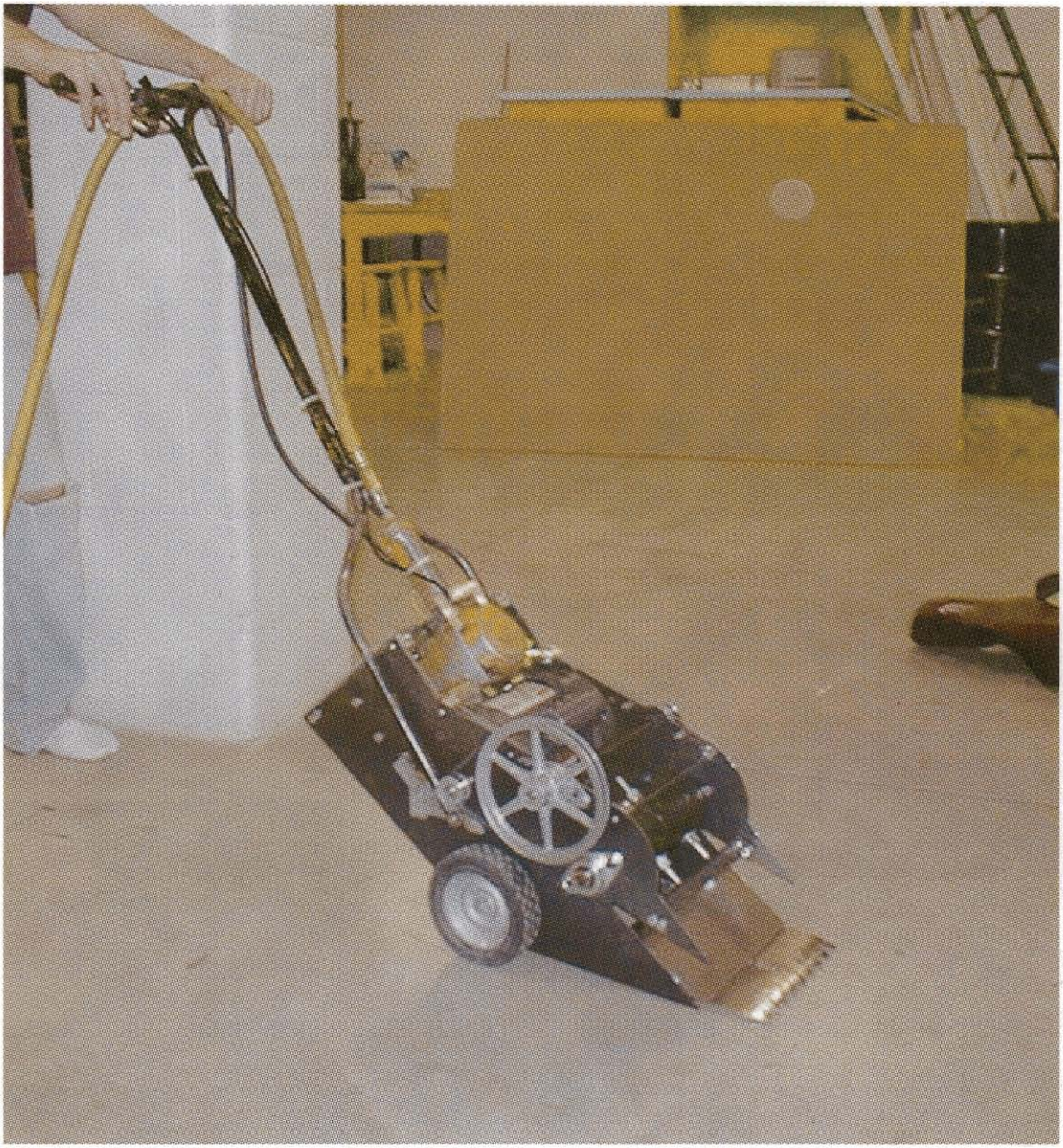

Automated Shingle Remover

Senior Project

Timothy Grant/Andrew Sayegh

May 14, 2001

ENGINEERING SENIOR PROJECT

Final Written Report

Automated Shingle Remover

Fall 2000-Spring 2001

Timothy P. Grant

Andrew G. Sayegh

April 5, 2001

Abstract

For decades, the roofing industry has relied on crude prying shovels to remove old shingles. This task is labor and time intensive, and typically accounts for approximately half of the time needed to re-shingle a roof. The current shingle removing process involves other limitations. Safety is a major issue when prying is done manually at significant heights. Furthermore, shingle fragments are typically heavy enough to damage the propeety protecting tarps, landscaping, and bystanders.

This project's goal is to design and create a machine that will automate the shingle removing process. The machine consists of 2 major technical elements; a motor-powered grinding wheel, and a pneumatic-powered lifting spade. With its ability to decrease time and labor, create a safer work environment, and break down shingles to a less dangerous and more easily recyclable size, the development of our machine will be an invaluable tool for the roofing industry.

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Acknowledgements

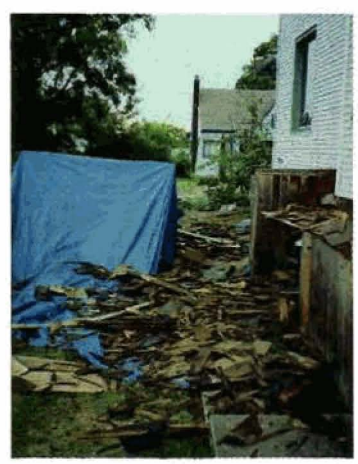
We would like to thank our advisor, David Gray, for his shared wisdom, support, and encouragement in our endeavor. We also thank Dr. Donald Pratt for his guidance and suggestions. We want to recognize Mike Dunleavy (Dunleavy Construction), Ghassan Sayegh (Birchwood Properties), Pete McKenna, Chris McMahn (McKenna Construction), Walt Johnson (S&K Roofing and Asphalt Shingle Recycling Inc.), Jerry Shillady, and William Thomas as helpful consultants. We owe much gratitude to United Rental in Harrisburg for donating us our nail gun, and Peter Davis for donating additional parts. Lastly, we thank the Messiah College Engineering Department for sponsoring and funding our project, and John Meyer for his invaluable assistance in the shop.

I. OVERVIEW

A. Problem

Roofing is a major industry throughout the world. It employs thousands of people such as general contractors, and the many who are specifically roofers by trade. State law mandates the number of layers of shingles that can be on a roof at one time. In most states the maximum allowed number of layers is two. If two layers already exist on a roof and the roof needs replacement, the existing layers must be removed. It is this specific task that our project addresses. Current methods used by professional, lifetime roofers involve taking a simple roofing shovel (pictured below[1]), jamming it under the shingles and prying up. This process is slow, tedious, and extremely labor-intensive. It usually takes at least as long to remove existing shingles as it does to put new ones on. Therefore, half the time and cost of a job doesn't even go into fixing the roof. In addition to actually removing the shingles, cleaning up after all the shingles are off the roof is also a laborious, back-breaking task.

Usually tarps are tacked to the edge of the roof so that when the pieces of ripped shingle fall to the ground they don't mark up the side of the house. However, the pieces of ripped shingle are very jagged and tend to rip holes, tearing up tarps, and rendering them ineffective. The falling shingles can also



[1] http://tools-plus.com/ufh46142.html

seriously damage foundation planting. Once the pieces of shingle are on the ground they must be picked up by hand, put into some kind of container, typically a trash can, and carried to a dumpster. This is a tiresome and monotonous task to say the least. Therefore, we hope to also include in our machine a way to dispose of the shingles, or at least lessen this task. We conducted research in attempts to discover any currently available machines capable and designed for shingle removal. No positive match was found. Several people in the roofing industry told us such a machine doesn't exist. Therefore, having established the problem, we proposed to construct a machine that removes and disposes existing shingles quickly and neatly.

The basic design of our machine is based in part on the existing ripping shovel concept. We plan to make a plate with jagged edges in front and hinged in the back that will be connected to a pneumatic piston mechanism that will lift the front end up, thereby ripping up the shingles. We hope to adapt the pneumatic piston device from an existing nail gun, which is a common roofing tool. Once the shingles are lifted from the roof we wish to design a way of grinding them into pieces roughly an inch square. These pieces would then be small enough to be swept down a tarp or off the edge of the roof a do very little or no damage in the process. Thus, the greater part of our project includes two parts. 1) a pneumatic powered piston-driven plate that rips up shingles 2) an electric powered device that grinds the shingles into small pieces.

B. <u>Current state-of-the-art</u>

Our primary encouragement for the need of our removal machine has come from many discussions with different roofing professionals. These discussions, more than anything else, give us insight into the roofing industry.

Peter McKenna- August 1997- Upon personally pleading with Mr. McKenna to rent something to aid in tearing off a roof at a job, he informed Tim that in his 25 years in construction and roofing he has never seen or heard of any such machine. His last comment was "You're the engineer, you build one".

We have kept in touch with Mr. McKenna and he repeated his claim that there is no such machine available as recent as early September 2000.

Michael Dunleavy- Mr. Dunleavy has been regularly consulted over the past year in regards to his awareness of any shingle removing machine. In addition to expressing his own ignorance, he has personally talked to several of his industry contacts to see if any of them are aware of the existence of such a machine. These contacts include roofers, contractors, rental salesmen, and roofing product distributors. Not one had heard of such a device.

Walt Johnson- Mr. Johnson is the owner of S&K Roofing and Asphalt Shingle Recycling Inc. in Mount Airy, Maryland. We have contacted and visited S&K in regards to the recycling of asphalt shingles, receiving a wealth of information and a guided tour of the facility.

W.W. Grainger Inc.- We were advised by Mr. Dunleavy to check both the Grainger Inc. catalog and website (www.grainger.com) saying, "If it's not in Grainger, it's not available". After extensive and thorough searching of these resources, we concluded our shingle removing machine does not exist

U.S. Patent Office Website- (http://www.uspto.gov) We conducted extensive research into the U.S. Patent Office patent archives in search of machines that have been patented but are simply not mass produced (and therefore probably not marketable devices). We found a few patented machines designed to remove existing shingles, one of which used pneumatic compression to operate an upward plate motion similar to our idea. In fact, the idea of using pneumatic compression in a shingle removing device was patented by the designer of this device.

Recycler's World- (http://www.recycle.net) We conducted research at the Recycler's World website to see if shingle recycling actually existed thereby making grinding the shingles in our machine advantageous. We contacted the people at Recycler's World by email to specifically inquire if such technology existed. Mr. Jo-Walter Spear Sr. replied to our questions saying, "Recycling of roofing shingle is a tried and proven technology". He told us recycled shingles are used in the manufacturing of bituminous cement, shingle manufacturing, and secondary fuels.

B. Solution

Our solution is a machine which uses the piston system of a nail gun to remove shingles. We feel that we've broken some ground in the area of alternatives to rigorous physical labor. As stated earlier, the labor that must be hired to do any ordinary roofing job is quite extensive and costly. Furthermore, having workers on roofs using shovels is dangerous. If our idea were to gain major success, it would forever change ~~in~~ how roofing labor is managed. Roofing would become more technical and operational. It would also be a safer field of work.

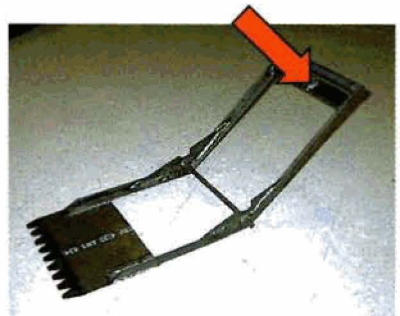
Early on we developed 5 major objectives, which are as follows:

1. to automate the prying up of shingles.
2. to grind shingles into 1-2 inch fragments.
3. to discard shingles.
4. portable (weigh 50 lbs. or less).
5. compatible with available resources (electricity, air compresser, etc.).

There are a few specific challenges of our design that will need to be addressed. Firstly, we'll need to be sure we can sufficiently pry up two layers of shingles and nails using the pneumatic piston. Another challenge is exactly how the shingles will be ground, and how to keep them in place while the grinding process occurs. Keeping the entire design at a low weight will be vital.

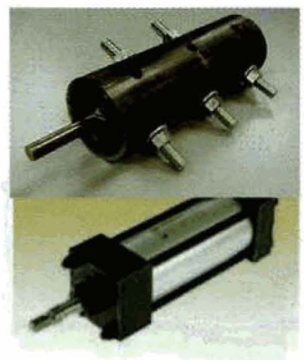
II. Results of the Design Process

Our design uses a pneumatically driven spade constructed of a single piece of metal bent at the midpoint to 135°. This bend serves as a fulcrum. At the leading edge of the spade are evenly spaced triangle grooves, each 1inch deep. The "points" of these triangles are cut off to prevent the spade from splintering underlying plywood. At the opposite end of the spade is a mounted nail gun. The nail gun's pneumatically powered piston is in direct

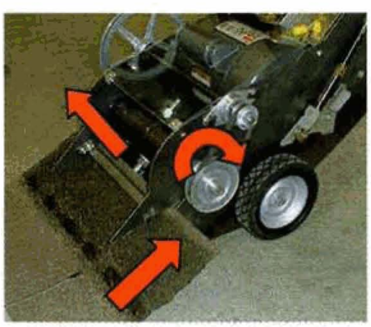


contact with upper region of the spade. The piston drives the back portion of the spade down, thus lifting the front edge, prying up old shingles.

The nail gun piston has a 2 ½-inch stroke and a 1 ¾-inch bore, which constitutes a piston head area of 1.767 in^2. Given this area and a compression of 90 psi, the calculated exerted force is 159 lbf. This force exceeds the estimated required force to pry shingles, between 60 and 90 lbf. However, the use of a nail gun is not the ideal pneumatic actuator. Given an extended budget, we would like to implement a more suitable piston for our application. After researching commercially available pneumatic actuators, we chose a Norgren EA Series pneumatic cylinder (EA2235A1-SR-2½x3) (see appendix). This cylinder has a, 3-inch stroke and a 2 ½-inch bore, which yields 491 lbf at 100 psi (737 lbf at 150 psi). Its other specifications include a threaded 5/8-inch piston rod, and a detachable cap clevis mounting.

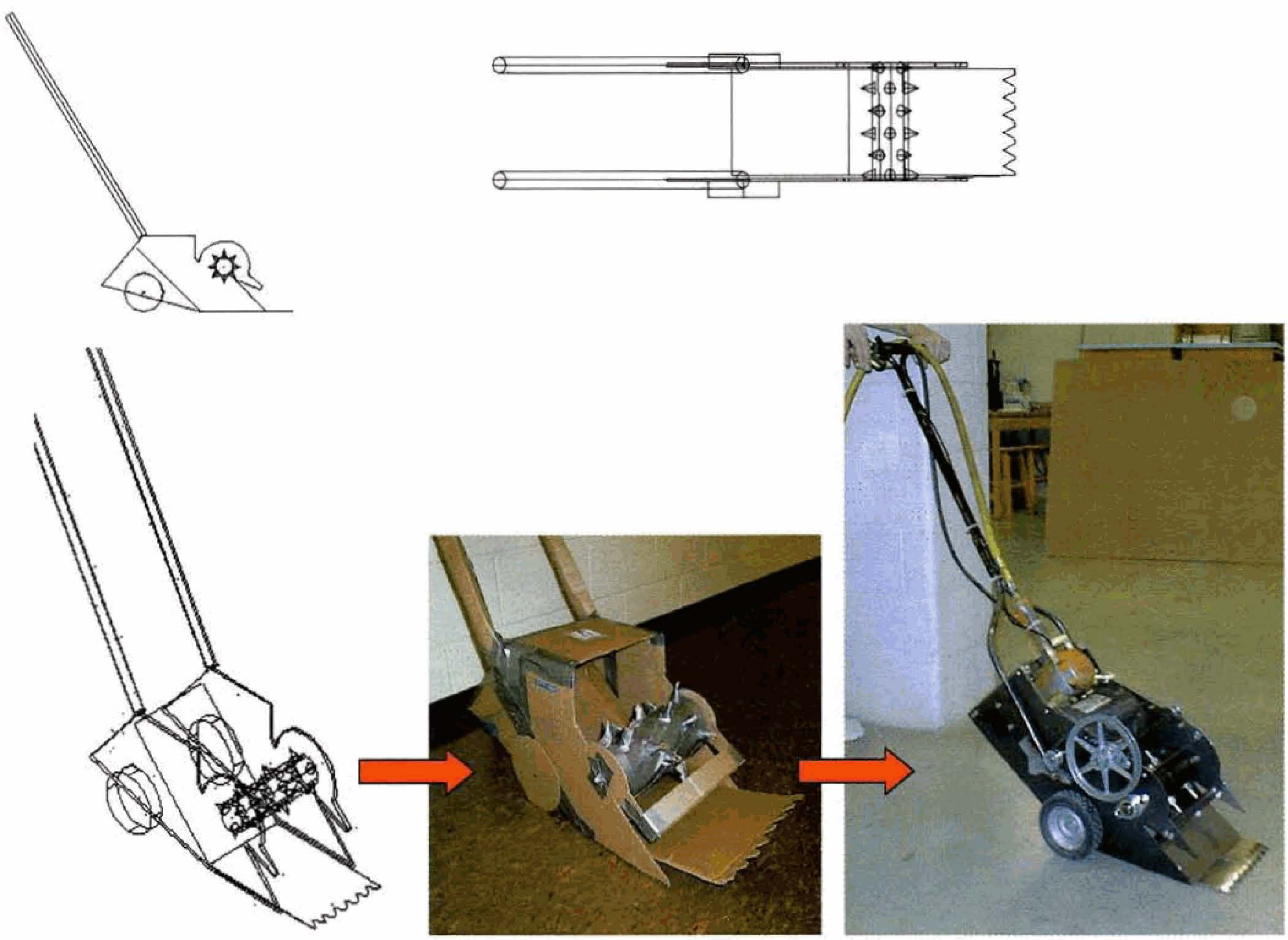


A 1/2 hp electric motor powers a spike laden cylinder that rotates away from the machine,



expelling small shingle pieces away from the machine, like a snow blower. On either side of the spade are metal rails, which guide the pried shingles up into the grinding mechanism. In case shingles are small enough to fit between the rails, a plastic piece, hinged just before the grinder teeth, completes the ramp for the shingles traveling towards the grinder. These rails also have catch bars to keep the shingles from being ejected out by the rotating grinding mechanism. Both the metal rails and the catch bars are part of the side panels of the machine. The grinder has a guard over the top, to protect the operator of the machine from being hit by ejected pieces of shingle. Two wheels at the bottom of the design make the entire machine more mobile.

The motor used to power the grinding cylinder is a ½ horsepower AC motor which runs at 1725 rpm. This velocity is significantly reduced after being geared down twice using different sized pulleys and belts. These pulleys are mounted to the frame of the machine using shafts and appropriate bearings.



III. Implementation

A. Construction

Weight consideration was a high priority during the construction process. We wanted the machine to weigh as little as possible, holding a goal to keep it under 50 lbs. This consideration affected mostly all of our decisions in construction. The grinding wheel is made of a hollow 3-inch diameter steel cylinder with protruding 1 ¾ X ½ inch bolts. Angle iron is used to construct the basic framework of the machine body, including the prying spade. The front edge of the spade is currently made of 4130 steel, a temporary solution for our testing and presentation prototype. We understand that if the model were to be mass produced, a stronger, lighter material, such as the steel used in conventional shovels, would be necessary for this particular part. At the opposite end of the spade is a reinforced, layered cross plate that will endure the repeating impact of the pneumatic piston. Two 10 gauge steel side panels form the sides of the machine. This design was beneficial because there were many holes that needed to be drilled in order to fasten the internal parts into a collective whole. The motor and nail gun are mounted to the frame by two crossing bars made of

angle iron with the ends folded up and holes drilled in the end portion. A large portion of the machine is welded together, although other parts are bolted as to make them accessible and/or

removable for replacement or repair. The steel was mostly machined using a standard drill press, band saw, and horizontal band saw.

B. Operation

The automated shingle remover was designed to be operated by the average adult. The operator stands behind the machine, similar to operating a lawnmower. The operator should always work from the peak of the roof down, as to not fall backward at great heights. The shingle remover as well as the individual should be harnessed safely, to prevent falling off the roof. The grinder runs constantly when turned on, and can be turned off by a switch at the operators left handle. On the right handle is a bicycle handbrake which triggers the pneumatic piston. The operator pushes the machine underneath the layered shingles from the back, prying them up into the grinding wheel. At this point, the shingles are ground into small bits and discarded. A plastic guard covers the grinding wheel to protect the operator from flying sharp fragments.

IV. Schedule

Gantt Chart

	September	October	November	December	January	February	March	April	May
Proposal	22								
Designing Model									
Obtain Parts, Materials									
Log Books due		6							
FALL BREAK		13-17							
Specifications due		20							
Dissect/Study Nail Gun									
First Draft EDR due			3						
Building/Assembly									
Oral Presentation				1 8					
Final Copy EDR due				8					
WINTER BREAK									
Testing Period									
Remodification Period									
SPRING BREAK									
Plan Presentation									
Presentation									4
Log Books due									14
Final Design Report due									14
Graduation									19

KEY: Proposed

Actual

√

IV. Budget

Estimated **Budget:**

• raw materials (metals and plastic)	$150
• pneumatic parts (connectors, valves, etc.)	$50
• motor	$100
• nail gun	$0 (donated)
TOTAL	**$300**

Actual **Budget:**

• raw materials (metals and plastic)	$ (?)
• pneumatic parts (connectors, valves, etc.)	$ 0.00
• motor	$144.73
• pulleys/belts (2/2)	$ 12.19
• bearings (4)	$ 32.64
• wheels (2)	$ 8.34
• nail gun	$ 0.00
TOTAL	**$267.90+**

V/. Conclusions

• We feel that our idea to implement a pneumatic powered actuator combined with a spade to pry shingles was a successful one. In testing (see appendix), we were able to remove shingles from a test board with little trouble using our machine.

• Secondly, we conclude that the nail gun ought to be replaced with a different piston. After our research, we have decided on such a replacement, which we discussed earlier.

• Thirdly, although motorized grinding is a promising initial concept, this is the area that could potentially use the most modification. As is, our design does not successfully grind shingles into the small fragments as we'd projected it would.

• Lastly, the weight of our design is slightly impractical for its intended use. Our goal was to build a machine weighing less than 50 lbs. Our final product weighs approximately 65 lbs. However, given the opportunity to select parts more carefully and eliminate unnecessary material, we believe a sub-50 lb machine is within our grasp.

• In conclusion, we feel that we have progressed in terms of solving the shingle removing problem. However, we recognize that further work could certainly be done to take our ideas further toward the ultimate goal.

VI(. Recommendations for Future Work

• Two additional elements to the entire advanced shingle removing system are a conveyor belt and a catch fence. The catch fence would collect all of the nails and shingle fragments and keep them from falling off the roof, eliminating potential damage to landscape or injury. The conveyor belt would transport this debris to a more safe disposal.

• We suggest that the current spade be replaced by one made of a lighter material. Currently, the spade is made of 4130 steel. Initially, we debated over what material to use for this important part, considering a heat treated metal or tool steel. Either of these two choices would most likely be more effective than our current part, and would most likely be much lighter.

• As mentioned already, we suggest a replacement of the nail gun with an lighter, more ideal pneumatic piston.

• For added safety, we also had the idea to incorporate a safety lever on the handle of the machine. This safety lever would need to be held down in order for the motor to run and for the piston to be actuated. In addition, releasing this lever would lock the wheels, preventing the machine from rolling on the slanted roofs.

• In order to improve the existing condition of the pulley and belt system, we propose its replacement with either a gearbox or a system comprised of chains and sprockets. This would prohibit the slippage of the belts on the pulleys, which was partly responsible for the negative results of the grinder's performance.

• Lastly, much can be done to reduce the overall weight of the machine. Weight constraints have been an important issue throughout the project, and can be reduced further by eliminating weight in several areas.

References

Hamrock, Bernard, Bo Jacobson, and Steven Schmid. Fundamentals of Machine Elements. McGraw Hill: New York, 1999.

Beer, Ferdinand and E. Russel Johnston. Dynamics. 5^{th} Ed. McGraw Hill: New York, 1997.

Beer, Ferdinand and E. Russel Johnston. Statics. 5^{th} Ed. McGraw Hill: New York, 1997.

Beer, Ferdinand and E. Russel Johnston. Mechanics of Materials. McGraw Hill: New York, 1998.

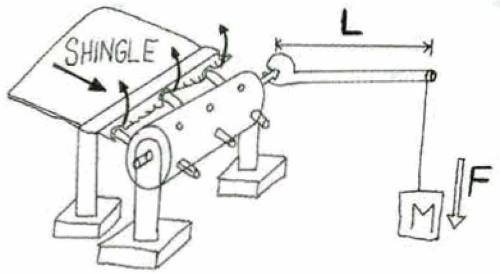
Bibliography

1. www.grainger.com
2. http://tools-plus.com/ufh46142.html
3. www.recycle.net
4. http://www.uspto.gov
5. www.mcmaster-carr.com
6. www.ajctools.com

Appendices

Test Data and Results:

- Torque test results:



Torque = (L)(F) = (1.83 ft)(23.5 lbs)=(43.08ft lb)

- By testing our machine on the test board, we found that it could affectively pry up shingles by use of the pneumatic piston and spade combination.

- The machine weighs approximately 65 lbs and is compatible with available electricity and compressed air resources.

- After testing, we conclude that our present design could not affectively grind shingles into 1-2 inch fragments, and consequently could also not discard the fragments.

MATERIAL USE/REQUEST FORM

COURSE: Senior Project

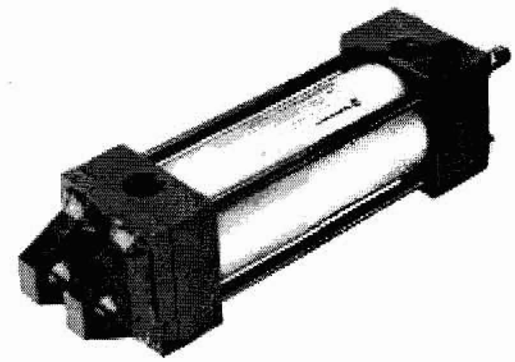
PROJECT: Shingle Remover

GROUP: Andrew Sayegh, Timothy Grant

DATE	QTY.	ITEM	PRICE	TOTAL	
2-28-01	5	½"-13 × 1¾ bolts	0.50	2.50	
"	5	½-13 Jam + Finish Hex nuts			
"	5	½-⅞" Flat washers	.10	0.50	
2-28-01	1	9" × 3½" diam × ¼" thick Pipe (steel)			
3-6-01	1	23" of ⅞" × 1" × ¼" angle iron			
4-6-01	1	157" of ¾" × ⅛" angle iron			
4-25-01	8	⅜-16 × ¾" bolts			
"	8	⅜-16 hex nuts			
"	2	½" lockwashers			
"	2	½"-13 hex nuts			
5-1-01	2	5/16-18 × ½" hex bolts			
"	2	5/16-18 × 1" hex bolts			
	—	4 ft² 10 guage sheet steel			
	—	78.5 in² 18 guage sheet steel			
	20	¼"-20 × ½" hex nuts	0.017	0.34	
	20	¼"-20 bolts			
	—	156.75" of ¾" angle iron			
	5	wire ties			
	1	9" × 7" × ⅛" 4130 steel sheet			
	1	11" × 7/16" diam steel rod shaft			
	2	½" diam 13" steel rod shaft			
	1	AC plug + grounded chord w/2 wire nuts			
	1	24" × 9¾" Polycarbonate sheet w/ clamp (Cryolon ZX-V)	5.94	5.94	
	10	10-24 hex machine screw nuts			
	10	10-24 × ½ roundhead screws			
	2	10 × 32 × ½ round head screws			
	2	10 × 32 hex machine screw nuts			

Cylinder with 22 (MP2) Detachable Cap Clevis

- **NFPA (MP2) 22 Detachable Cap Clevis Mount for 1-1/2" to 8" bore sizes.**
- **Series A Cylinders rated to 250 PSI air, 400 PSI hydraulic (non-shock). Series EA Cylinders rated to 250 PSI air only.**
- **Designed for non-lube service.**
- **Switches available on all bore sizes. (See pages 62 & 63 for ordering information.)**



Cylinder Order Information

__ 22 - __ __ - __ __ - ______ - ______

A	Series A Cylinder
EA	Series EA Cylinder

Mounting Options	
01	Side Tapped (MS4)
03	Head Rectangular Flange (MF1)
03	Head Square (ME3) - 7" & 8" Bores
04	Cap Rectangular Flange (MF2)
04	Cap Square (ME4) - 7" & 8" Bores
05	Basic Cylinder No Mounting (MX0)
06	Both Ends (4) Tie Rods Ext. (MX1)
6B	Both Ends (2) Tie Rods Ext. (MX4)
6C	Cap Tie Rods Ext. (MX2)
6R	Head Tie Rods Ext. (MX3)
7R	Head Trunnion (MT1)
8R	Cap Trunnion (MT2)
09	Side Lugs (MS2)
10	Center Trunnion (MT4)
11	Side End Angles (MS1)
12	Cap Fixed Clevis (MP1)
15	Side End Lugs (MS7)
16	Sleeve Nut Construction (Universal)
20	Head Square Flange (MF5)
21	Cap Square Flange (MF6)
22	**Detachable Cap Clevis (MP2)**
32	Cap Fixed Eye (MP3)
42	Detachable Cap Eye (MP4)
52	Spherical Bearing
60	Base Bar (Not NFPA)

Cushion in Head	
3	None
5[1]	Non-Adjustable Cushion
7	Adjustable Cushion (Position 2)

[1]Standard with EA

Cushion in Cap	
3	None
5[1]	Non-Adjustable Cushion
7	Adjustable Cushion (Position 2)

[1]Standard with EA

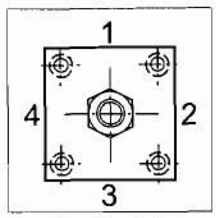
Bore and Stroke (write out)

Additional Options – order alphabetically – More on page 67.	
HR	Case Hardened (45 Rc)
L(_ _)	Port Location position 1 standard: L(Head Cap) (specify position 1 thru 4 for head and/or cap)
MS	Metal Rod Scraper
N(_ _)	Cushion Adjust Screw Location position 2 standard: N(Head Cap) (specify position 1 thru 4 for head and/or cap)
P(_)*	Non-Standard Port Sizes: [specify port size for P(_H) head only, P(_C) cap only, or P(_) both head & cap]
PS	Magnetic Piston
RS	Rod Stud
	Type 1 (5/8" - 1 3/4" øRod)
	Type 2 (5/8" & 1" øRod)
RX	Rod Extensions (specify length of additional rod extension)
SC	Single Acting Spring Extend (Cap End)–See page 67
SR	Single Acting Spring Retract (Rod End)–See page 67
SS	303 Stainless Steel (Hard Chrome Plated)
ST(_C)	Stop Tube (Cap End) (specify stop tube length)
ST(_R)	Stop Tube (Rod End) (specify stop tube length)
T	Special Rod Threads (specify rod thread)
TX	Thread Extensions (specify length of thread extension)
V	Viton® Seals

*1 1/2", 2", 2 1/2" bore cylinders have 3/8" NPT Standard, 1/2" NPT oversize. 3 1/4", 4", 5" bore cylinders have 1/2" NPT Standard, 3/4" NPT oversize. This will add 1/8" to the overall cylinder length.

Piston Rod Threads Type	
1	Small Male (Solid)
2	Intermediate Thread Male (Solid)
3	Female
6	Full Thread Male (Solid)
7	Plain Rod End

Piston Rod Diameters		
A	5/8"	Standard on 1 1/2", 2", 2 1/2"
B	1"	Standard on 3 1/4", 4", 5"
		Oversized on 1 1/2", 2", 2 1/2"
C	1 3/8"	Standard on 6", 7", 8"
		Oversized on 3 1/4", 4", 5"
D	1 3/4"	Oversized on 6", 7", 8"

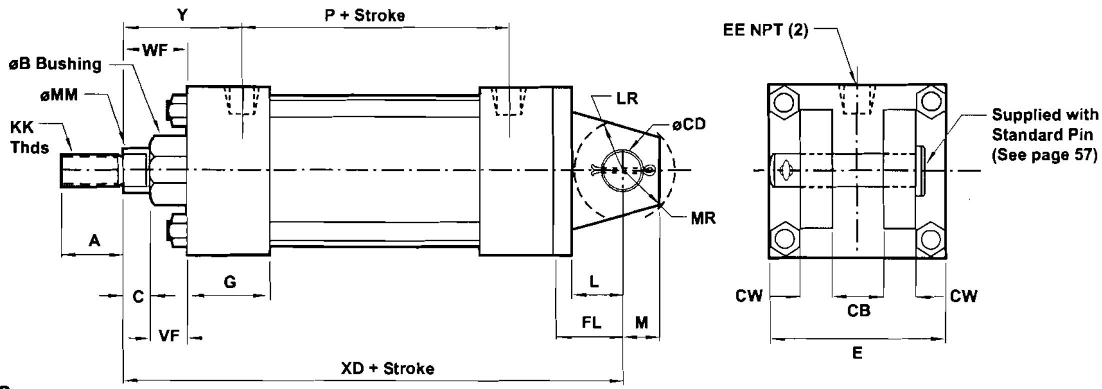


Port and Cushion Adjustment Positions (As viewed from rod end: Port standard position 1, Cushion Adjustment standard position 2.)
NOTE: A Port and a Cushion Adjustment cannot be in the same position.

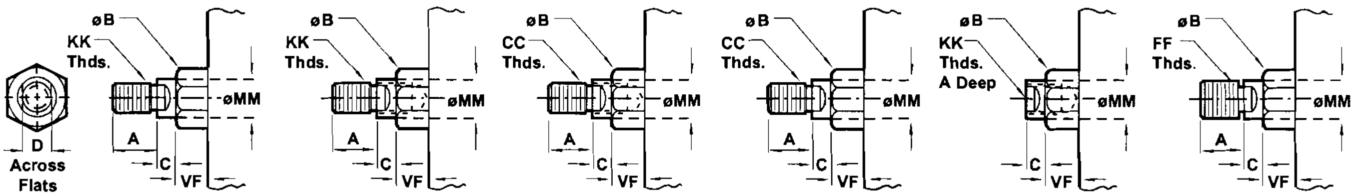
See page 68 for complete instructions on how to order cylinders.

Series A & EA, NFPA Aluminum Air Cylinder with 22 (MP2) Detachable Cap Clevis

All Dimensions in Inches (mm)



Standard & Optional Rod Ends



Type 1 Solid (Standard Male)

Type 1 Studded (Studded Male Optional)

Type 2 Studded (Intermediate Thread Male Optional)

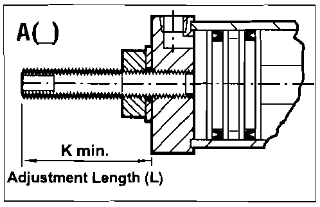
Type 2 Solid (Intermediate Thread Male Optional)

Type 3 Female (Optional)

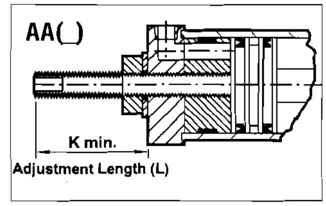
Type 6 Solid (Full Thread Male Optional)

Dimension		1 1/2" Bore (38.10)	2" Bore (50.80)	2 1/2" Bore (63.50)	3 1/4" Bore (82.55)	4" Bore (101.60)	5" Bore (127.00)	6" Bore (152.40)	7" Bore (177.80)	8" Bore (203.20)
ø Rod	Std.	5/8" (15.88)	5/8" (15.88)	5/8" (15.88)	1" (25.40)	1" (25.40)	1" (25.40)	1 3/8" (34.93)	1 3/8" (34.93)	1 3/8" (34.93)
	O.S.	1" (25.40)	1" (25.40)	1" (25.40)	1 3/8" (34.93)	1 3/8" (34.93)	1 3/8" (34.93)	1 3/4" (44.45)	1 3/4" (44.45)	1 3/4" (44.45)
A	Std.	.750 (19.05)	.750 (19.05)	.750 (19.05)	1.125 (28.58)	1.125 (28.58)	1.125 (28.58)	1.625 (41.28)	1.625 (41.28)	1.625 (41.28)
	O.S.	1.125 (28.58)	1.125 (28.58)	1.125 (28.58)	1.625 (41.28)	1.625 (41.28)	1.625 (41.28)	2.000 (50.80)	2.000 (50.80)	2.000 (50.80)
B +.000 -.002	Std.	1.124 (28.55)	1.124 (28.55)	1.124 (28.55)	1.499 (38.08)	1.499 (38.08)	1.499 (38.08)	1.999 (50.78)	1.999 (50.78)	1.999 (50.78)
	O.S.	1.499 (38.08)	1.499 (38.08)	1.499 (38.08)	1.999 (50.78)	1.999 (50.78)	1.999 (50.78)	2.374 (60.30)	2.374 (60.30)	2.374 (60.30)
C	Std.	.375 (9.53)	.375 (9.53)	.375 (9.53)	.500 (12.70)	.500 (12.70)	.500 (12.70)	.625 (15.88)	.625 (15.88)	.625 (15.88)
	O.S.	.500 (12.70)	.500 (12.70)	.500 (12.70)	.625 (15.88)	.625 (15.88)	.625 (15.88)	.750 (19.05)	.750 (19.05)	.750 (19.05)
CB		.750 (19.05)	.750 (19.05)	.750 (19.05)	1.250 (31.75)	1.250 (31.75)	1.250 (31.75)	1.500 (38.10)	1.500 (38.10)	1.500 (38.10)
CC	Std.	1/2 – 20	1/2 – 20	1/2 – 20	7/8 – 14	7/8 – 14	7/8 – 14	1 1/4 – 12	1 1/4 – 12	1 1/4 – 12
	O.S.	7/8 – 14	7/8 – 14	7/8 – 14	1 1/4 – 12	1 1/4 – 12	1 1/4 – 12	1 1/2 – 12	1 1/2 – 12	1 1/2 – 12
CD		.500 (12.70)	.500 (12.70)	.500 (12.70)	.750 (19.05)	.750 (19.05)	.750 (19.05)	1.000 (25.40)	1.000 (25.40)	1.000 (25.40)
CW		.500 (12.70)	.500 (12.70)	.500 (12.70)	.625 (15.88)	.625 (15.88)	.625 (15.88)	.750 (19.05)	.750 (19.05)	.750 (19.05)
D	Std.	.500 (12.70)	.500 (12.70)	.500 (12.70)	.813 (20.64)	.813 (20.64)	.813 (20.64)	1.125 (28.58)	1.125 (28.58)	1.125 (28.58)
	O.S.	.813 (20.64)	.813 (20.64)	.813 (20.64)	1.125 (28.58)	1.125 (28.58)	1.125 (28.58)	1.500 (38.10)	1.500 (38.10)	1.500 (38.10)
E		2.000 (50.80)	2.500 (63.50)	3.000 (76.20)	3.750 (95.25)	4.500 (114.30)	5.500 (139.70)	6.500 (165.10)	7.500 (190.50)	8.500 (215.90)
EE		.375 (9.53)	.375 (9.53)	.375 (9.53)	.500 (12.70)	.500 (12.70)	.500 (12.70)	.750 (19.05)	.750 (19.05)	.750 (19.05)
FF	Std.	5/8 – 18	5/8 – 18	5/8 – 18	1 – 14	1 – 14	1 – 14	1 3/8 – 12	1 3/8 – 12	1 3/8 – 12
	O.S.	1 – 14	1 – 14	1 – 14	1 3/8 – 12	1 3/8 – 12	1 3/8 – 12	1 3/4 – 12	1 3/4 – 12	1 3/4 – 12
FL		1.125 (28.58)	1.125 (28.58)	1.125 (28.58)	1.875 (47.63)	1.875 (47.63)	1.875 (47.63)	2.250 (57.15)	2.250 (57.15)	2.250 (57.15)
G		1.500 (38.10)	1.500 (38.10)	1.500 (38.10)	1.750 (44.45)	1.750 (44.45)	1.750 (44.45)	2.000 (50.80)	2.000 (50.80)	2.000 (50.80)
J		1.000 (25.40)	1.000 (25.40)	1.000 (25.40)	1.250 (31.75)	1.250 (31.75)	1.250 (31.75)	1.500 (38.10)	1.500 (38.10)	1.500 (38.10)
K		.250 (6.35)	.313 (7.94)	.313 (7.94)	.375 (9.53)	.375 (9.53)	.438 (11.11)	.438 (11.11)	.563 (14.29)	.563 (14.29)
KK	Std.	7/16 – 20	7/16 – 20	7/16 – 20	3/4 – 16	3/4 – 16	3/4 – 16	1 – 14	1 – 14	1 – 14
	O.S.	3/4 – 16	3/4 – 16	3/4 – 16	1 – 14	1 – 14	1 – 14	1 1/4 – 12	1 1/4 – 12	1 1/4 – 12
L		.750 (19.05)	.750 (19.05)	.750 (19.05)	1.250 (31.75)	1.250 (31.75)	1.250 (31.75)	1.500 (38.10)	1.500 (38.10)	1.500 (38.10)
LB		3.625 (92.08)	3.625 (92.08)	3.750 (95.25)	4.250 (107.95)	4.250 (107.95)	4.500 (114.30)	5.000 (127.00)	5.125 (130.18)	5.125 (130.18)
LR		.750 (19.05)	.750 (19.05)	.750 (19.05)	1.250 (31.75)	1.250 (31.75)	1.250 (31.75)	1.500 (38.10)	1.500 (38.10)	1.500 (38.10)
M		.500 (12.70)	.500 (12.70)	.500 (12.70)	.750 (19.05)	.750 (19.05)	.750 (19.05)	1.000 (25.40)	1.000 (25.40)	1.000 (25.40)
MM	Std.	.625 (15.88)	.625 (15.88)	.625 (15.88)	1.000 (25.40)	1.000 (25.40)	1.000 (25.40)	1.375 (34.93)	1.375 (34.93)	1.375 (34.93)
	O.S.	1.000 (25.40)	1.000 (25.40)	1.000 (25.40)	1.375 (34.93)	1.375 (34.93)	1.375 (34.93)	1.750 (44.45)	1.750 (44.45)	1.750 (44.45)
MR		.625 (15.88)	.625 (15.88)	.625 (15.88)	.938 (23.81)	.938 (23.81)	.938 (23.81)	1.188 (30.16)	1.188 (30.16)	1.188 (30.16)
P		2.313 (58.74)	2.313 (58.74)	2.438 (61.91)	2.625 (66.68)	2.625 (66.68)	2.875 (73.03)	3.125 (79.38)	3.250 (82.55)	3.250 (82.55)
VF	Std.	.625 (15.88)	.625 (15.88)	.625 (15.88)	.875 (22.23)	.875 (22.23)	.875 (22.23)	1.000 (25.40)	1.000 (25.40)	1.000 (25.40)
	O.S.	.875 (22.23)	.875 (22.23)	.875 (22.23)	1.000 (25.40)	1.000 (25.40)	1.000 (25.40)	1.125 (28.58)	1.125 (28.58)	1.125 (28.58)
WF	Std.	1.000 (25.40)	1.000 (25.40)	1.000 (25.40)	1.375 (34.93)	1.375 (34.93)	1.375 (34.93)	1.625 (41.28)	1.625 (41.28)	1.625 (41.28)
	O.S.	1.375 (34.93)	1.375 (34.93)	1.375 (34.93)	1.625 (41.28)	1.625 (41.28)	1.625 (41.28)	1.875 (47.62)	1.875 (47.62)	1.875 (47.62)
XD	Std.	5.750 (146.05)	5.750 (146.05)	5.875 (149.23)	7.500 (190.50)	7.500 (190.50)	7.750 (196.85)	8.875 (225.43)	9.000 (228.60)	9.000 (228.60)
	O.S.	6.125 (155.58)	6.125 (155.58)	6.250 (158.75)	7.750 (196.85)	7.750 (196.85)	8.000 (203.20)	9.125 (231.78)	9.250 (234.95)	9.250 (234.95)
Y	Std.	1.875 (47.63)	1.875 (47.63)	1.875 (47.63)	2.438 (61.91)	2.438 (61.91)	2.438 (61.91)	2.813 (71.44)	2.813 (71.44)	2.813 (71.44)
	O.S.	2.250 (57.15)	2.250 (57.15)	2.250 (57.15)	2.688 (68.26)	2.688 (68.26)	2.688 (68.26)	3.063 (77.79)	3.063 (77.79)	3.063 (77.79)

Adjustable Stroke
Provides variable reduction of the retract stroke and serves as a positive stop for the cylinder piston. Consists of a threaded stud located in the cap end of the cylinder. Milled wrench flats on the end of the adjustment stud allow for simple yet precise positioning to accommodate varying retract stroke requirements.
TO ORDER: Enter option code **A( )**.
Specify adjustable stroke length.



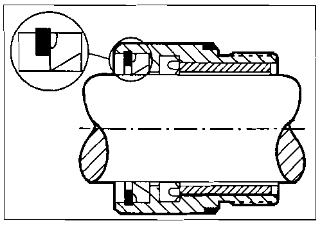
Adjustable Stroke with Piston
Provides variable reduction of the retract stroke and serves as a positive stop for the cylinder piston. Consists of an adjustable stop piston attached to a threaded stud located in the cap end of the cylinder. Milled wrench flats on the end of the adjustment stud allow for simple yet precise positioning of the stop piston to accommodate varying retract stroke requirements.
TO ORDER: Enter option code **AA( )**. Specify adjustable stroke length.



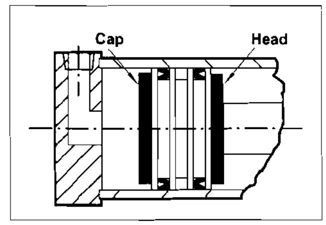
Maximum Adjustable Stroke Length

Bore	1 1/2" (38.10)	2" (50.80)	2 1/2" (63.50)	3 1/4" (82.55)	4" (101.60)	5" (127.00)	6" (152.40)	7" (177.80)	8" (203.20)
K min.	1 (25.40)	1 (25.40)	1.375 (34.93)	1.375 (34.93)	1.375 (34.93)	1.625 (41.28)	1.625 (41.28)	2 (50.80)	2 (50.80)
A (L max.)	5 (127.00)	5 (127.00)	8 (203.20)	8 (203.20)	8 (203.20)	9 (228.60)	9 (228.60)	12 (304.80)	12 (304.80)
AA (L max.)	10 (254.00)	10 (254.00)	16 (406.40)	16 (406.40)	16 (406.40)	18 (457.20)	18 (457.20)	20 (508.00)	20 (508.00)

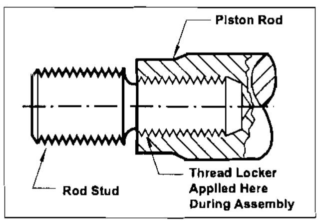
Metallic Rod Scraper
Aggressively scrapes the exposed portion of the piston rod free of weld spatter, paint spray, abrasive powders or many other foreign materials that could damage the rod seal.
TO ORDER: Enter option code **MS**.



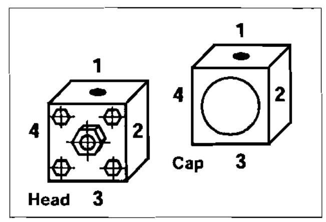
Noise Dampening Bumper
Urethane Bumper is attached to cap and/or head of piston surface. NOTE: When a cushion is used in combination with a Urethane Bumper, that end will be supplied with standard length cushion for all stroke lengths. (Short head cushion sleeve and short cap cushion spear will not apply on the same side with a bumper.)
TO ORDER: Enter option code **UB** = both ends, **UC** = cap end or **UH** = head end.



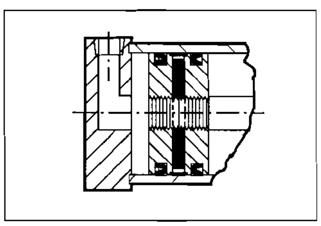
Piston Rod Stud
Reduces the chance for piston rod failure. The rod stud can be installed with different thread locker. TO ORDER, enter:
Option code **BL** – removable adhesive
Option code **RS** – high strength thread locker adhesive.
NOTE: Type 2 studded rod shown.



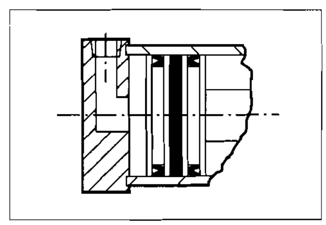
Cushion Adjust Screw Optional Locations
Option code **N(_ _)**
Specify optional location.
Example: **N(4 2)** cushion location 4 Head end, standard position 2 Cap end.
When using option code **N**, head and cap locations must be specified 1, 2, 3, or 4.



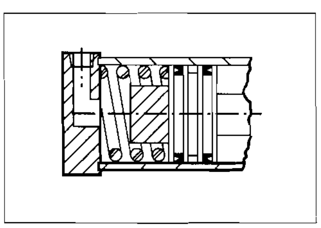
Pinned Piston to Rod
Norgren will supply a full size piston rod to piston joint, in addition to pinning the piston to the rod, for severe applications. If under normal operating conditions, the pinned piston and rod become detached, Norgren will replace the piston and rod assembly free of charge.
TO ORDER: Enter option code **PN**.



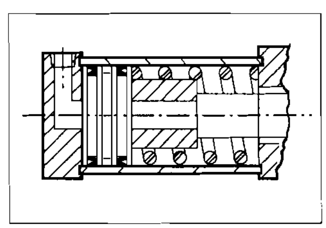
Magnetic Piston (No Wear Ring)
When position sensing of the cylinder rod is required, a "magnetic piston" must be specified. A magnetic band is placed at the center of the piston which creates a magnetic field to actuate **Norgren's** reed, solid state or hall effect switch. NOTE: We cannot guarantee the operation of other manufacturers' switches.
TO ORDER: Enter option code **PS**.



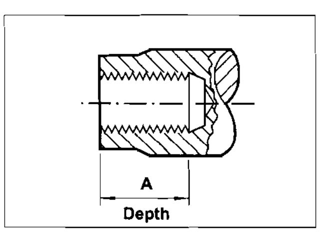
Single Acting Spring Extend
Available on Cap End of Cylinder for 1 1/2", 2", and 2 1/2" bore sizes, 12" maximum stroke.
NOTE: Standard spring extend cylinder has 12 lbs. force pre-load, 30 lbs. force compressed. For other spring forces, bore sizes or longer strokes, consult factory.
TO ORDER: Enter option code **SC**.



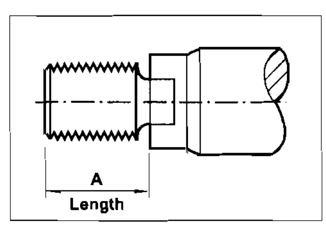
Single Acting Spring Retract
Available on Rod End of Cylinder for 1 1/2", 2", and 2 1/2" bore sizes, 12" maximum stroke.
NOTE: Standard spring retract cylinder has 12 lbs. force pre-load, 30 lbs. force compressed. For other spring forces, bore sizes or longer strokes, consult factory.
TO ORDER: Enter option code **SR**.



Additional Female Thread Depth
Piston rod thread depth can be ordered over standard.
TO ORDER: Enter option code **TF( )** and specify additional "A" depth.



Additional Male Thread Length
Piston rod thread extension can be ordered over standard.
TO ORDER: Enter option code **TX( )** and specify additional "A" length.



9" 2.5"

DEMCO

V-BELT DRIVE SPEED GUIDE

FORM 5S1196

DAYTON ELECTRIC MANUFACTURING CO. CHICAGO 60648

TO DETERMINE DRIVEN SHEAVE SPEED:

1. Read across the top of the table to the appropriate driver (motor) sheave pitch diameter column.
2. Read down the column on the left to the appropriate driven sheave pitch diameter.
3. The figure where the driver (motor) sheave column and the driven sheave line intersect is the speed of the driven sheave. Speeds shown are approximate and are affected by belt and sheave dimensional variations, wear, and belt tension.

   The driven sheave speed figures in this table are based on a 1725 RPM driver (motor).

   For 3450 RPM motors, double the driven sheave speed figures (multiply by 2).

   For 1140 RPM motors, reduce the driven sheave speed figures by 1/3 (multiply by .666).

4. The table also may be used to determine required driven sheave pitch diameter if motor speed, driver (motor) sheave pitch diameter, and desired driven sheave speed are known.

DRIVEN SHEAVE SPEED (RPM) WITH 1725 RPM MOTOR

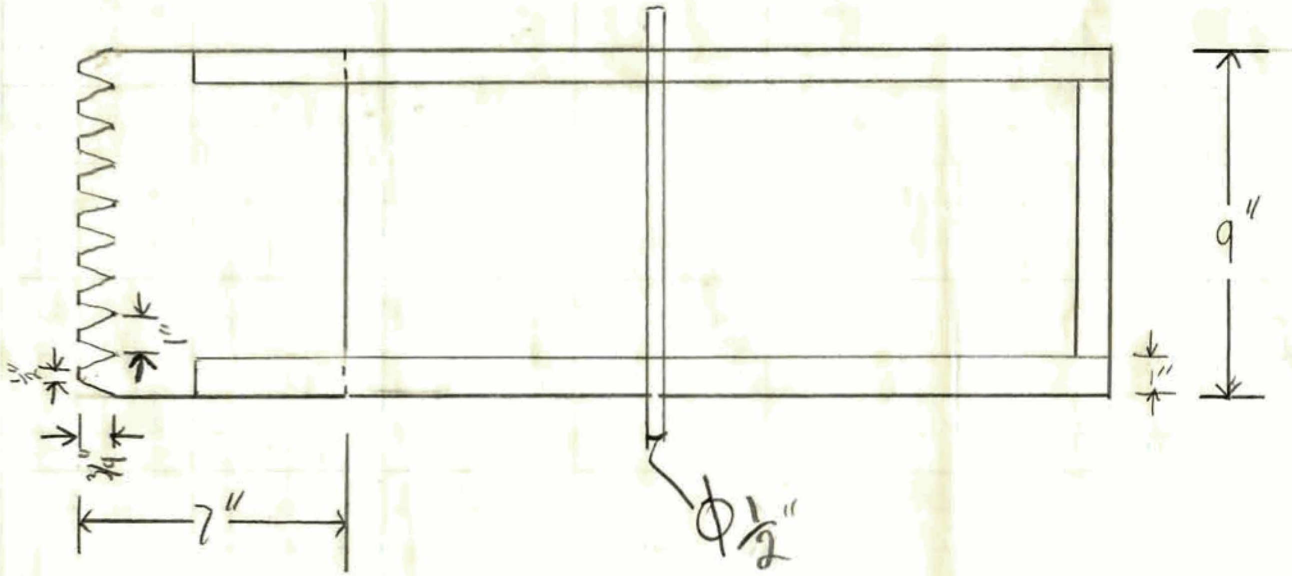
Driven Sheave Pitch Diameter	DRIVER (MOTOR) SHEAVE PITCH DIAMETER														
	1.5"	1.8"	2.0"	2.3"	2.5"	2.8"	3.0"	3.2"	3.5"	3.7"	4.0"	4.2"	4.5"	4.7"	5.0"
1.5"	1725	2070	2300	2645	2875	3220	3450	3680	4025	4255	4600	4830	5175	5405	5750
1.8	1438	1725	1917	2204	2396	2683	2875	3067	3354	3545	3833	4025	4313	4504	4792
2.0	1294	1553	1725	1984	2156	2415	2588	2760	3019	3191	3450	3623	3881	4054	4313
2.3	1125	1350	1500	1725	1875	2100	2250	2400	2625	2775	3000	3150	3375	3525	3750
2.5	1035	1242	1380	1587	1725	1932	2070	2208	2415	2553	2760	2898	3105	3243	3450
2.8	925	1109	1232	1417	1540	1725	1848	1971	2156	2279	2464	2588	2772	2896	3080
3.0	863	1035	1150	1323	1438	1610	1725	1840	2013	2128	2300	2415	2588	2703	2875
3.2	809	970	1078	1240	1348	1509	1617	1725	1887	1995	2156	2264	2426	2534	2695
3.5	740	887	986	1134	1232	1380	1479	1577	1725	1824	1971	2070	2218	2316	2464
3.7	700	839	932	1072	1166	1305	1399	1492	1632	1725	1865	1958	2098	2191	2331
4.0	647	776	863	992	1078	1208	1294	1380	1509	1596	1725	1811	1941	2027	2156
4.2	616	739	821	945	1027	1150	1232	1314	1438	1520	1643	1725	1848	1930	2054
4.5	575	690	767	882	958	1073	1150	1227	1342	1418	1533	1610	1725	1802	1917
4.7	551	661	734	844	918	1028	1101	1174	1285	1358	1468	1541	1652	1725	1835
5.0	518	621	690	794	863	966	1035	1140	1208	1277	1380	1449	1553	1622	1725
5.2	498	597	663	763	829	929	995	1062	1161	1227	1327	1393	1493	1559	1659
5.5	471	565	627	721	784	878	941	1004	1098	1160	1255	1317	1411	1474	1568
5.7	454	545	605	696	757	847	908	968	1059	1120	1211	1271	1362	1422	1513
6.0	432	518	575	661	719	805	863	920	1006	1064	1150	1208	1294	1351	1438
6.5	398	478	531	610	663	743	796	849	929	982	1062	1115	1194	1247	1327
7.0	370	444	493	567	616	690	739	789	863	912	986	1035	1109	1158	1232
7.5	345	414	460	529	575	644	690	736	805	851	920	966	1035	1081	1150
8.0	324	388	431	496	539	604	647	690	755	798	863	906	970	1013	1078
8.5	305	365	406	467	507	568	609	649	710	751	812	852	913	954	1015
9.0	288	345	383	441	479	537	575	613	671	709	767	805	863	901	958
9.5	273	327	363	418	454	508	545	581	636	672	726	763	817	853	908
10.0	259	311	345	397	431	483	518	552	604	638	690	725	776	811	863
10.5	247	296	329	378	411	460	493	526	575	608	657	690	739	772	821
11.0	236	282	314	361	392	439	470	502	549	580	627	659	706	737	784
12.0	216	259	288	331	359	403	431	460	503	532	575	604	647	676	719
13.0	199	239	265	305	332	372	398	425	464	491	531	557	597	624	663
14.0	185	222	246	283	308	345	370	394	431	456	493	518	554	579	616
15.0	173	207	230	265	288	322	345	368	403	426	460	483	518	541	575
18.0	144	173	192	220	240	268	288	307	335	355	383	403	431	450	479

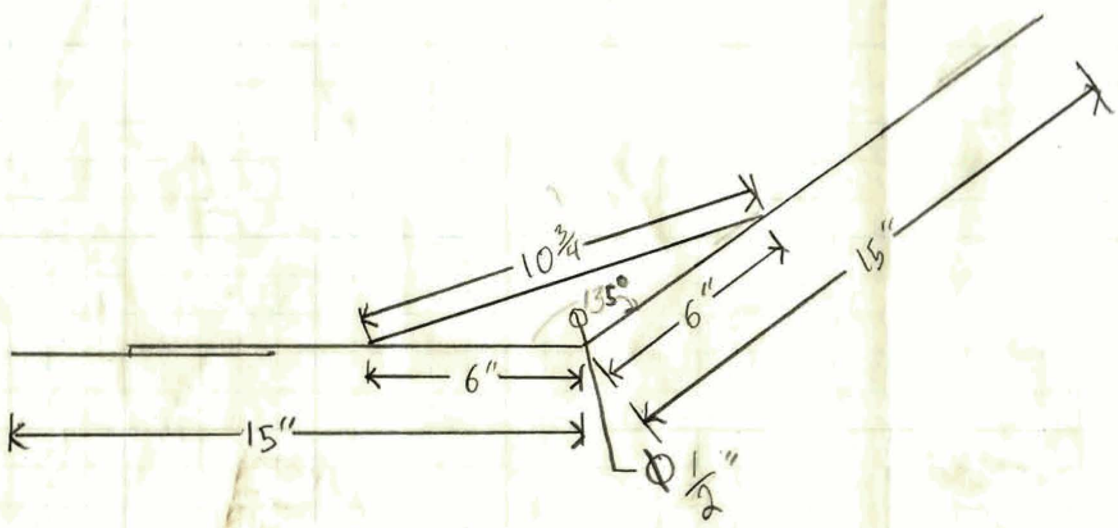
To determine driven speeds for pitch diameters not shown use formula below:

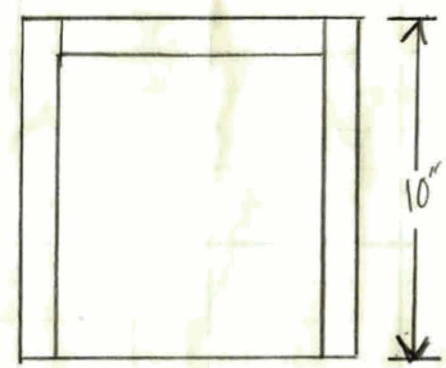
$$\text{Driven Speed} = \frac{\text{Driver [Motor] Sheave Pitch Dia.}}{\text{Driven Sheave Pitch Dia.}} \times \text{Driver [Motor] Speed}$$

Litho in U.S.A. 76/451

Tim Grant
Andrew Sayegh







Tim Grant
Andrew Sayegh
Sr. Project

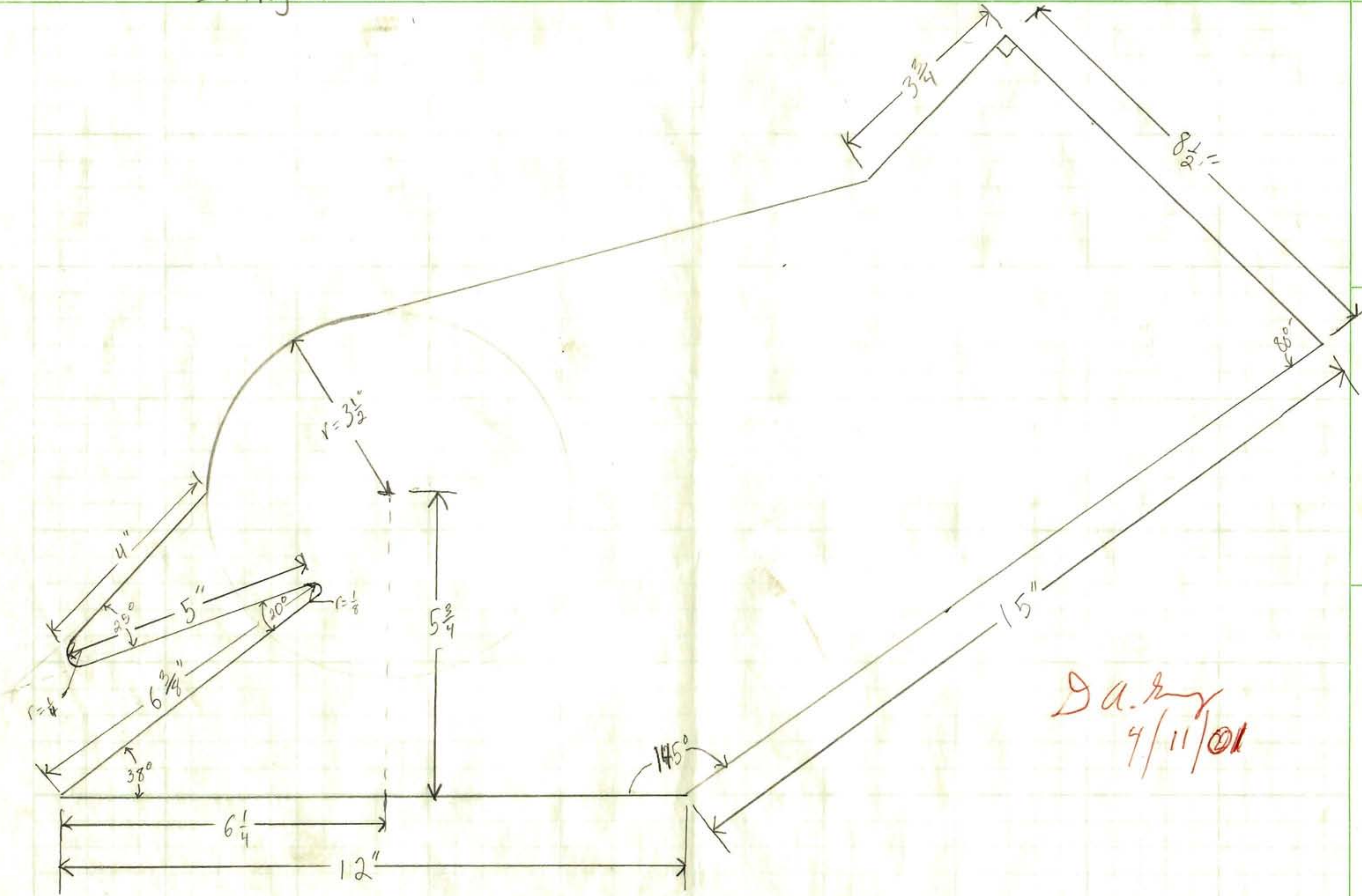
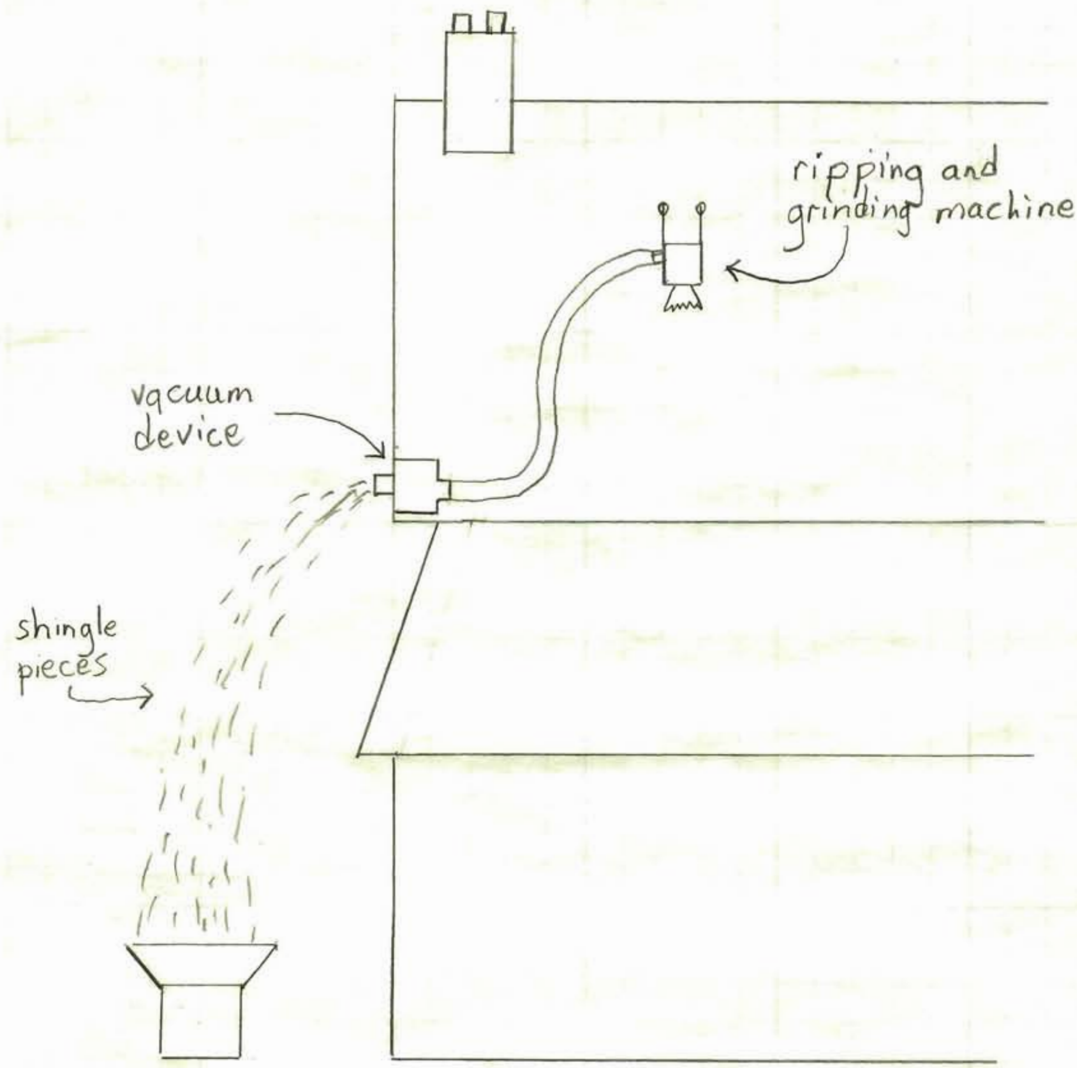
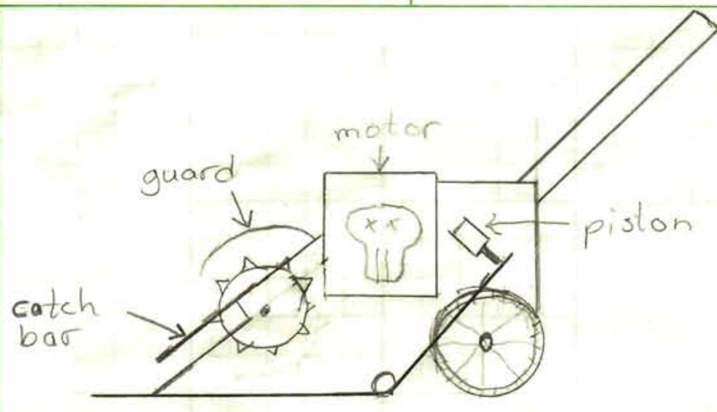
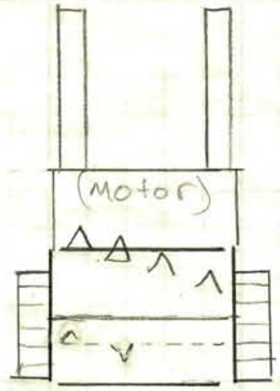


Figure 1


ripping and grinding machine
vacuum device
shingle pieces



side



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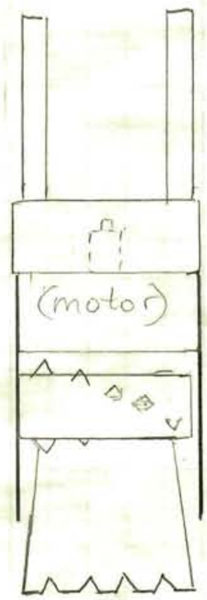

TOP