Roscommon Equipment Center Program

Project Number 17

POWER BLOWERS AS

FIRELINE BUILDING TOOLS

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Northeast Forest Fire Supervisors

In Cooperation with

Michigan's Forest Fire Experiment Station

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Acknowledgments

The Roscommon Equipment Center would like to thank the power blower users from many agencies who responded to our survey; these responses provided valuable assistance. Questionnaire replies were the heart of this study, the following agencies returned responses:

- Indiana Department of Natural Resources
- Kentucky Division of Forestry
- Missouri Department of Conservation
- New Jersey Department of Environmental Protection & Energy
- Ohio Department of Natural Resources
- Pennsylvania Department of Environmental Resources
- Tennessee Department of Agriculture
- Virginia Department of Forestry
- West Virginia Department of Forestry
- Plus several fire departments in the above states.

The Missouri Department of Conservation initiated the project, tested the handlebar design and provided much information, including specifications.

The Kentucky Division of Forestry provided their handbook on using blowers in fire control.

Disclaimer

Introduction

In the relatively level terrain of most of the eastern United States, fireline construction has generally been performed mechanically by the use of plows. However, the more rugged terrain of the Appalachian and Ozark chains often renders plowing equipment unsuitable. In these areas, hardwood leaf litter makes up a fair amount of the fuel. In the late 1950s, the Missouri Department of Conservation started using a wheeled type air blower to remove some of this debris as part of the process of producing fireline (Figure 1).

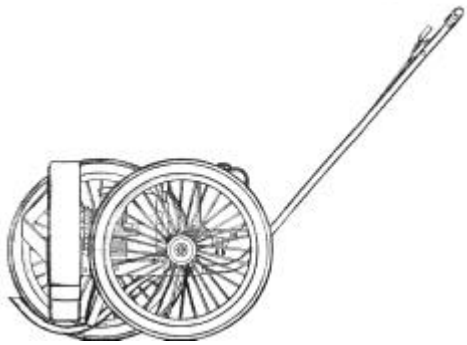

Figure 1 - Missouri wheeled blower (circa 1960).

At one time, Missouri requested REC help in development modifications to this equipment to better perform the job. This project was first proposed to evaluate those needs.

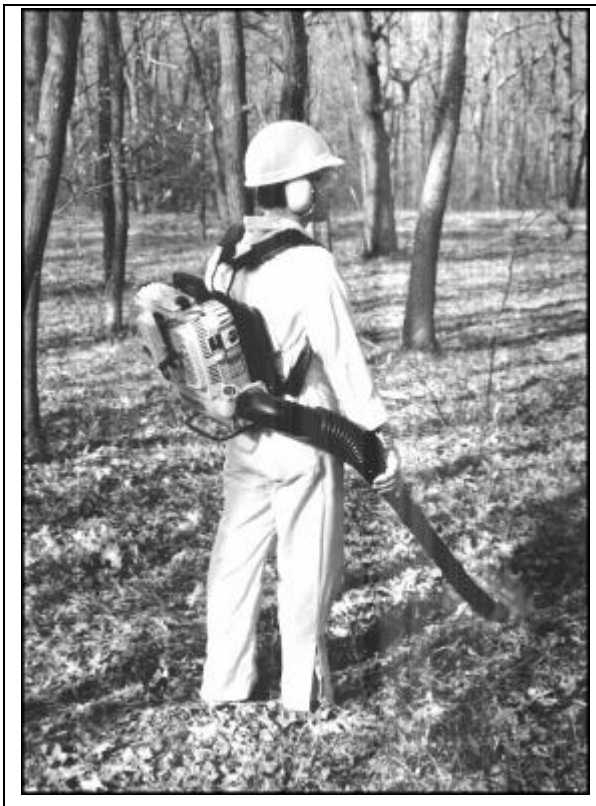

Figure 2 - Typical power blower.

In the 1960s, again in Missouri, the US Forest Service experimented with backpack type mist blowers to accomplish this same task. The mist tank was removed and air velocity from the nozzle moved the leaf litter. In more recent years, several manufacturers, primarily in Europe and Japan, have produced backpack leaf blowers for yard maintenance (Figure 2). In this publication we will refer to these machines as *power blowers*.

Several states have adopted this equipment for use in appropriate areas; this includes Indiana, Kentucky, Missouri, New Jersey, Ohio, Pennsylvania, Tennessee, Virginia and West Virginia. Power blowers have become a mechanized way to help produce fireline in areas where large equipment is not practical.

A 2-cycle, 3 to 4 horsepower, air cooled engine powers the typical backpack blower. The blowers deliver air at a speed of 180 to 225 MPH, with flow volumes of 350 to 500 cubic feet per minute. The engine turns a large fan that delivers the air through a flexible air duct that is generally made of plastic. Of the blowers studied, all delivered air to a wand controlled by the right arm. Normally the left arm controlled the engine throttle. Dry weight for these units is about 20 pounds. They may weigh from 25 up to 30 pounds when fully fueled and equipped with various modifications. Table 1 shows manufacturer's data for typical blowers being used in fire control.

Table 1 – Manufacturer's Data for Power Blowers Common in Fire Control.

Company	Model	Engine Displ. cc	Nozzle Velocity FPS	Air Flow CFM	Fuel Cap Qt.	Dry Wgt. Lbs.
Buntin	LBB43M	43	476	777	2.7	21.2
Deere	5e	44	264	388	1.6	19.8
ECHO	PB-4500	44	264	388	1.6	19.8
Green Machine	4600LP	42	293	600	2.0	17.2
Hoffco	BP550	36	330	530	2.0	23.0
Solo	412B		312	431		17.0
Solo	449	70	330	468	1.2	22.0
Stihl	BR400	56	260	476	1.6	18.5
Stihl	BR320	45	236	435	1.6	18.5
Toro		40	262	389	2.1	22.5
Vandermolen	66BE	40	330	640	4.0	21.5

The project goals included:

1. A Survey of experienced power blower users to tabulate information on desirable modifications, safety needs, tips on use and tactics and requirements for building meaningful specifications.

2. Development of a general set of specifications: By surveying the manufacturers, as well as the users, a salient features list was developed that can be helpful when building purchasing specifications. This can be used as a List of Requirements that must be met by prospective vendors, or as a checklist to help insure a blower meets certain necessary requirements.

3. Improve efficiency and safety. Some of the demand of this project resulted from casually identified need for better ergonomics in machine operation, as well as modifications to meet certain safety concerns. We list solutions developed by REC, or others, to help resolve the needs most often voiced in the user survey.

Use And Tactics

Power blowers have been used to build fireline primarily in hardwood leaf litter, and in hilly or mountainous terrain best accessible by foot traffic. They have also been used in other fuels, including removal of pine needle litter. Typically, the operator uses a back-and-forth or side-to-side motion, with the nozzle a few inches from the ground, directing the leaf litter and debris from the fire side of the fireline towards the unburned area. Power blowers are used for indirect attack fireline construction and are generally not used for direct attack.

A typical blower crew includes one person as a line locator, followed by the blower operator, followed by someone with a rake or other hand tool to improve the line, then followed by a line igniter. This crew organization may be reduced or expanded, depending on the conditions, but generally the power blower is used to reduce the number of fire fighters needed by a traditional hand line crew. In most instances the blower itself will not make a complete fireline. The utility of backpack blowers is demonstrated by the following advantages:

- Depending on the terrain, fuels, blower size and line construction team, fireline can be constructed up to 25 chains per man hour[1].

- In rocky terrain, traditional hand tools can have a difficult time. Blowers effectively remove fuel between rocks, where hand tools have problems reaching.

- An operator familiar with handline construction needs only additional training in the operation of the blower and some practice in its use.

- Blowers are one of the few pieces of engine driven equipment that can be used wherever walking access is needed.

- While blowers with good power and air velocity can move most leaf litter, as well as small sticks and debris, care must be taken to produce an adequate line. Small roots, larger limbs, matted leaves, vines and live plants may remain. If these are not removed by other methods or tools, the blower's work may be valueless.

Survey Results

REC asked operators from several agencies that utilize power blowers to answer a questionnaire. Of the returned questionnaires, 57 respondents indicated that they routinely used power blowers. Their answers were tabulated and results are summarized in this section. Results concerning blower characteristics seem to parallel the model of the blower that the operator used. For example, when asked, "How much horsepower an efficient airblower for fire control use should have?", we normally got an answer that was equal to the horsepower of the blower that the respondent used. Because of this, we chose not to use all the information received from questionnaires.

In general, respondents indicated that power blowers used for fire control should have a *minimum* air flow output of 250 cubic feet per minute, with a velocity greater than 150 miles per hour. Most respondents *preferred* greater volume and air speed. Operators also wanted at least one hour, and preferably two hours of operation before refueling was needed.

Several safety and operator comfort needs were identified. Nearly all respondents felt that earplugs or muffs were necessary to reduce noise levels. Operator manuals for these machines cite hearing protection as needed for their operation. Eye protection was the most cited need by users. Most used goggles, some preferred a face shield. About 10 percent of respondents used some type of respiration filter at least part of the time. This was primarily for providing relief from dust and dirt sent airborne from the blower's use. In the survey, we listed some discomforts that might be caused by using this equipment. Figure 3 shows the responses. Noise, back strain and fatigue were cited by over 80 percent of

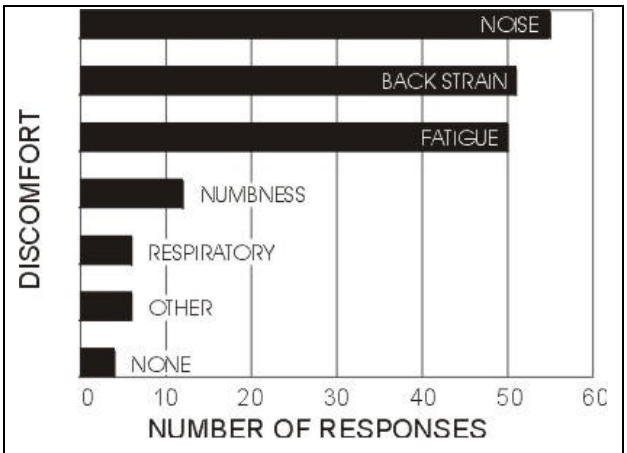

Figure 3 - Safety and Operator Comfort Needs

[1] *Use of Backpack Blowers for Wildfire Suppression*, Kentucky Division of Forestry, July 1983.

respondents. Most wished to have the blower weight less than 30 pounds. Narrative responses discussed arm fatigue associated with holding and using the wand. A design to reduce arm fatigue is found in the next section.

Another safety issue frequently discussed in the narratives was fuel leakage. Fuel lines of some blower models are vulnerable in the forest. They can be snagged or loosened by rugged use. Some agencies have modified their machines by securing fuel lines with additional clips or adding protective covers to limit vulnerability. Others have added a safety release, such as a seat belt clasp, to the shoulder strap, enabling the operator to quickly detach the blower should fuel from the machine be ignited.

We asked operators to rank six items, from highest to lowest priority. Table 2 shows the consensus ranking of these items, which was remarkably consistent. Low noise and strap comfort ranked at the bottom of the list behind blower performance factors. Operators apparently have found ways to adapt to some of the discomforts, such as using ear protection and "home" developed strap modifications. Engine reliability needs ranked highest. The small 2-cycle blower engines performed well when tuned properly, but they seem particularly prone to losing these adjustments in fire control's harsh environment. Dirty air, smoke, steep slope operation and general "bouncing around" may contribute to the already delicate tuning needs of these engines. The need for high nozzle air speed and a lighter weight machine were the other characteristics that ranked in the top half of this listing.

Table 2 – Survey Ranking of Six Power Blower Characteristics from Highest to Lowest Priority

1	**Engine Reliability**
2	**High Nozzle Speed**
3	**Light Weight**
4	**High Fuel Capacity**
5	**Comfortable Straps**
6	**Lower Noise**

Improving Ergonomics of Power Blowers

The user survey indicated that arm and shoulder fatigue occurred during operation of these blowers. Power blowers were designed to blow leaves ahead of an operator. This is a fairly comfortable and reasonably ergonomic situation. For fire control the air, and thus the movement of debris, must be to the side. Fatigue results from the relatively poor position of the right arm in relation to the force exerted by expelling air from the wand (see Figure 4).

The force of the air discharge at the nozzle is small (about 2 lbf)[2]. However, the operator's arm must overcome a disadvantage in leverage. Figure 4 shows the important forces acting on the system and operator. To hold the wand steady, the operator must counteract force developed by the air discharged noted by "F_a" in the diagram. For the John Deere 5E standard nozzle F_a=2 lbf and its moment arm length is 20-1/2 inches. The average operator's arm will exert its force about ten inches from the wand's swivel point. The resultant force needed by the operator's arm to counteract the air force, is about 4 lbf. This does not seem like much effort, but the arm must

[2] This force estimate was calculated for an open throttle, John Deere 5E blower, using a pitot tube and water filled manometer to measure nozzle pressure and assuming an air discharge velocity of 180 mph as advertised by the manufacturer. Other blowers will be different.

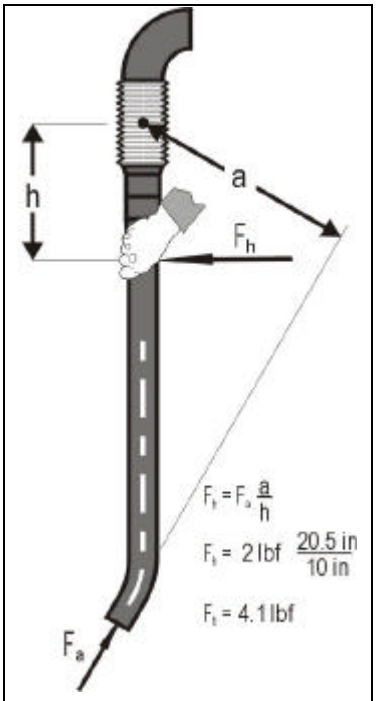

Figure 4 - Forces

be straight (or nearly straight) to grab the wand comfortably. The situation is similar to holding a large book with the arm fully outstretched in front. The gravitational force caused by the book is only a few pounds, but muscles are not well suited to deal with such a force in that position. A person will soon tire.

Two things can be done to correct this situation. One is to frequently change positions of the arm on the wand to try to use different muscles. This gives fatigued muscles some relief. With power blowers there are not many possible positions. Operators with long arms can use the left arm to occasionally help the right arm. The second way is to provide grip points for the hands that will better counteract the air discharge. REC designed a "handlebar" for the wand that accomplishes both (Figure 5). Note that the handlebars are designed for the John Deere 5E[3]. However, the concept can be slightly altered for other machines.

Figure 6 shows the system of forces acting on the operator with the handlebars in place. With the right hand on the upper handle, the left hand can push down to move the nozzle to the right. The force needed is about half that needed by the right arm in the first example. More importantly, muscle position is also much better. It allows the arm to take advantage of its inherent leverage. By easing off with the left hand, the nozzle force will return the wand to the left. This finishes a side-to-side sweeping action.

Moving the right hand to the lower handle position, with the forearm underneath the upper handle, allows for a back and forth action. In this case, the left arm counteracts the nozzle force. The right hand moves the wand, splitting the duties and better distributing the muscle usage.

Besides giving the operator leverage against the thrust from the air handlebars also:

- Rotate out of the way for removing and putting on blower.
- Quickly remove for storage.
- Quickly adjust or rotate about the wand to set the desired angle between the nozzle and handle-bars.

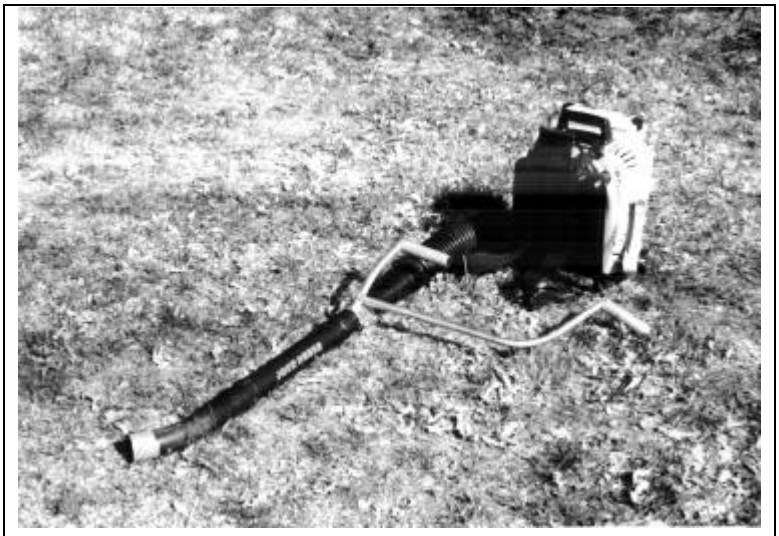

Figure 5 - REC Handlebar prototype with John Deere 5E blower.

[3] REC used the John Deere 5E blower because it was the most used blower by questionnaire respondents. The Echo PB4500 is essentially the same machine.

- Quickly adjust up and down the wand to allow fit for various body sizes and arm lengths.

Appendix drawings show the construction of the handlebars in detail. Users of other models can use this design concept to adapt to other machine models. Use an average size operator to check and measure for comfortable hand positions. Make sure the final design is adjustable for other physiques and meets the four bulleted characteristics above.

The handlebars were tested by the Missouri Department of Conservation in 1992. Two comments made by field testers may be valuable to those interested in making similar devices. For use in areas with heavy brush, removal of the left hand support tube and grip has advantages. This could be accomplished by welding a peg to the right support arm, of a size that the left support tube would tightly fit over. A thumb screw or other such device would be needed to tighten the assembly. Secondly, if a handlebar is used on different blowers with different wand tube diameters, an adjustable attachment sleeve will be needed.

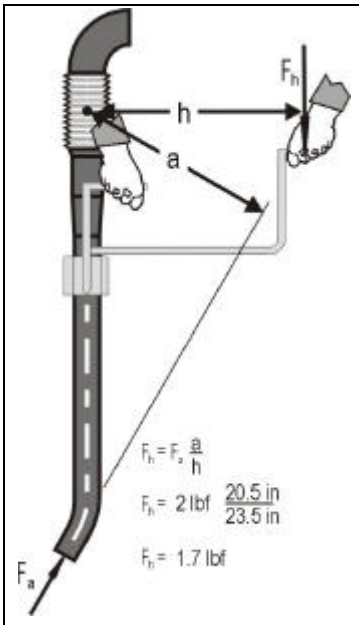

Figure 6 - Forces after handle bar modification.

Some field users have replaced the manufacturer's wand with one they made from PVC pipe. This increases durability that might be necessary under certain conditions. Secondly, the users can design the wand to direct air flow in a manner they prefer. The increased weight of these wands may make handlebars even more desirable.

Safety

Many of the safety items necessary for the operation of power blowers are common in wildfire use. These include gloves, good work boots and hard hats. Additionally, goggles or face shields should be utilized to protect the operator from air borne debris. Hearing protection is necessary for all existing power blowers. Either ear muffs or plugs can be used. Make sure that the device selected reduces the noise to an acceptable level.

In the survey, operators reported problems with fuel leakage from the machines. This resulted from any of three sources: leakage from vented type fuel caps, ruptured or cracked plastic fuel tanks and damaged or unsecured fuel lines. In a situation near the fire ine, the safety concerns are obvious. Users have reduced the problem of fuel leakage in two ways: first, by improving the integrity of the equipment's fuel system and, second, by designing quick methods to release the shoulder straps, removing the blower from the operator.

The need for improving the integrity of the fuel system varies with the numerous models of blowers. Shielding tanks and fuel lines with lightweight guards is one method. Securing fuel lines in additional places with metal clips, so they are less vulnerable to being snagged, is another. Some agencies have replaced the thin plastic fuel lines with materials with tougher covers. Specially vented caps might be found to replace those with simple vents that can spill. In any case, regular inspection of the tank and fuel lines should be done for the operator's safety.

In our experience, the backpack blower can be removed fairly quickly, but this may vary with the operator's physique or the model used. Aircraft type seat belt straps have been used to replace the existing straps on the blowers for a quicker release. Avoid using push-button safety belts;

the chance of accidental release of this type is greater when working in the forest. Operators should practice removal of the leaf blower and be conscious of the "stop, drop and roll" procedure for extinguishing clothing on fire.

For some power blower models, exhaust systems or hot engine parts may be exposed. In these cases, operator's should be careful to prevent burns.

Power blowers add about 25 pounds to the operator. This weight is distributed higher than the operator's center of gravity, changing a person's stability. Since much of the operation of backpack blowers is in rugged or hilly areas, the operators should increase their caution and watch their footing. Having a scout ahead of the blower operator is a good procedure.

Back strain and fatigue were discomforts cited often by operators. Power blowers are excellent tools for improving line production. Regularly rotating the crew members into the blower operator position will reduce fatigue and help production.

Important Power Blower Features

Each agency judges its particular situation when developing specifications for equipment. The amount of use, terrain, types of vegetation litter being removed and budgetary constraints may all contribute in some way to the specifications. The discussions presented here are intended to help guide the specification building process to help agencies get the equipment that will do the job.

All the power blowers currently on the market were designed for landscape use. Modifications may be necessary to make fuel lines, fuel tanks and wands less vulnerable to damage when working in the forest. These needs will best be done after purchase. This section will deal with blower characteristics that should be specified prior to ordering.

Weight: A 20 pound pack on an individual will increase the energy consumed by 10 percent[4]. Look for blowers with a good weight-to-power ratio. Most manufacturers list dry weights. Fuel will add nearly one pound per pint. This adds 2 to 5 pounds of fuel, depending on the model. Modifications such as adding heavier duty PVC pipe wands, quick release latches and guards can add several pounds to the system. User surveys indicate that blowers weighing 25 pounds or less are preferable.

Air Volume and Air Speed: These two items are related. They are the primary measurable data that tells how much work you will get from the machine. Every manufacturer states this data. On the basis of user surveys, the minimum air flow should be no less than 350 CFM, with an air speed no less than 250 FPS. A blower with these flows will be about 18-20 pounds dry weight. The largest backpack blowers are around 750-800 CFM and weigh 20 to 24 pounds dry.

Carburetor and Fuel System: Surveys report that float type carburetors and vented fuel caps often caused fuel leakage. This leakage caused potential safety problems. All position diaphragm carburetors with fuel pumps generally are preferable for fire control, especially since these machines are being used in hilly terrain and near sources of ignition.

Fuel Line Protection: Some makes have protective covers over fuel lines and other fuel system components. This helps prevent rupture of lines from snagging over other incidental damage. Specify that these components are enclosed or expect to make after-purchase modifications to protect these items.

[4] Sharkey, Brian; Research Physiologist: Personal conversation, May 6, 1992.

Mufflers: A covered muffler will help protect the operator from burns.

Conclusions

Power blowers have been shown useful in fireline construction. They can reduce the crew size needed to build line. Their value increases when heavy equipment is not available or cannot be used. While production rates were not measured for this project, the following advantages are apparent:

- Power blowers will remove litter, especially hardwood leaves, with smaller sized crews than typical hand tools alone.

- No hand tools exists that remove leaf litter well in rock crevices. Power blowers can be very effective in these places.

- Power blowers add a measure of mechanization at relatively low cost for hand line type construction.

Like many commercial products, design and model changes of power blowers change frequently. This makes it important to determine the salient features needed for fire control, then look for products that have those features. Fire control use demands greater air speed and flows than for most home owner leaf blowing applications. "Top of the Line" power blowers are generally most practical.

Some safety and operator comfort concerns exist. It is possible for fuel to leak from gas lines, tanks or carburetors. Since power blowers are used near a flame source, precautions must be made. All position carburetors, fuel pumps and fuel tank caps can be specified to reduce this problem. Fuel lines and other parts of the fuel system, vulnerable to damage, can be covered or protected. Operational procedures should be developed to guide the user should the blower or clothing catch on fire. Training of quick removal and "stop, drop and roll" procedures should be conducted. Other members of the crew may need hearing and eye protection as well.

The small two-stroke engines are sensitive and fire control work is more than these machines were designed for. Maintenance will need to be done regularly. Well trained small engine mechanics will be valuable.

Fatigue can be reduced by rotating operators and by utilizing a device such as REC's handbars to improve the operator's control of the wand.

The landscaping type leaf blower is another example of fire control personnel adapting a common product to its special need. Its use is widespread in areas of rugged terrain. With few other mechanized devices for increasing production in that terrain looming on the horizon, we can expect power blower use to increase in the future.

Glossary
(A list of terms used in the publication.)

Arm: Refers to operator's arm, not the wand of the blower.

CFM: Abbreviation for the volume of air flow measured as cubic feet per minute.

Dry Weight: The weight of a power blower excluding fuel, lubricating and other fluids.

Handlebar: A modification added to the blower wand to provide better control of the wand with less operator fatigue.

lbf: Abbreviation of force measured as pounds force in English units.

MPH: Abbreviation for air speed measured in miles per hour.

Nozzle: The air discharge end of the wand.

Power Blower: Term used to represent the variety of leaf, mist or air blowers. In wildfire control these are normally limited to backpack type powered by 2-cycle engines and weighing about 20 pounds dry.

Wand: The plastic (usually) air discharge tube of the blower. Usually consists of several interconnecting sections.

Appendix
Handlebar Drawings

Drawing No. 90-1700C - Handlebar: Leaf Blower.
Drawing No. 90-1701C - Handlebar: Leaf Blower Details.

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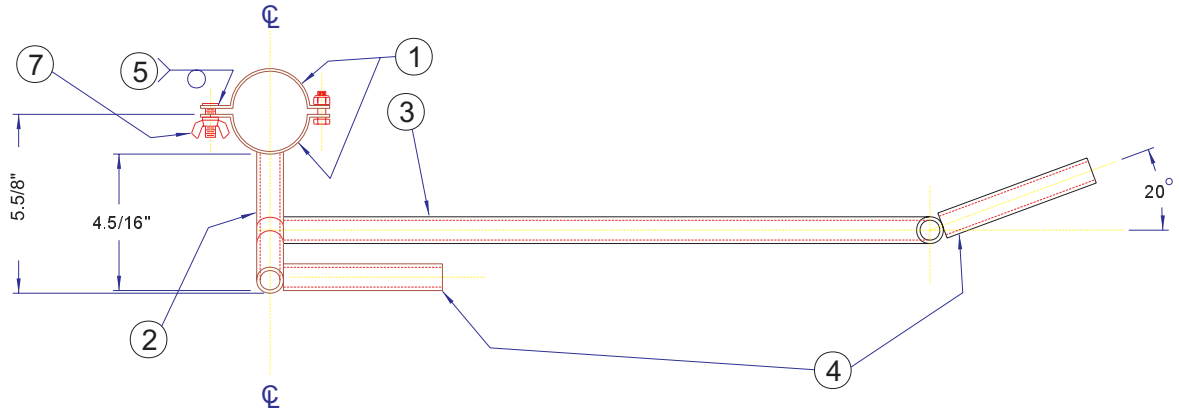
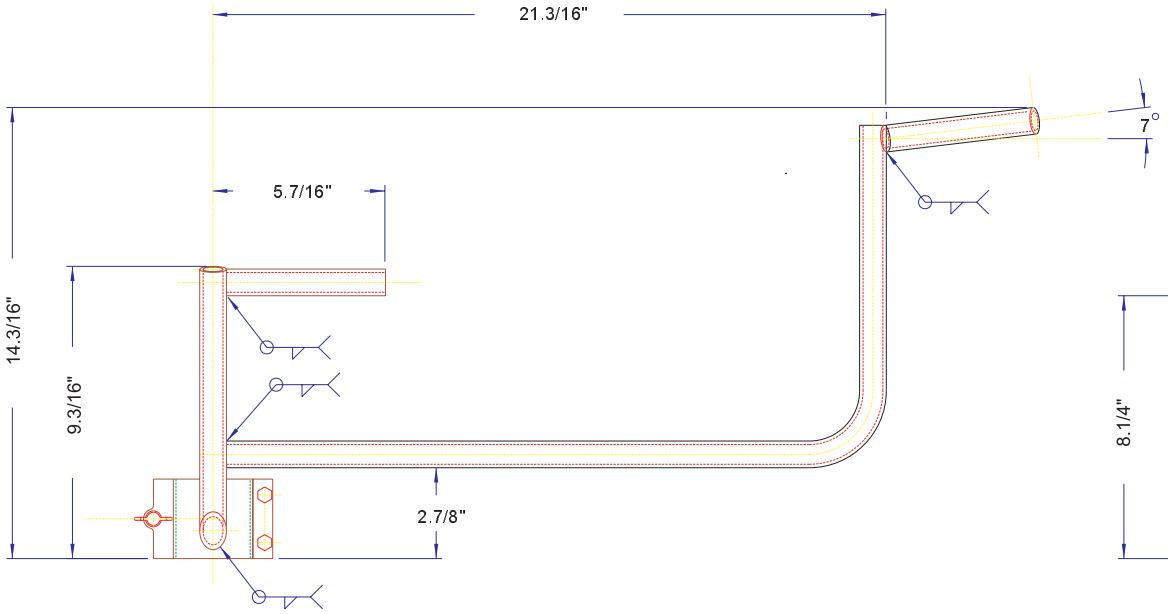
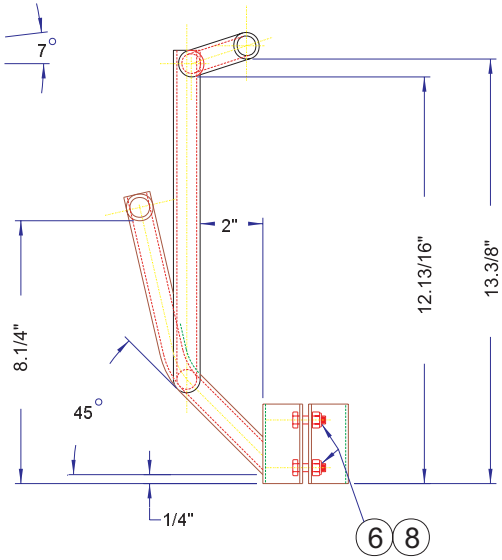


ITEM	DESCRIPTION	QTY	EST WT
1	SLEEVE HALF	2	0.10
2	SUPPORT ARM, RIGHT	1	0.23
3	SUPPORT ARM, LEFT	1	0.72
4	TUBE, HAND GRIP	2	0.12
5	5/16-18 x 1" LONG ALUM SCREW	1	
6	1/4-20 x 7/8" LONG PLATED STL HHCS	2	
7	5/16-18 PLATED STL WING NUT	1	
8	1/4-20 PLATED STL NYLON LOCKNUT	2	
9	* 3/4" ID WATER HOSE - 5" LONG	2	0.17

*WATER HOSE IS USED FOR HAND GRIPS ON ALUMINUM TUBE. FOR CLARITY IT IS NOT SHOWN.

APPROX WGT = 1.8 LBS





SHEET 1 OF 2

HANDLEBAR ASSY FOR ATTACHING TO AIR TUBE OF JOHN DEERE 5E OR ECHO PB4800

NORTHEAST FOREST FIRE SUPERVISORS

ROSCOMMON EQUIPMENT CENTER

FOREST FIRE EXPERIMENT STATION

P.O. BOX 68 ROSCOMMON, MICHIGAN 48653

PROJECT 17

TITLE:	SCALE:	DATE:	DWG NO.
HANDLEBAR; LEAF BLOWER	NTS	5/14/92	90-1700C

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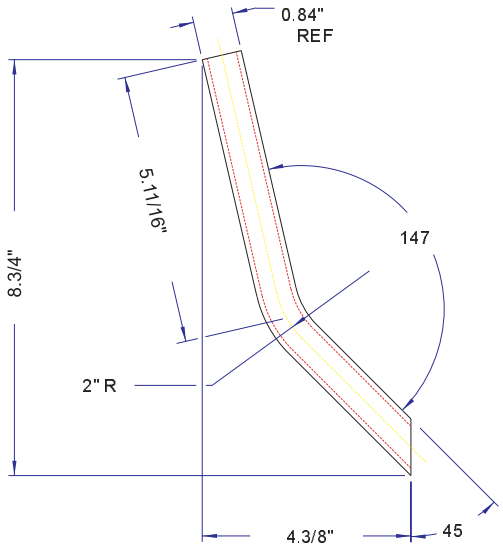
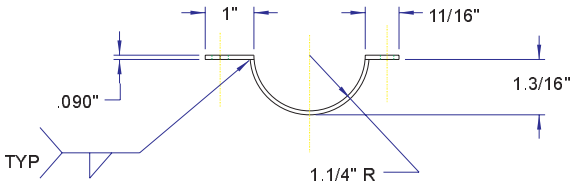


(2) SUPPORT ARM, RIGHT

MAT'L: 1/2" ALUM SCH 40 PIPE
APPROX LENGTH BEFORE BENDING = 9.7/8"
WGT: 0.23 LBS

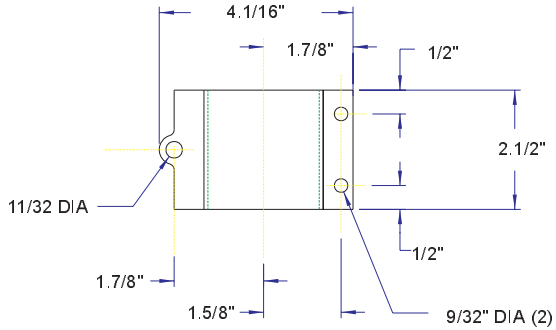
(3) SUPPORT ARM, LEFT

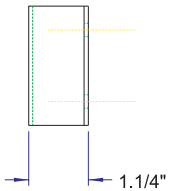
MAT'L: 1/2" ALUM SCH 40 PIPE
APPROX LENGTH BEFORE BENDING = 29.3/16"
BEND 90 20° FROM END
WGT: 0.72 LBS

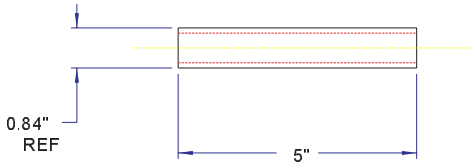


(1) SLEEVE; HALF

MAT'L: 2.1/2 x .083w 6061 ALUM TUBE
.090" 6061 ALUM
WGT: 0.10 LBS







(4) TUBE; HAND GRIP

MAT'L: 1/2" ALUM SCH 40 PIPE
WGT: 0.12 LBS

SHEET 2 OF 2

NORTHEAST FOREST FIRE SUPERVISORS
ROSCOMMON EQUIPMENT CENTER
FOREST FIRE EXPERIMENT STATION
P.O. BOX 68 ROSCOMMON, MICHIGAN 48653

TITLE: HANDLEBAR; LEAF BLOWER DETAILS
SCALE: NTS
DATE: 5/14/92
DWG NO. 90-1701C
PROJECT 17

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