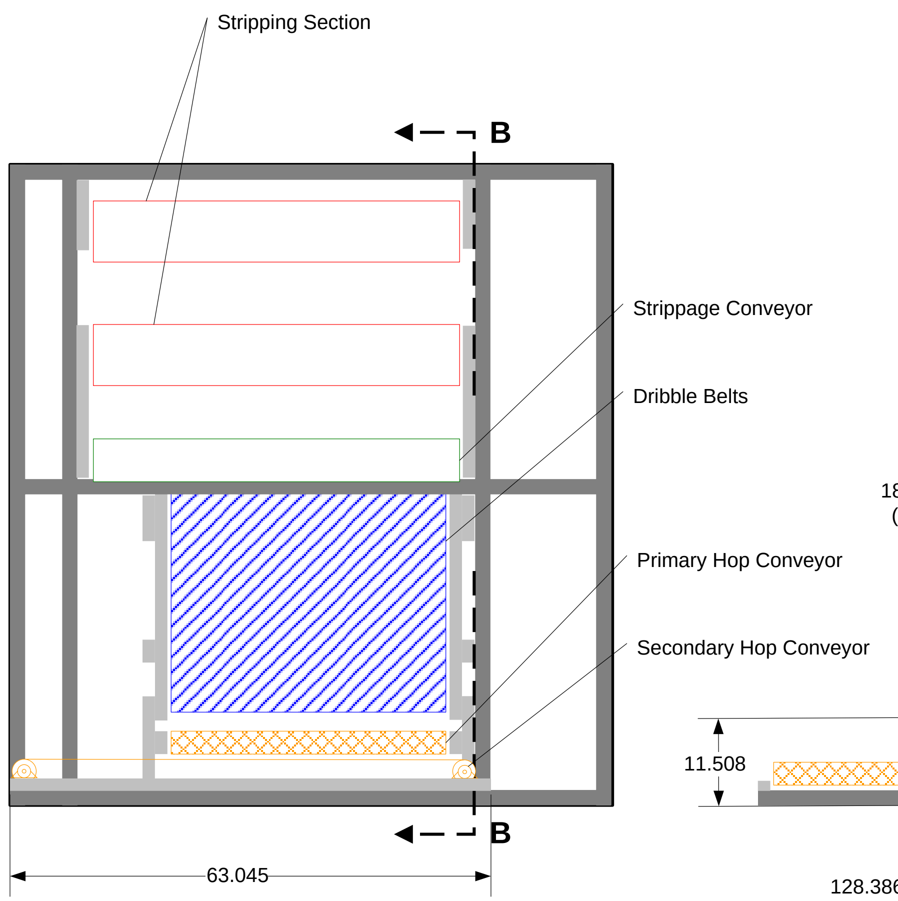
DISCHARGE SIDE

The UNIVERSITY of VERMONT EXTENSION	UVM Hops Project – Portable Picker & Cleaner			
	MAIN FRAMING			
DRAWN BY: C. Callahan	SIZE B	FSCM NO	DWG NO UVM-CE-2011-0001	REV -
	SCALE 1/2" = 1'-0"	2012 04 10	SHEET 1 OF 1	

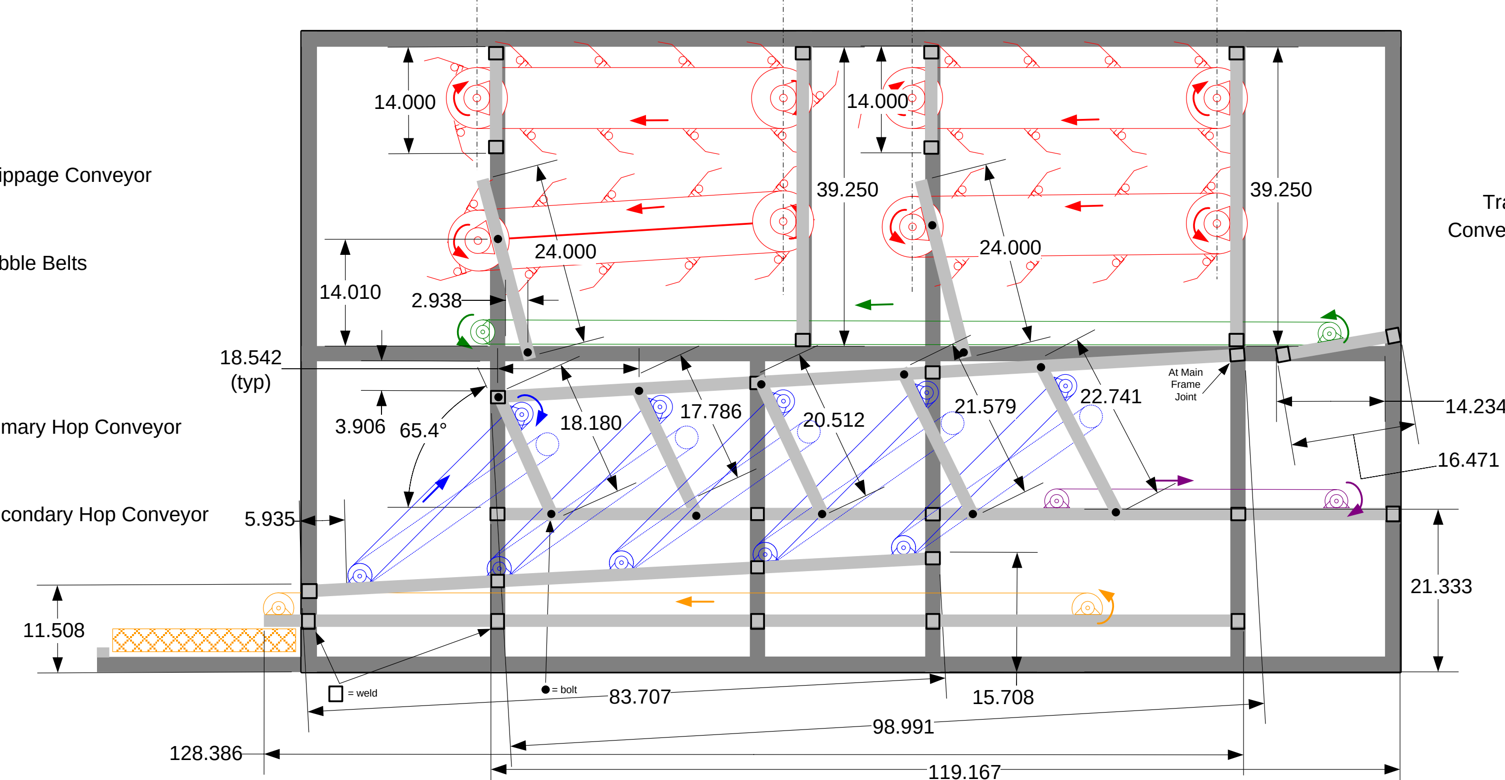


NOTES

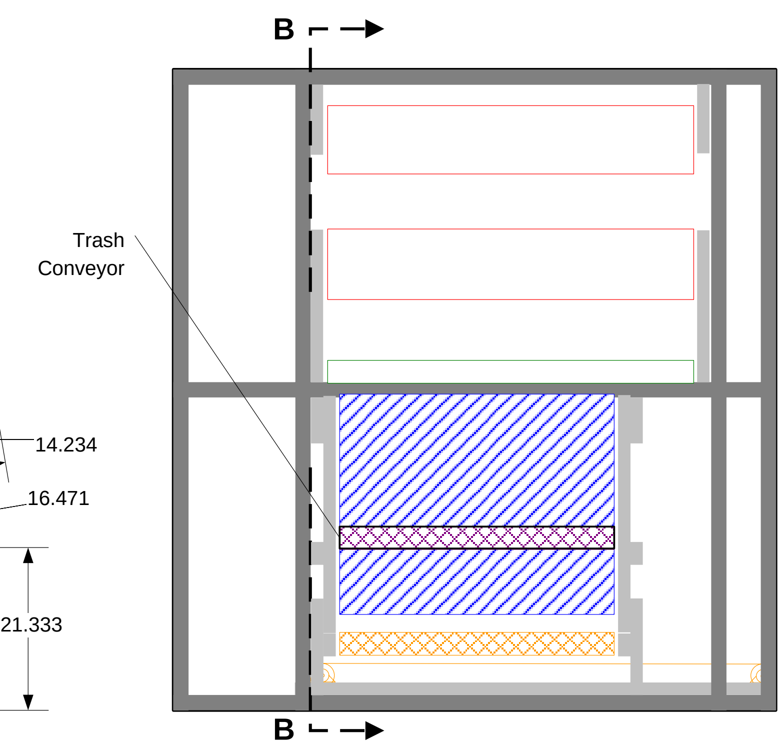
1. All dimensions are decimal inches unless otherwise noted.
2. Belts and stripping section shown for reference only. See schedule of belts & rollers for specifications.
3. Construction from 1.625"x1.625"x14g UniStrut or similar. Break all cut edges.
4. All corners square (90 deg) unless otherwise noted. Diagonal dimensions provided for reference field verification of square.
5. Tolerances: Linear +/- .0625". Angular +/- 2 deg.
6. UnitStrut will generally face bearing block base for attachment using spring nuts.
7. Dimensions should be field checked based on need for landing area where attached to main frame and other sub-frame members.



FEED SIDE



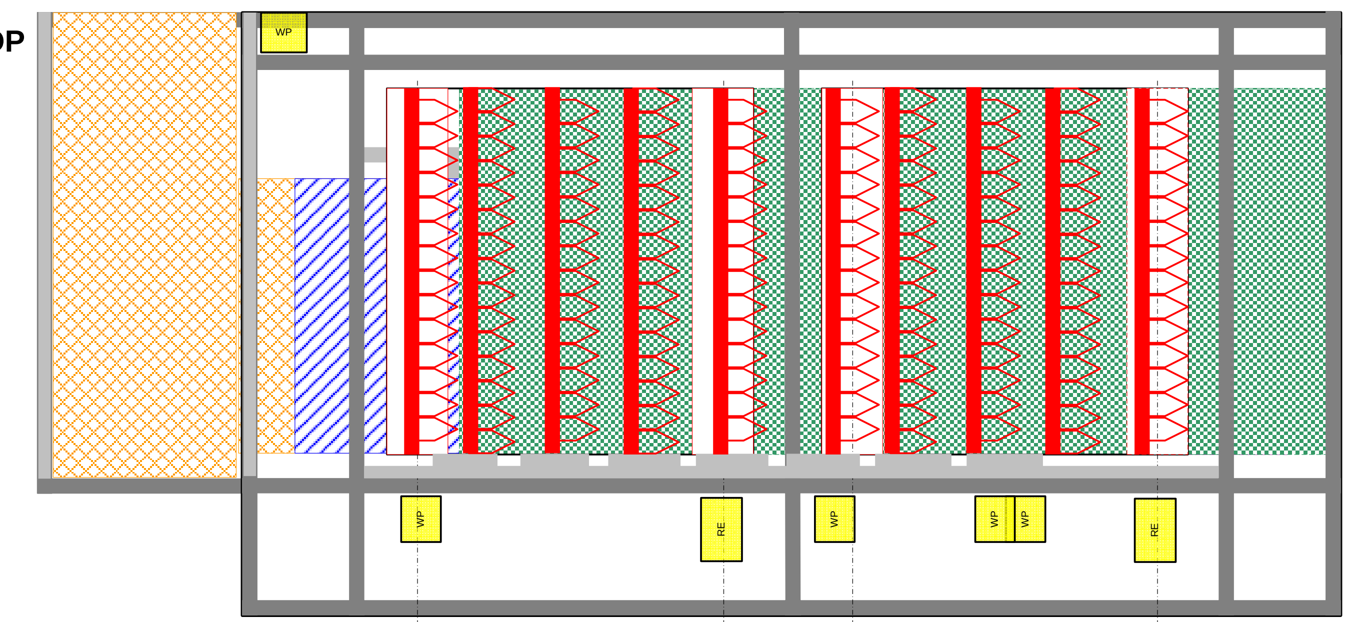
ELEVATION VIEW
(SECTION B-B)



DISCHARGE SIDE
(Cover Removed)

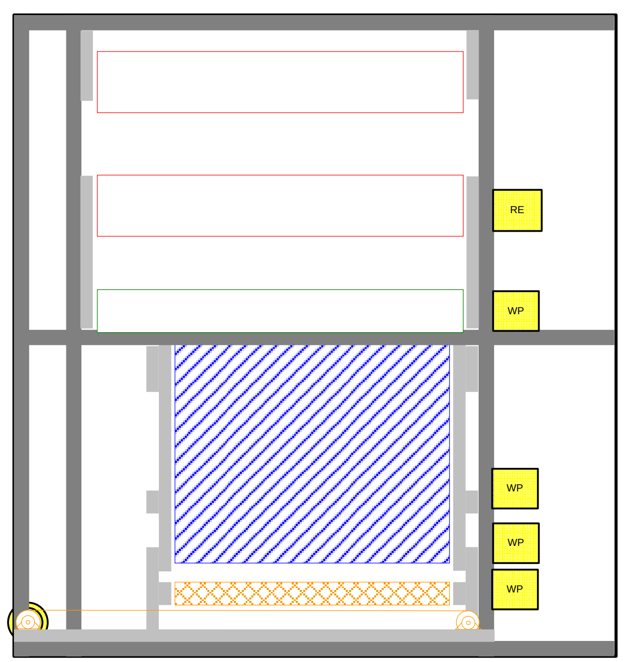
The UNIVERSITY of VERMONT EXTENSION	UVM Hops Project – Portable Picker & Cleaner			
	SUB-FRAMING			
DRAWN BY: C. Callahan	SIZE B	FSCM NO	DWG NO CE-UVM-2011-0002	REV -
	SCALE 1/2" = 1'-0"	2012 04 10	SHEET 1 OF 1	

TOP

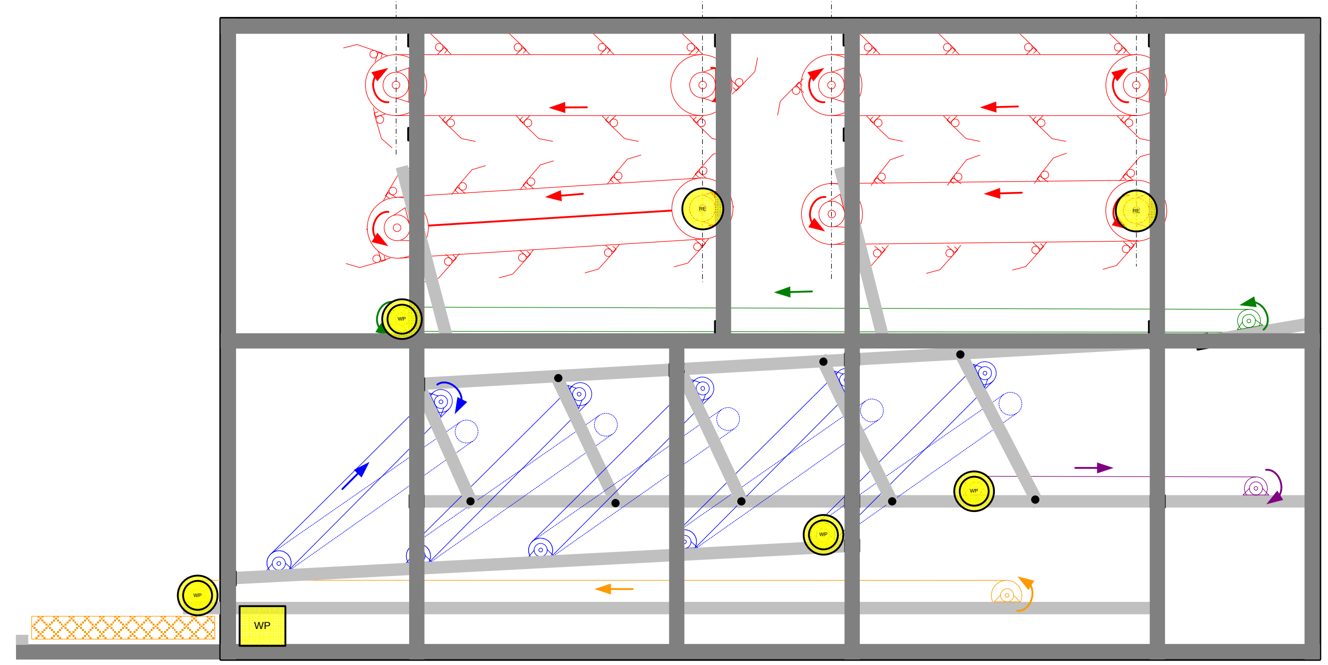


NOTES

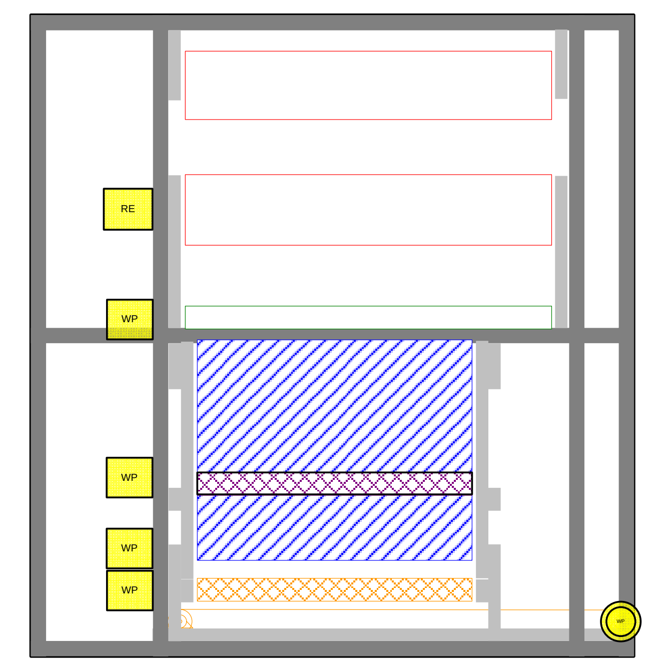
1. See Schedule of Motors and Bill of Materials for full specifications of each motor.
2. Motors were preferentially positioned on one side of the machine to allow easier adjustment of speed via needle valves on outlet of each.
3. See Bine Feed Detail drawing for mounting location of the bine feed motor.
4. The Stripping Section drives require a reversing chain transmission shown in the detail.



FEED SIDE



ELEVATION VIEW



DISCHARGE SIDE
(Cover Removed)

The UNIVERSITY of VERMONT EXTENSION

UVM Hops Project – Portable Picker & Cleaner

HYDRAULIC MOTOR MOUNTING LOCATIONS

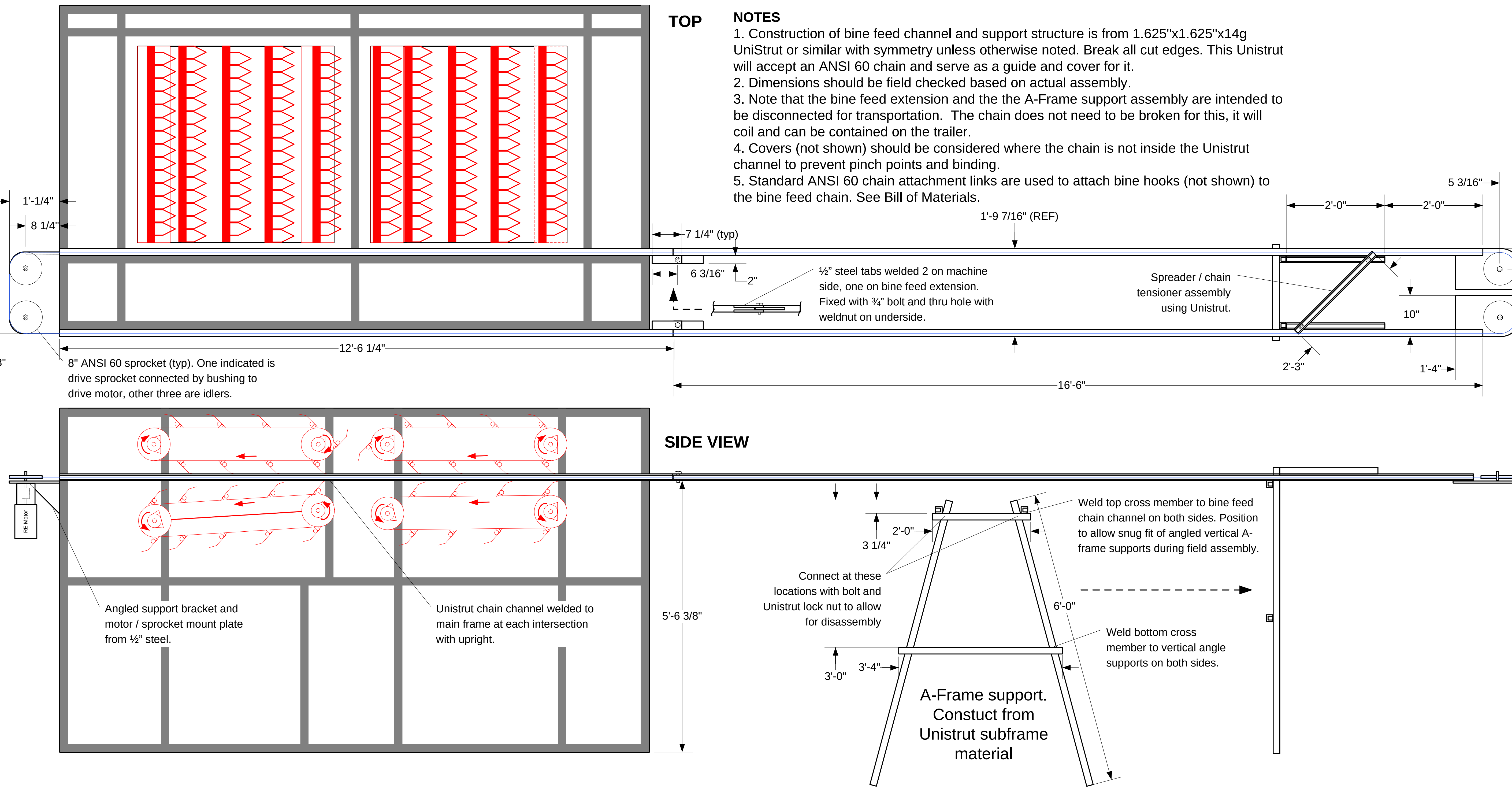
DRAWN BY: C. Callahan

SIZE	FSCM NO	DWG NO	REV
B		CE-UVM-2011-0003	-

SCALE	1/2" = 1'-0"	2012 04 10	SHEET	1 OF 1

NOTES

1. Construction of bine feed channel and support structure is from 1.625"x1.625"x14g UniStrut or similar with symmetry unless otherwise noted. Break all cut edges. This Unistrut will accept an ANSI 60 chain and serve as a guide and cover for it.
2. Dimensions should be field checked based on actual assembly.
3. Note that the bine feed extension and the the A-Frame support assembly are intended to be disconnected for transportation. The chain does not need to be broken for this, it will coil and can be contained on the trailer.
4. Covers (not shown) should be considered where the chain is not inside the Unistrut channel to prevent pinch points and binding.
5. Standard ANSI 60 chain attachment links are used to attach bine hooks (not shown) to the bine feed chain. See Bill of Materials.



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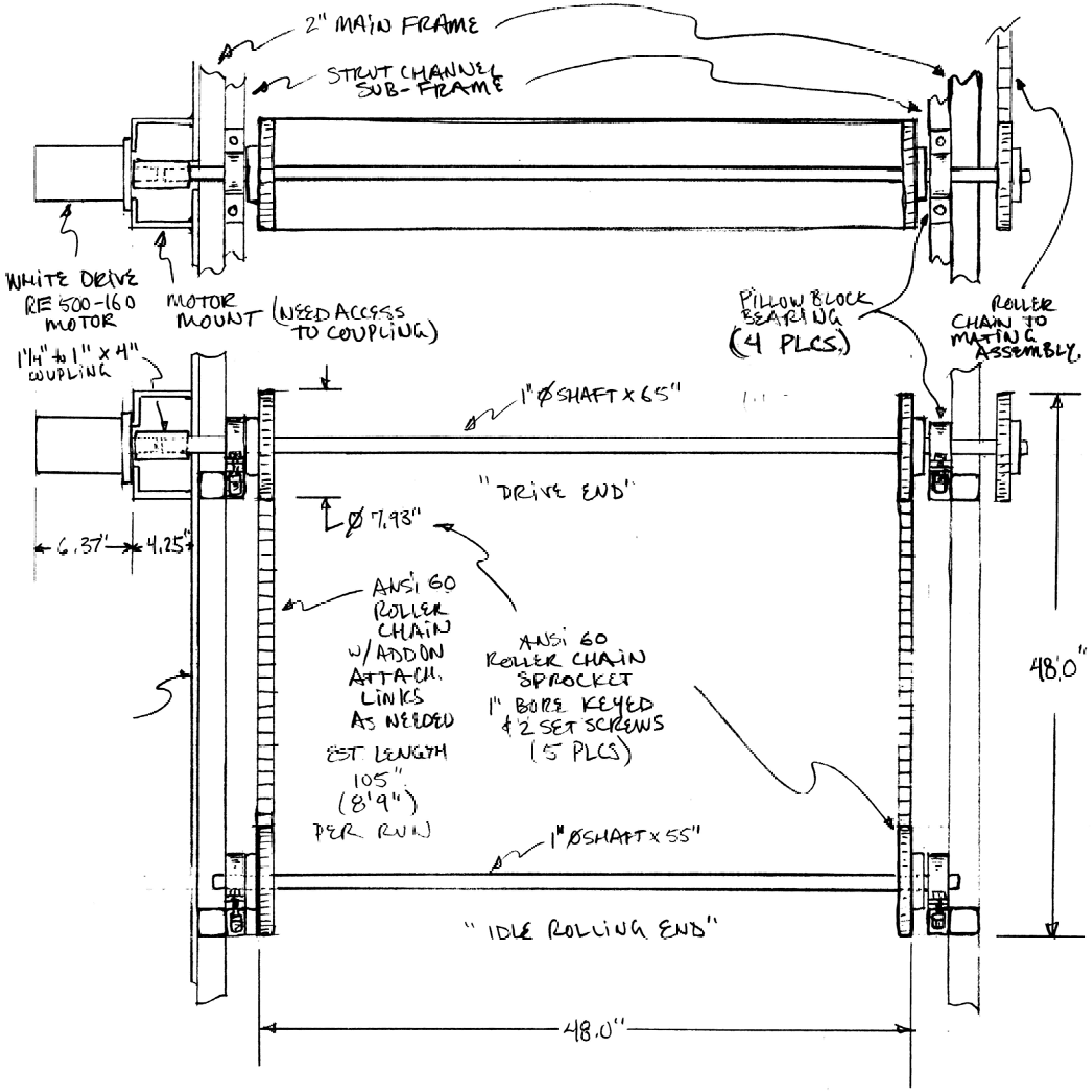
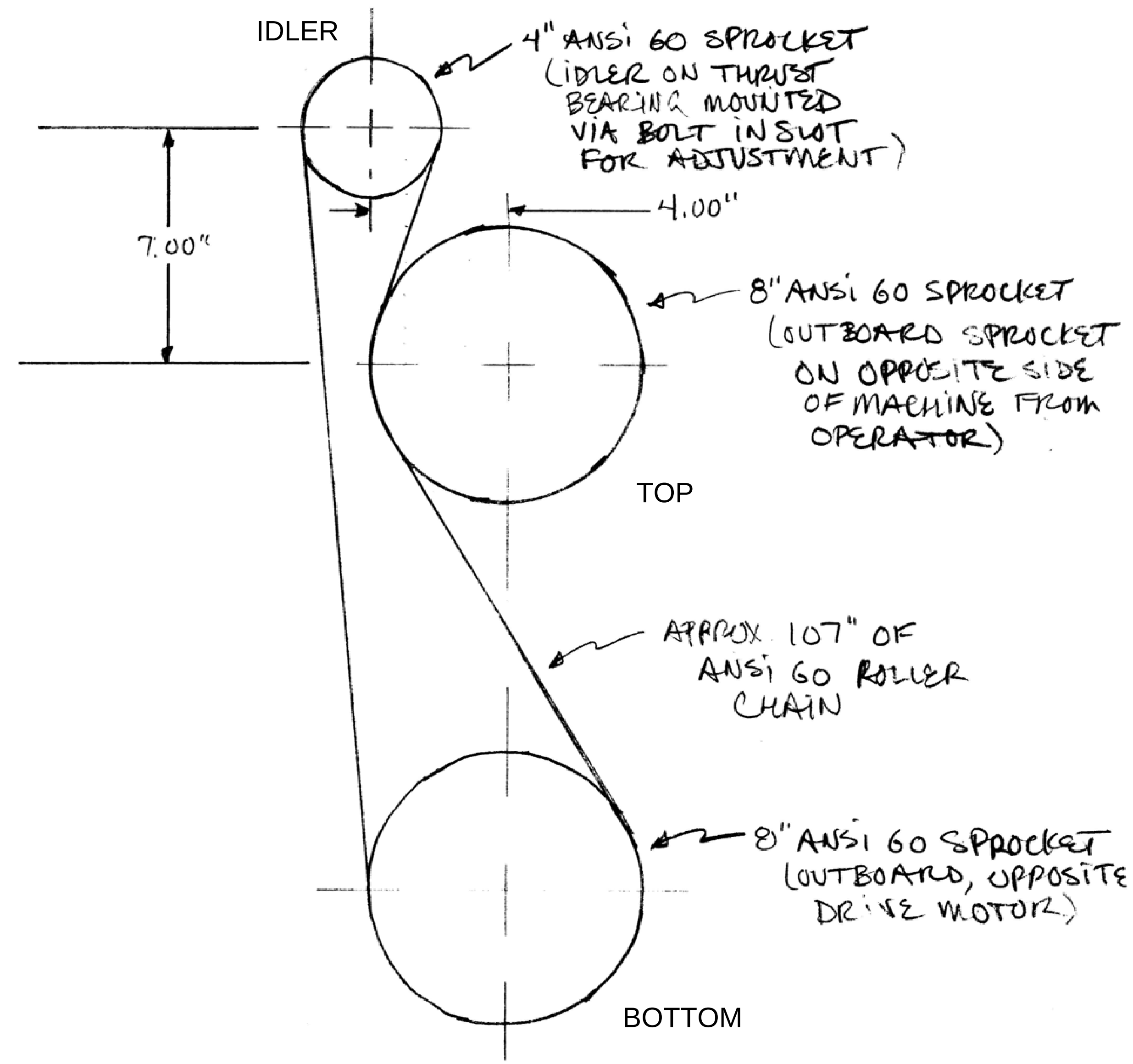
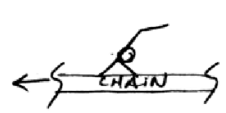
UVM Hops Project – Portable Picker & Cleaner					
BINE FEED SYSTEM - Detail					
SIZE	FSCM NO	DWG NO			REV
B		CE-UVM-2011-0004			-
SCALE	1/2" = 1'-0"	2012 04 10	SHEET	1 OF 1	





48" STRIPPING BARS TO BE MOUNTED ACROSS ROLLER CHAIN @ 8.75" SPACING ALONG ROLLER CHAIN (12 BARS PER ASSEMBLY). STRIPPING FINGERS SHOULD RECLINE AWAY FROM DIRECTION OF TRAVEL.



USE McMASTER # 7321K16 OR SIMILAR SINGLE PITCH ADDING LINKS.

The UNIVERSITY of VERMONT EXTENSION

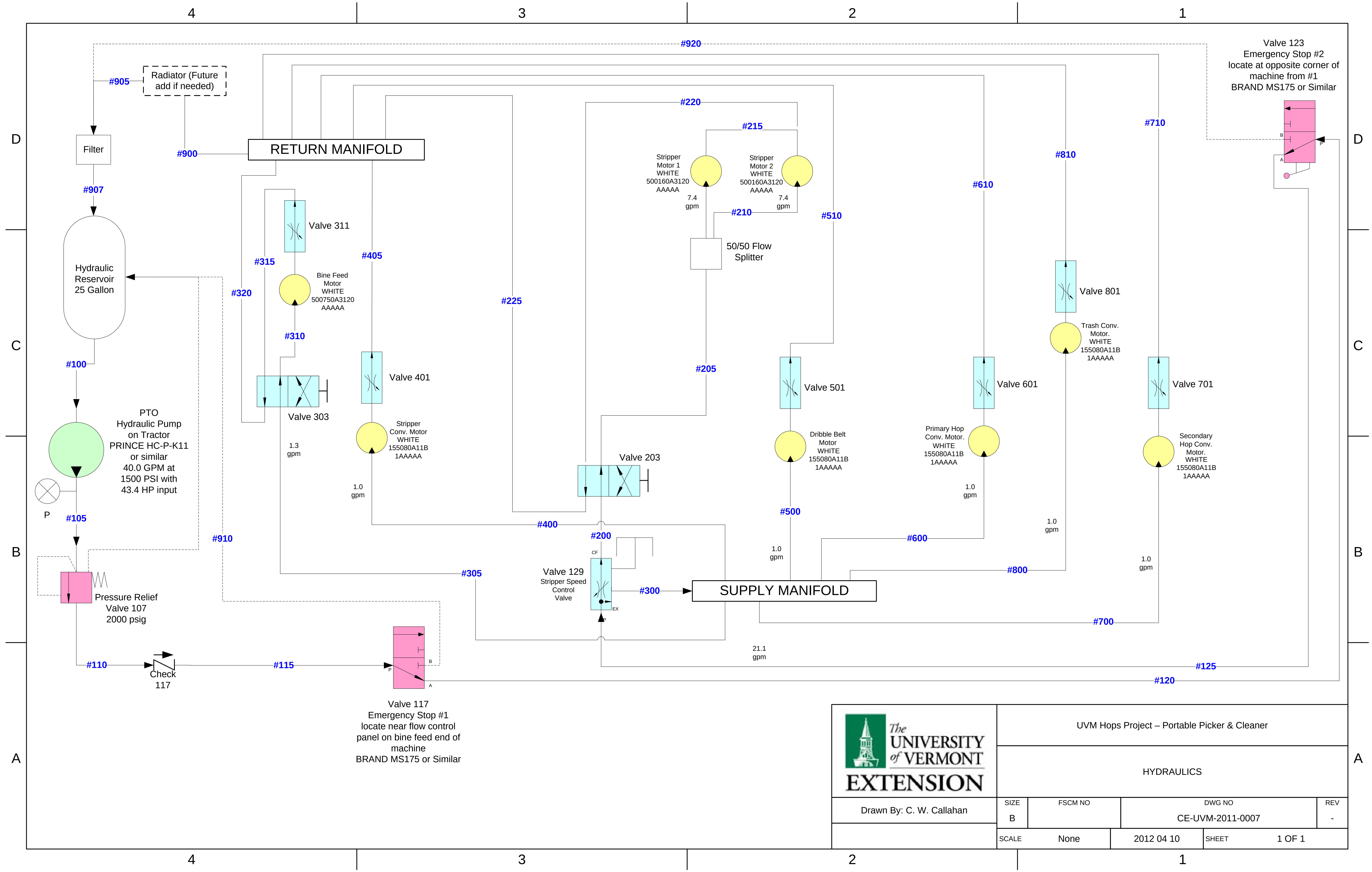
Drawn By: C. W. Callahan

UVM Hops Project – Portable Picker & Cleaner

STRIPPING SECTION DETAILS

SIZE	FSCM NO	DWG NO	REV
B		CE-UVM-2011-0005	-

SCALE	None	2012 04 10	SHEET	1 OF 1



RETURN MANIFOLD
SUPPLY MANIFOLD
Radiator (Future add if needed)
Filter
Hydraulic Reservoir 25 Gallon
PTO Hydraulic Pump on Tractor PRINCE HC-P-K11 or similar 40.0 GPM at 1500 PSI with 43.4 HP input
P
Pressure Relief Valve 107 2000 psig
Check 117
Valve 117 Emergency Stop #1 locate near flow control panel on bine feed end of machine BRAND MS175 or Similar
Valve 123 Emergency Stop #2 locate at opposite corner of machine from #1 BRAND MS175 or Similar
Valve 129 Stripper Speed Control Valve
CF
EX
Valve 203
Valve 303
Valve 311
Valve 401
Valve 501
Valve 601
Valve 701
Valve 801
50/50 Flow Splitter
Stripper Motor 1 WHITE 500160A3120 AAAAA
Stripper Motor 2 WHITE 500160A3120 AAAAA
Bine Feed Motor WHITE 500750A3120 AAAAA
Stripper Conv. Motor WHITE 155080A11B 1AAAAA
Dribble Belt Motor WHITE 155080A11B 1AAAAA
Primary Hop Conv. Motor. WHITE 155080A11B 1AAAAA
Trash Conv. Motor. WHITE 155080A11B 1AAAAA
Secondary Hop Conv. Motor. WHITE 155080A11B 1AAAAA
7.4 gpm
7.4 gpm
1.3 gpm
1.0 gpm
1.0 gpm
1.0 gpm
1.0 gpm
1.0 gpm
21.1 gpm
#100
#105
#110
#115
#120
#125
#200
#205
#210
#215
#220
#225
#300
#305
#310
#315
#320
#400
#405
#500
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#600
#610
#700
#710
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#810
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#905
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4
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The UNIVERSITY of VERMONT EXTENSION
UVM Hops Project – Portable Picker & Cleaner
HYDRAULICS
Drawn By: C. W. Callahan
SIZE B
FSCM NO
DWG NO CE-UVM-2011-0007
REV -
SCALE None
2012 04 10
SHEET 1 OF 1

UVM Mobile Hop Harvester

2012 Modifications and Lessons Learned &
Case Studies of Other Harvester Versions

Appended January 8, 2013

C. Callahan, UVM Extension

Design Modifications & Tuning

Relocated & Shortened Bine Feed

One lesson learned from the first year of operation in 2011 was that the right sided bine feed would tend to pull the bines through the machine only along one side of the machine. The initial design intent was to have a cowling or collar holding the bines on the opposite side of the inlet throat in order to have them pulled diagonally through the stripping mechanism. In trials during 2011 with manual traction being applied, this method worked until the trailing end of the bine passed the inlet throat. Once that happened, the bine would quickly be straightened by the stripping force and fall in line behind the right-sided bine feed on one side of the stripping mechanism.

To remedy this problem, two stripping fingers were removed from the center of each stripping bar and the bine feed channel was relocated to pull the bine through the center of the stripping section. This required a change in the bine attachment method as noted below. But the relocation of the fine feed helped use the stripping section more fully and resulted in hop cones falling more reliably on the primary conveyor. Previously, when pulled to one side, many cones would either not be picked or, if picked, would fall over the side.

Additionally, the bine feed on the exit end of the machine was shortened in 2012 (Figure 1). This removed the need for setting up the bine feed extension at each site. In 2011, we found that the extension was not necessary if there was a tender on the exit side of the machine anyway.

Changed Bine Attachment Method

The relocation of the bine feed required that the relatively large bine hooks be removed (Figure 2). They would not pass by the stripping fingers without interference and the team was concerned about the stripping fingers actually detaching or shearing the central bine from the hook. Instead, we removed the hooks and left the attachment bolt chain add-on in place. To this we attached 200 lb nylon clothes line with approximately 18” of length. This allows for relatively secure and expeditious attachment of bines using a slip knot. This can be done while standing on the ground. The rope does wear and break over time, but is easily replaced at little cost. Improved attachment methods will be explored in 2013.

Figure 1 - The bine feed was shortened on the exit end and was also moved to be centered in the stripping section.

Figure 2 - The new location of the bine feed is now centered. The cord used for bine attachment is also shown in this view.

Added Fences and Chutes

Although they lacked guarding, chutes and fencing enabled easy access during 2011 for trial runs and troubleshooting, this did result in considerable net yield loss of cones due to lack of containment. In 2012 fences were added to the sides of each dribble belt and the primary conveyor (Figure 3). Additionally a backstop and chute was added at the inlet throat which caught and redirected most cones stripped at the very front of the machine (Figure 4). These additions were made with flexible and temporary PVC sheet material in order to make templates for more permanent modifications in 2013. One of the big factors in net yield loss appears to have also been wind blowing across the machine. With the machine being used at different locations and on multiple days, this impact was varied. But it does point to the need for exterior skin on the machine which is also intended prior to the 2013 season.

Figure 3 - Containment fences are be seen on the primary conveyor and dribble belts in this view.

Another addition was a rolling inlet throat guide which allowed for a more gentle transition of the bine into the machine. This reduces the amount of manual guiding required by one of the operators. Once the bine was cleared around the front corner of the machine, it would generally be fed automatically into the machine.

Shaft Replacement

As noted in the initial design report, aluminum shafts were used for several of the conveyor roller assemblies. Our intent in 2012 was to replace all of these with steel shafts, but due to schedule pressure and limited personnel availability we were forced to do it on an as-needed basis. Two shaft failures occurred during operation; the first was at Nation Hops in Ontario and the second was at Borderview Farm in Alburgh, VT. In each case, the failure prevented further operation of the machine for the day. We intend to replace all aluminum shafts with steel prior to the 2013 season.

Conveyor Support Rollers

The longer conveyors in the machine require more roller support than initially planned. The installation of roller idler assemblies reduces the tension in the belt, which reduces the loading on the drive and tail pulley and thus reduces the tracking issues noted in 2011. These assemblies also included “fencing” along the long edge of the conveyor belt which provides slight force to help maintain belt tracking. The roller assemblies used were salvage, and often come from warehouses where they are used to convey goods packed in cardboard boxes.

Tuning Trials

Toward the end of the 2012 picking season we were able to use the machine to harvest some of the UVM hop trials at Borderview Farm in Alburgh, VT (Figure 5, Figure 6). The research nature of this harvest allowed for time between each set of bines and, thus, allowed for adjustment of the machine to assess how it can be better “tuned.”

Overheating

Although a hydraulic radiator was obtained for the 2012 harvest season, the overheating problems of 2011 were mostly resolved by running the harvester on a low RPM PTO input. In 2011, the machine was run on high speed PTO inputs that now appear to have been more than needed for operation. No overheating was experienced while running the machine outdoors in 2012. The radiator will be incorporated prior to the 2013 harvest to provide flexibility of operation.

Figure 4 - The trial inlet chute that directs stripped cones to the dribble belts is visible in this view (black PVC sheet).

Figure 5 - Tuning trial runs of single bines were laid out for assessment of machine performance.

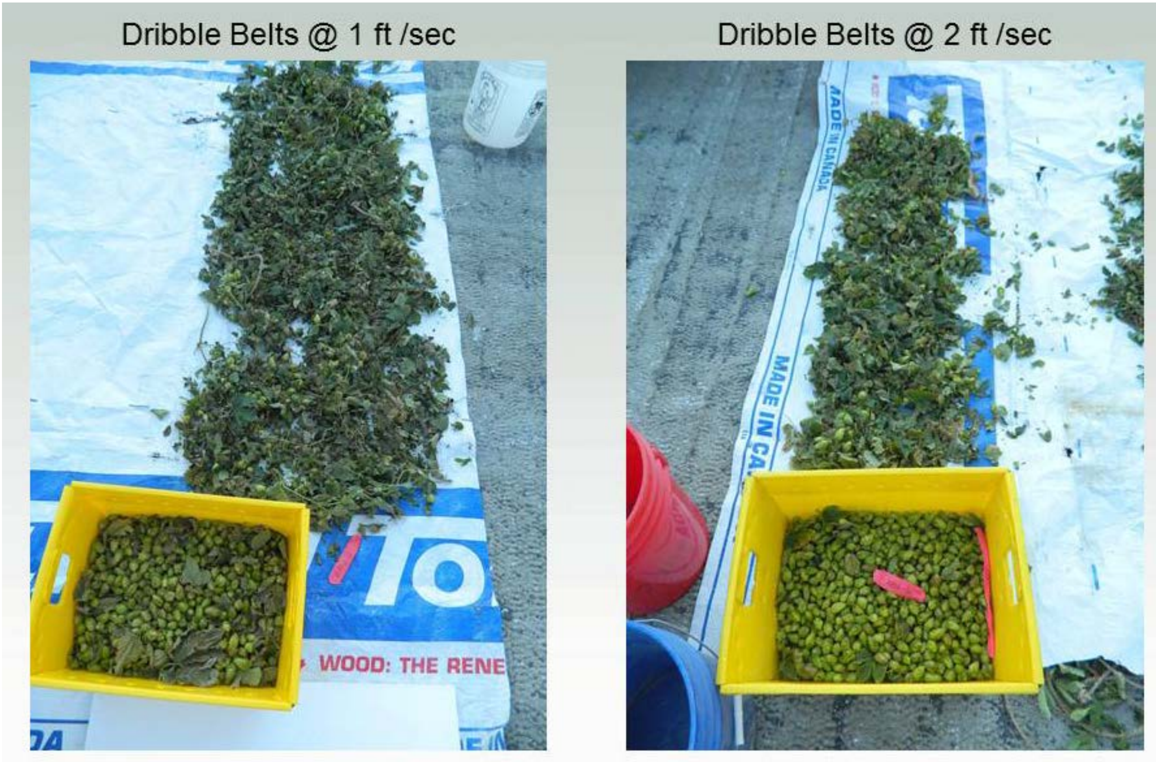

Figure 6 - We found faster dribble belt speed resulted in cleaner cones.

Operational Personnel and Logistics

The team found that the machine could be run most effectively with a two person team of people experienced with farm machinery. The first person attached bines from a neatly laid pile at the side of the machine and guided them around to the inlet throat. The second person would tend the exit end of the machine which involves raking the bine laterally across the stripping fingers to ensure complete stripping of cones in some cases. This is most necessary with more mature and dense hop bines. Some operators found that rolling or rotating the bine in the direction opposite its natural spiral aided in the stripping of the cones. The second person also detaches the bine from the bine feed chain, leaving the attachment cord in place. Lastly, this second person pulls the bine through the remainder of the machine and disposes of it.

While it is possible to effectively operate the machine with two people, the delivery of bines to the machine and the removal of picked and cleaned cones from the machine require additional personnel and logistics. An overall team of approximately six people is recommended. The most effective operation of the machine occurs when a team of 2-3 people is assigned to cut bines and transport them to the machine in an orderly and consistent fashion. We found a full size pickup truck worked well for this at our relatively small scale hop yards. The bines can be laid roughly horizontally in the bed of the truck with the thick (bottom) end lying over the cab (Figure 7). The bines should all be laid in the same direction (all bottoms facing one direction), and care should be taken to avoid tangling them. This allows for easy “peeling” off of a single bine by the operator who is attaching to the feed chain. Additionally, one person should be assigned to monitoring the cones coming of the machine (Figure 8). Occasionally some leaves are included in the final hop cone stream and a final manual observer can help minimize this. This person can also shuttle picked and cleaned cones to the oast for drying.

Figure 7 - A typical setup in 2012, this one at Square Nail Hops Farm in Ferrisburgh, VT.

Figure 8 - Fletcher Bach of Square Nail Hops Farm attends to cones coming off the harvester.

CASE STUDIES

Two hop farmers report that they are building harvesting machines based on the UVM design. Rich Andrews (J.M. Andrews Family Farm LLLP, Boulder, Colorado) and Daniel Sabourin (Vankleek Hill, Ontario) have based some portions of their harvesters on the UVM design.

Case Study 1

RICH ANDREWS

"I built and operated a small scale stationary hop picker/sorter during 2012 that worked quite well. We picked the hops from our farm (Andrews Family Farm), plus hops from nearby Niwot Hops and from Colorado State University hops research farm at Fort Collins, Colo. Were able to boost our picking and sorting efficiency greatly. We picked about 20 pounds per hour with two people with the machine. It is smaller and was not built to achieve the higher rates as the UVM machine, nor to be mobile. It runs with electric power from PV panels on the barn roof. My design and construction work was done in-house (not a grant) and I drew on the design parameters of the research and demonstration work done by UVM with its hop picker. I thank UVM and all involved for the guidance I received, and the detailed drawings that were shared. The hops we picked this year were sold to about 8 or 9 local craft brewers, plus some home brewers, and some to local herb companies for teas and various extracts.

Figure 7 - Rich Andrew's Picker and Sorter. (Photo credit: Rich Andrews)

The top finger bars are stationary with adjustable spacing between bars and between the moving finger assembly. The bottom fingers move on a track away for feeding operator position. Some spacing adjustments were made to deal with different character of hop bines. The moving finger assembly is driven by two variable speed motors, a push 3 phase varibelt motor and a slip clutch pull DC motor. Operator stands on platform and feeds hop bines in between the fingers and holds bines in tension while being stripped.   Stripped twine/bine is then removed & discarded.   Multiple bines can be fed simultaneously, the number depending upon the branching character of the hops. Hop and leaf fall onto an inclined chute beneath the picking fingers that feeds to a 8 inch wide transfer cleated belt conveyor.   Second operator does limited hand sorting on the transfer conveyor, dealing with hop clusters that may have been stripped intact. Transfer conveyor feeds to the flower-leaf separator, a series of 30 to 35 degree angle and speed adjustable belts.   Hops roll down the belts to a catcher tray underneath and leaf-stem trash carries upward on belt series to a leaf trash bin.   The leaf-flower sorter is a separate unit on casters from the picker system; operates very cleanly with good separation. Hops are then either bagged for fresh hops sales or placed in solar hot air dryer.

Figure 8 - Rich Andrews' picker in use, top view. (Photo credit: Rich Andrews)

Figure 9 - Cone collection chute and conveyor. (Photo credit: Rich Andrews)

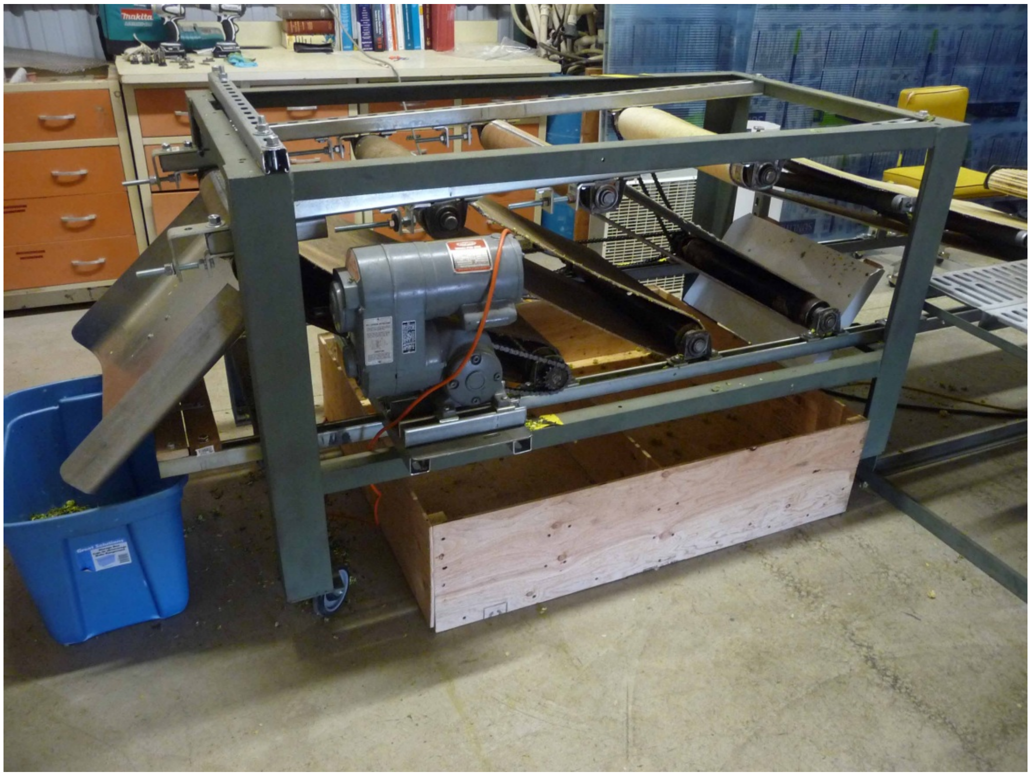

Figure 10 - Leaf/cone sorter. (Photo credit: Rich Andrews)

The entire hop picker system is powered by solar PV panels on the barn roof, which also powers all other electrical energy uses on the farm, irrigation system pumps, shop, some other herb drying ovens, home, etc. Excess electrical is sold to local utility with a net meter.

For next year and time permitting, I may replace the top set of fixed position picking finger bars with another moving finger bar assembly, more similar to the UVM picker. Also may install a solenoid vibrator on the incline chute to keep the picked flowers moving more effectively onto the transfer conveyor. They tended to accumulate. These improvements may even make the entire operation able to be run by a single operator.

Our solar hop dryer is powered by heat collected from the top of a greenhouse that is attached to the barn. This 840 sq ft greenhouse is totally solar using soil heating from hot air collection system, supplemented as needed with solar hot water system that also heats barn shop floor with radiant in floor tubing.

Also am building a walk in chiller with Coolbot temperature controller. In coming years will be building another solar adsorptive cooling technology chiller that requires little to no electrical energy or moving parts; to compare performance with the Coolbot system.

Other plans call for an ammonia gas collection system from the composting operation.

Our objective is to ultimately make the entire farm solar powered. Only the truck and tractor fuel is left to deal with; maybe someday biodiesel."

Case Study 2

DANIEL SABOURIN

“I'm writing you to let you know that that the UVM harvester plans that you supplied to help in the design of my own harvester is the best reference as a hop grower and hobbyist builder like myself can get! In my design I only have 1 striping section and its left to right with a feed drive made from two lawnmower tires with hydraulic leaver to feed the plant into the striping section.

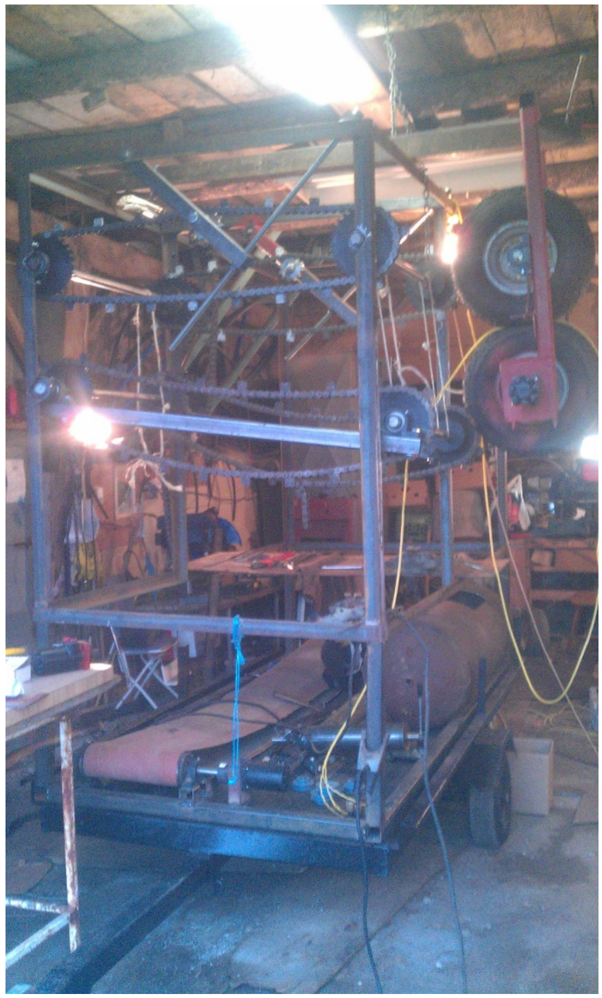

Figure 11 - Front view of Daniel Sabourin's harvesting machine showing stripping section (top), bine feed wheels (right), and early stages of the conveyors (bottom). (Photo credit: Daniel Sabourin)

My machine will fit in a 8' box of a pickup truck and will be mobile. I used a total of three hydraulic motors fed by a Prince PTO pump like the UVM design. I have changed the dribble belt from 5 to 3 belts and have replaced the two last ones with a slotted drum with knives to cut twigs and leaves. The drum is 21" diameter and knives will be powered by gas engine the idea to replace the dribble belts came to me on your visit with your harvester during last Fall’s harvest. Like we discussed, while running the machine the thrash had too many cones to leave unsorted.

For a small scale operation no hops must be wasted. The drum separator can be installed on the back of my harvester or it can be taken off to use as a separate unit. It is not a new design, if you look on you tube there are other examples. I just built my own version. It is not completely done yet but with the funding I received with the letters of support I got from you and several OHGA members the prototype will be done shortly.

Figure 12 - Daniel chose two lawn mower tires to pinch and pull the bine through the stripping section. (Photo credit: Daniel Sabourin)

The total cost of material and labor comes to around $19,000 (CAN) but this will include a bine cutter to cut top off of the trellis. I would like to be able to show you now the finished project but it is not done yet. Attached are some production shots."