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Improved Ignition Systems

by

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Prelude

Mr. Chairman, fellow panelists, Ladies and Gentlemen - My topic on this panel is new ignition systems. Time does not permit me to discuss every ignition device that has shown on the market. Many very good specialized systems and devices have been adequately documented in the literature. In the limited time available I decided to concentrate on two developments that I am familiar with and that have not been so well documented. Please don't be offended if I fail to mention your favourite system.

Introduction

The ability to provide ignition at the proper time, sequence and place has long been recognized as a prime requirement for successful prescribed burning.

In Prescribed Fire Planning in the Intermountain West, Beaufait 1966, emphasized the importance of ignition devices with the following statement "Proper ignition devices should provide rapid controlled lighting of lines of fire along predetermined routes. The success of the burn frequently depends upon the speed and efficiency of ignition crews". In "A Guide to Broadcast Burning of Logging Slash in British Columbia", Annon. 1969 the stated objective for the ignition phase is to ignite the entire area in one burning period and to complete the burn as rapidly as possible. The need to adjust the pattern and rate of ignition and to maintain flexibility in the ignition pattern is strongly emphasized.

Background

In British Columbia the requirement for improved ignition systems was strongly emphasized in the early 1960's with the use of prescribed fire for post logging treatment in the interior of the province. Larger cut blocks, generally level terrain (requiring more ignition per acre than slopes) and less available manpower emphasized the need for better ignition techniques in order to improve the use of prescribed fire. To respond to this need the PFRC fire research group, established an informal, ongoing surveillance, testing and development study. Similar studies of varying degrees of formality were being conducted by a number of agencies involved with prescribed burning in the U.S. and Canada. Through the course of these quasi-operational trials virtually anything that could carry fire or be ignited was carried, thrown, launched, propelled or flew was tried.

Incendiary bullets fired at strategically located bottles of fuel, the bow and flaming arrow and even the slingshot resulted in some successes but more often embarrassed burners.

Our particular interpretation of ignition needs in British Columbia suggested that cost, safety, and availability largely dictated the users acceptability. From the outset it was obvious that the drip torch was by far the most efficient, safe and versatile direct ignition tool. It was also obvious that devices that deposited burning material were far more efficient than systems that only provided an open flame. If ignited fuel was deposited such as with a drip or drag torch the rate of ignition was influenced primarily by the rate of transport.

With the non-deposition devices such as a fusee or propane torch the ignition rate is further limited by the time required to preheat and ignite the fuels being treated. For this reason we rejected all such devices as being uneconomical for a substained operational prescribed burning program.

Another early conclusion was that users did not want to be involved in fabrication of devices. They were willing to fabricate on a trial basis but would never seem to allow enough time to fabricate for operational use. If a system could not be purchased off the shelf it was generally non-acceptable.

Operational Cost Analysis

A rough estimate of expected operational costs of the various components that together form an ignition system emphasized that improved ignition devices themselves was only part of the answer and that consideration of each aspect of a system was required to isolate and compare the costs of various alternatives.

For the purpose of these estimates capital costs for specialized non-comsumptive equipment such as torches, pumps or dispensers were not considered because of the unknown and variable use that they would experience. We felt that capital costs could best be justified by the user based on their individual needs and expected use. A factor that was unknown to us.

To compare the costs of various systems we estimated the cost of the various components per 1000 ft of ignition line. We thought a cost per length of ignition line was more appropriate than a cost per acre because it considered the variations of ignition requirements due to slope and shape of area. More importantly the planning phase of prescribed burning and resulting crew allocation is based on the total length of ignition line required and time constraints rather than the number of acres.

We considered an ignition system to consist of at least three components that could be assigned a cost on a use basis.

The ignition device or material - is the material or chemicals that either ignites or is ignited by the dispenser. The device or material including its containers is the direct cause of flame transfer to the fuel complex. I.e. liquid hydrocarbons, grenades, contained chemicals.

The dispenser - is the specialized equipment required to meter and or charge the ignition device or to cause ignition in the case of free flowing liquids. The dispenser is part of or carried by the transporter. I.e. torches, dispersing charges, AID dispensers.

The transporter - is the means by which the other ignition system components are located to achieve the desired ignition pattern. I.e. personnel on foot, all terrain vehicles, aircraft, or launch systems.

The component cost of obtaining a 1000 ft of line fire by a variety of techniques are shown in Table 1.

Development of Flying Drip Torch

We recognized that superheated droplets of diesel or other liquid hydrocarbon was the most economical ignition material. The dispenser or drip torch was a simple tool. On small accessible areas a man could provide adequate transport to achieve an efficient ignition system. However, on large areas, the slow rate of manual transport required large, highly organized crews which in most cases did not satisfy considerations of safety, time constraints, and overall fire behaviour observation. The problem was one of transportation.

The helicopter was the obvious answer especially after our cost estimates showed that at 20 miles per hour a G47B helicopter could be moved 1000 ft for 1.42 whereas a man at 1 mile per hour would cost 1.13[1/].

[1/] Helicopter and crewperson cost based on $150.00 and $6.00/hour, respectively.

TABLE 1. Cost estimates for ignition system components, $/1000 feet of ignition line.

IGNITION DEVICE OR MATERIAL type	unit cost $	rate of use per + 1000 ft	container number and cost	total cost /1000 ft of line
Hydro Carbons				
Liquid, Gas-Diesel	.60/gallon	0.5 gallons	Free flowing	.30
		1.0 "	"	.60
		2.0 "	"	1.20
Jellied Gas	.61/gallon	1.0 "	10@.15=1.50	2.11
Solid, Fire Starter	.09/cube	20 cubes	Fuse 1.20 (40'@.03/ft.)	3.00
Chemical Devices				
D.A.I.D.	.18 each	10 units	Self contained	1.80
Grenades	3.00 "	5 "	Included	15.00
$KmNo_4$-Glycol	.07 "	15 "	Included	1.05
or	.02 "	15 "	15@.02=.30	.60
DISPENSING EQUIPMENT				
Hand Drip Torch	60.00 each			
Flying Drip Torch	800.00 +			
AID Dispensers	1500.00 est.	100,000 units		.22
Electrical Wire	10.00/1000'	1,200 ft.		18.00
Caps	65.00/100	10 units		
Fuse - B Line	46.00/1000'	1,200 ft.		55.20
TRANSPORT METHOD				
Person on Foot	6.00/hr	1 mile/hour		1.13
ATV	20.00/hr	4 miles/hour		.95
Helicopter				
47G3	150.00/hr	15 miles/hour		1.88
		40 " / "		.71
		60 " / "		.47
206	300.00/hr	15 " / "		3.77
		40 " / "		1.41
		60 " / "		.94
Launch Systems	4.00/shell	5 units/1000		20.00

Consolidation of the entire ignition task into a moving space platform that provided complete surveillance of fire behaviour, the extreme flexibility of ignition patterns, the ability to manipulate fire behaviour and oversee control needs seemed a bargain for the extra $.29 per 1000 feet.

We determined that an ordinary drip torch could drop fire from a height of at least 40 feet, (determined from the roof of our laboratory building). From our experiences with drip torches from moving vehicles we knew favourable burning characteristics at the torch could be maintained at least up to an air speed of 10 miles per hour. We thought we could maintain flame characteristics at higher air speeds and provide protection from rotor wash with protective coverings at the torch.

In the summer of 1973, after advancing the concept of a flying drip torch to a number of skeptical users, Northwood Pulp and Paper in Prince George provided the staff of their Service Centre to construct a prototype. After a few embarrassing demonstrations we achieved a protective shroud for the torch that allowed constant combustion at the torch with enough super-heated fuel remaining to carry fire to the ground. The prototype flying drip torch is very similiar to a hand torch consisting of an angle iron frame which supports a ten gallon fuel drum, vented and secured by shock cords. Fuel is conducted from the drum via a one way flapper valve, a manual valve, a quick couple into 1/4 inch black iron pipe with flash back hoop. Upon entering the hooded torch the fuel conductor is "U" shaped to provide a heating coil for the fuel with the exit at the top of the shrouded torch. A conventional asbestos pad provides a combustion area. The orginal torch also had a solenoid valve to shut off the fuel flow however this was discarded because of power cord breakage when the torch twisted. The torch is suspended approximately

20 feet below the helicopter by fore and aft lines to a ring which are secured to the helicopter. The prototype drip torch was first operationally demonstrated on a 200 acre slash burn on the Summit Lake District in 1973. Subsequent to this Northwood, using Northern Mountain Helicopters burned approximately 2200 acres with a record performance of 30 minutes to prescribe burn a 250 acre block for a direct ignition cost of about .35 per acre.

Briefly the mode of operation was to select a landing at the edge of each area to be burned where the control crew and ground support crew with extra helicopter and drip torch fuel could rendevous with the helicopter. The torch was ignited on the landing and vertically lifted in excess of 200 feet so that burning fuel would be extinguished in the air. The aircraft would then fly to the start of the ignition pattern and descend to operational elevation. The procedure was reversed to return to the landing. If additional drip torch fuel was required the quick connections and shock cord tie-downs required only a few minutes to replace the empty fuel drum. Normally the torch would be flown from 15-20 feet above the slash at an air speed between 15 and 20 knots. A 50-50 percent gas-diesel fuel mix provided the best performance from this torch. The greatest operational problem was to maintain the torch in a steady flight attitudes, oscillations and twisting tender to disrupt the fuel flow or cause complete combustion of fuel within the burning chamber.

The performance of the flying drip torch was to encouraging that two additional models were constructed by the Prince George and Kamloops forest districts in the fall of 1973. Although little operational use was made of these units they allowed further non-operational trials. A co-operative development project was initiated by John Young of the B.C. Forest Service, Prince George and Okanagan helicopters in the fall of 1973. This program resulted in a larger torch with a fuel capacity of 45 gallons remote fuel flow control using a motorized gate valve and electrical ignition system for in-flight ignition. The most important contribution however was the design of a slinging arrangement that provided in-flight stability to the torch. This consisted of a "hockey stick" shaped pipe that acted as a spreader on the two supervisor cables and locked into the wheel well of the skid pool. This design held the torch at right angles to the helicopter to provide better torch visibility from either side of the helicopter and prevented twisting. The increased fuel flow allows use of a 40% gas to 60% diesel fuel mix and an increased operational altitude. Torches of this design, requiring a Bell 206 or equivalent helicopter were used extensively through the province in the 1974 and 1975 prescribed burn programs. There are presently at least 15 flying drip torches throughout British Columbia most of which are owned by Okanagan helicopters, the remainder owned by the Forest Service, other helicopter charterers and Forest operators. Working drawings are contained in the final report by Fielder 1975, available from Protection Division, B.C. Forest Service, Victoria, B.C., V8V 1X5.

Through the development and use of this new ignition tool we learned some valuable lessons, the most important being:

(1) Efficient use of the drip torch required good planning and ground support to provide extra fuel for both the torch and the helicopter.

(2) Aerial ignition should be planned to include as large an acreage as possible in the same trip to write off ferry time - either on single large blocks or a number of small blocks.

(3) The person in charge of the burn or their delegate must accompany the pilot to operate the torch controls. This removes the responsibility for the ignition pattern from the pilot and allows him to concentrate wholly on the flying. The torch operator can provide instructions via the intercom on course changes, altitude, air speed and general torch performance while maintaining communication with the control crew.

(4) Extreme care must be exercised on perimeters, to avoid rotor wash from scattering fire across the line and also to avoid inadvertent ignition by the torch.

(5) Critical perimeters such as top edge should be ignited by hand drip torches to ensure a good downslope burn. It is virtually impossible to make a second pass along the perimeter without blowing fire across the line.

(6) Small modifications are necessary to allow the torch operator to estimate the amount of fuel remaining so he can plan his ignition pattern in phase with refueling requirements. Either a fuel gage or a selsyn system on the motorized gate valve would provide this refinement.

<u>Development of the AID system.</u>

The flying drip torch adequately provided an aerial ignition system for line firing on clear cut areas or areas not obstructed by trees. Interception and shattering of the superheated droplets and the additional altitude required to clear tree tops did not allow effective use of the drip torch in tall, dense forest canopies. It would not be particularly desirable for ignition to occur in the crowns if the objective was to underburn.

There was a clear need for an aerial system suitable for prescribed fire treatment under forest stands. Variable spacing of point source ignitions were required to manipulate fire intensity to satisfy a variety of land management of objectives through the use of underburning. In addition to the increased future requirements of prescribed under burning the potential for aerial ignition systems for wildfire management had already been demonstrated by Hodgson and Cheney, 1970 in Australia and by Lait and Taylor, 1972 in the Yukon. Alaskan use of a military air to ground system has also been documented by Ramberg, 1974. The immediate need for an aerial ignition system for use under a canopy was expressed through a request to provide ignition capability for aspen eradication burns in the Peace River area of B.C. All indications including our component cost analysis suggested the Australian technique described by Baxter Parkham and Peet, 1966 and Packham and Peet, 1967 of injecting a container of potassium permangate with ethyl glycol offered most advantages. The size constraints of the particular job and anticipated future use suggested a helicopter rather than a fixed wing operation. The weak point for our application was the dispersing component of the ignition system. Neither the hand powered and hand loaded prototype constructed at the Northern Forest Research Centre nor the Australian hand loaded but motorized dispensers satisfied our needs. We instinctivly felt that an automated feed system was required so that the operator could sustain a long term operation and also achieve a high rate of dispensing for future back firing application.

Our first model, designed to meet the immediate need utilized a pressurized glycol reservoir accessed by way of a solenoid valve which was energized when the hollow needle penetrated the top of a styrene vial containing potassium permangate. The vials were contained in a 100 vial capacity magazine and gravity fed into the dispenser, charged and allowed to drop through the tube.

The second unit incorporated a centrifugal pump to force glycol through the needle on valve opening and provided for a slightly faster drop rate of 1.5 devices per second. At about this time Roy Kruiger of the Alberta Forest Service Equipment Development section became interested and after consultation with the staff at PFRC turned their attention to designing an automatic feed system. It was not long before the idea of using a spherical container for the permangate rather than a cylindrical vial was proposed. This obvious solution to the problem of a hopper feed system turned us all green with envy. The Alberta people then initiated development of a gravity feed system supplied single spheres to a rotating arm which caused them to be impinged on a hinged needle, injected and then ejected from the unit. This dispenser is hung from the hook of a helicopter and is self contained. It has been operationally tested in Alberta. I regret I don't have slides of the unit however the modified feed system on our third unit illustrates the general principle.

In the meantime we had designed a prototype dispenser utilizing a hopper feed system for spherical containers. Basically this dispenser consisted of four metal slippers moving back and forth in a horizontal plane through an eccentric drive. As each slipper moved forward an internal cavity was aligned with an opening, allowing a sphere to fall into the cavity. As the slipper continued to move forward the captive sphere is impringed on a stationary needle and a mechanical valve opened to allow glycol flow. The slipper then reverses direction carrying the captive sphere past the point of pickup to the rear extremety of travel where the sphere exits through an aperature in a lower plate. The spheres are stored in a rotating hopper above the machine and fed through chutes to the slipper assembly.

The hopper has a capacity of about 400 - 1¼ inch diameter spheres and is easily refilled from auxillary containers in the helicopter. The previous models were mounted externally on the skid of the helicopter whereas this model sits on the floor of a Bell 206 but will adopt to other machines. It can be used from either rear door, which must be removed, and is powered directly from the aircraft supply. It has a gravity fed fire extinguishing system and is secured in the aircraft by an external belly band and by the seat belts. The top loading assembly is quickly detachable in the event of feed problems which occurrs occassionally with a fractured sphere. A softer but stronger styrene will be used to reduce the frequency of fracturing. Maximum dispersal rate is 4 spheres per second with a maximum aircraft speed of 60 knots and an elevation of 200 feet. The 50-50 glycol-water solution allows approximately 24 seconds before ignition.

The important aspect of this development is the entire system can be purchased. Five production models of the dispenser have been manufactured by a local machinist[1/]. Three of these units were constructed under contract two for the Yukon Forest Service and one for the Ontario Ministry Natural Resources.

The 1¼ inch styrene spheres either in the half shell for user charging or in the charged and sealed mode are produced by a Victoria Company 2/ . The charged and sealed spheres have been designated as AID

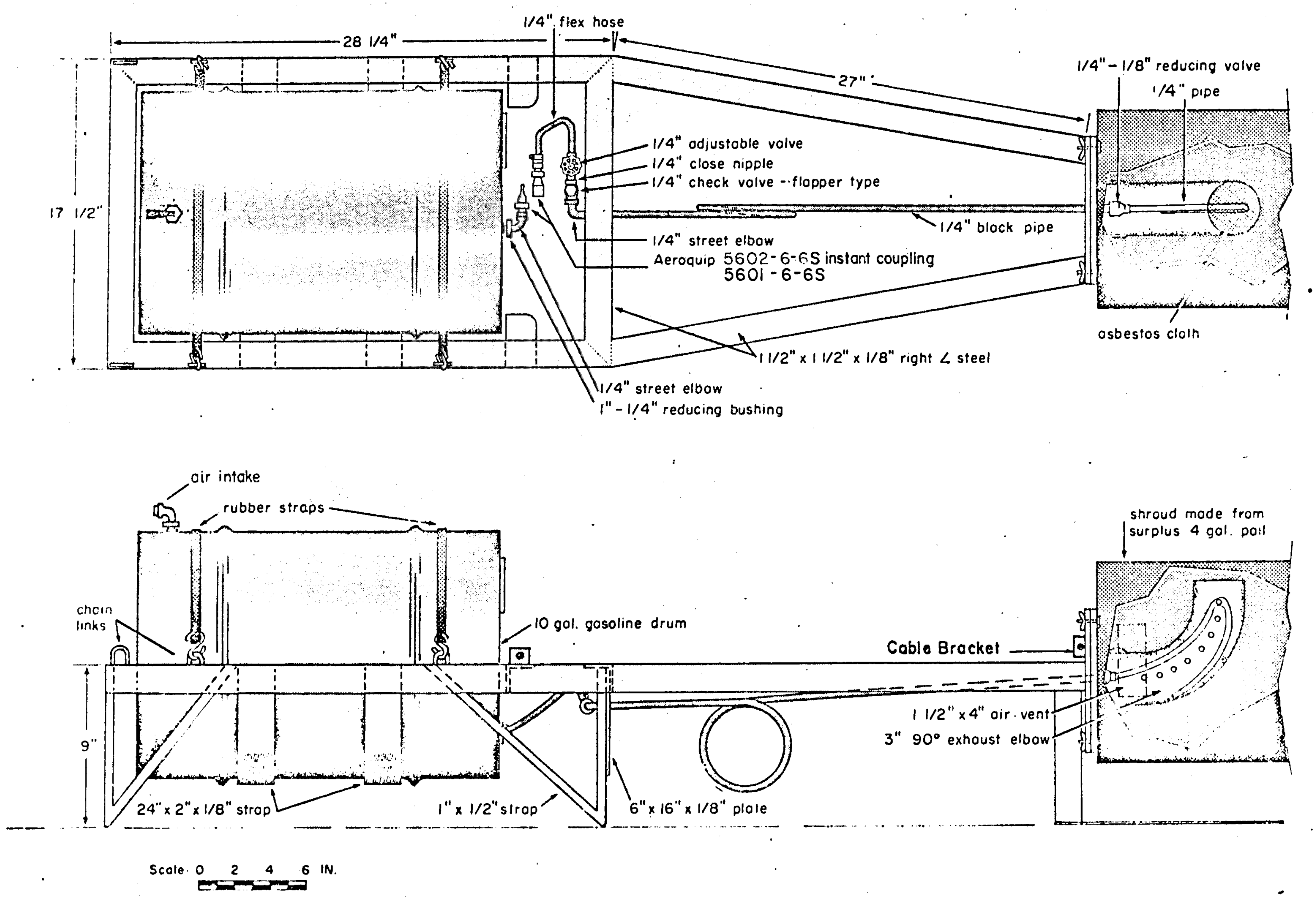
1/ Quentin C. Wilson, Fulford Harbour, B.C.

2/ Premo Plastics Engineering, 863 Viewfield Rd., Victoria, B.C.

standing for Aerial Ignition Device.

Conclusion

Well people as you've probably detected, I'm rather biased, however I'm personally satisfied that the problem of ignition has ceased to exist. As long as fuel costs don't price us out of use, the conventional drip torch, the flying drip torch and the AID systems should satisfy the majority of prescribed and wildfire management ignition requirements.



1/4" flex hose
28 1/4"
27"
17 1/2"
1/4" - 1/8" reducing valve
1/4" pipe
1/4" adjustable valve
1/4" close nipple
1/4" check valve -- flapper type
1/4" black pipe
1/4" street elbow
Aeroquip 5602-6-6S instant coupling
5601-6-6S
asbestos cloth
1 1/2" x 1 1/2" x 1/8" right ∠ steel
1/4" street elbow
1" - 1/4" reducing bushing
air intake
rubber straps
shroud made from
surplus 4 gal. pail
chain
links
10 gal. gasoline drum
Cable Bracket
1 1/2" x 4" air vent
3" 90° exhaust elbow
9"
24" x 2" x 1/8" strap
1" x 1/2" strap
6" x 16" x 1/8" plate
Scale 0 2 4 6 IN.