

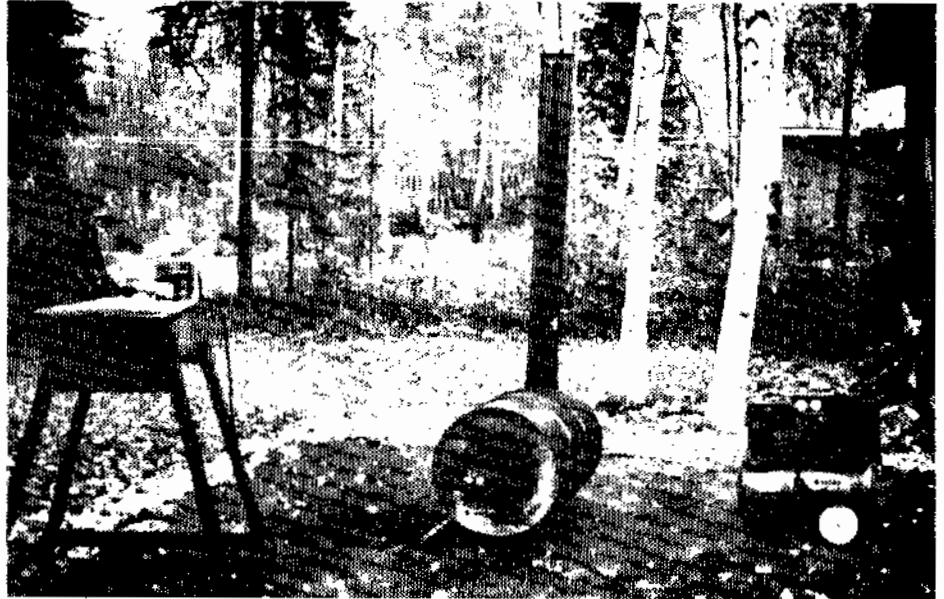
Small-Scale Waste Oil Incinerators

INTRODUCTION

Waste oil poses a significant environmental problem in rural Alaska. Careful management of the fragile environment is difficult without adequate means to dispose of waste oil from crankcases of vehicles, generators and other machinery. Commercially available incinerators do not meet the requirements for bush application, where a waste-oil incinerator capable of being transported in small aircraft is needed. The U.S. Environmental Protection Agency agreed that the problem needed investigation, and the work reported here was performed for their contract order (# B1376NTSA).

This article details the design and operation of two waste oil incinerators. One unit is capable of burning up to 1.0 gallon/hour and the other may burn up to 10 gal/hr of waste oil products. The small burner is designed to be used for space heating of residential or workshop areas, whereas the larger burner can be used at a collection center as an incinerator to dispose of large quantities of waste oil.

The incinerators discussed in this report may serve as an approved means of disposing of waste oil at its source. The burners are designed for easy air transport, being constructed of lightweight materials and made for easy assembly. Both units utilize common materials available throughout Alaska and have been designed for a reasonably safe



Burner # 1 operating in a barrel stove.

and simple operation. Neither unit should be left to operate unattended, due to the varying characteristics of the fuel and to their simple fuel handling systems. Routine attention will be required during operation.

The waste oil used to test both burners was collected from various sources in Fairbanks. It is a mixture of all known types; more than half of it was used vehicle motor oil, about a third machinery lubricants, and the remainder aircraft lube oils, solvents, and automotive rear-end grease and transmission fluids. Approximate grade of the mixture was between an SAE 20 and SAE 30 weight for viscosity and flow characteristics.

BURNER # 1

This unit operates on gravity-fed waste oil from an elevated supply tank.

The burner is installed on a barrel stove made from a standard 55-gallon steel drum. The unit's oil nozzle uses compressed air to atomize the dense waste oil for combustion. The amount of fuel burned depends on the air pressure at the nozzle, which can be adjusted by a regulator mounted at the rear of the burner. A fuel control valve tunes the oil flow for a proper flame pattern at the nozzle. Approximate total cost of the unit is \$515 (Fairbanks, Alaska 1980).

A very small amount of compressed air is required to operate the burner, ranging between 0.1 and 0.3 standard cubic feet per minute (scfm). Any small portable shop compressor with a storage tank can easily provide this amount. A typical 1/2 horsepower compressor with a tank capable of 1.5 scfm at 40 pounds per square inch pressure (100 psi max),

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consuming 800 watts of 110-volt AC, is adequate. The unit's storage tank allows it to cycle efficiently and maintain continuous operation without overheating the compressor head.

The burner is started using a standard propane bottle torch, which the operator aims into the side air ports of the burner flame chamber. With the torch lit, the air pressure to the burner nozzle is adjusted to 30-40 psi and the oil control valve slowly opened until ignition occurs. The oil control valve must be adjusted so sufficient oil is supplied to the nozzle to keep a steady flame. Too much oil will cause the burner to smoke and the used oil will also drip from the end of the nozzle instead of being entirely vaporized. Once a steady flame is achieved, the burner will continue to ignite the waste oil without the propane torch.

The manufacturer's instructions state that any suitable tank or barrel may be used for an oil supply tank. The tank may be located outside the building with a pipe of at least one-inch diameter leading into the filter inside the building. The outlet of the tank must be raised sufficiently above the burner to give the needed head pressure (gravity feed).

If the ambient temperature is below freezing or if high viscosity oil is being

used, the oil supply line just in front of the manual oil control valve should be heated for approximately one minute. If the temperature is extremely cold or if extra-high viscosity oil is to be burned, an insulated storage tank is needed and more preheating may be required.

As the oil heats up in the supply line, it will flow faster and the oil flow valve should be closed enough to obtain a bright and steady flame. Once the stove reaches its operating temperature, this oil flow setting should remain fairly constant.

When the stove reaches its operating temperature, the air pressure should be reduced to about 10 to 20 pounds or less and the draft control closed. This causes more suction through the burner can. The more draft or suction, the less air pressure needed. But the stove must be hot before the draft is completely closed or this suction will pull the flame down out of the burner can and extinguish it.

The air pressure regulator should always be set for the amount of heat desired. If more heat is desired, more air pressure will be required to give a smooth, even spray pattern. If too little air pressure is used, the oil will not be broken up well enough, the resulting flame will be

rich, and there may be carbon buildup in the burner can. If too much air pressure is used for a given flow setting, the flame will tend to surge and may go out. This burner is designed to work well on from 5 to 50 psi air pressure, depending on the size of flame desired.

Following the manufacturer's instructions for barrel-burner assembly did not produce satisfactory performance, and alterations were made accordingly. The burner was mounted onto the barrel stove door, which positions it near the barrel's center. Firebrick also lines the bottom of the barrel to radiate heat upward into the flame and help atomize the oil spray for improved combustion. Also, an adjustable air intake on the stove door has been modified to introduce preheated over-fire air at the outlet of the burner to provide additional combustion air and turbulence at the higher burning rates. These changes improve combustion efficiency and reduce smoke conditions over the burner's full range of operation.

Tests were run on the new stove design to verify actual combustion performance, using a Dwyer Model 1100 Portable Combustion Analyzer; results are summarized in Table I. The stove is capable of burning between 0.3 and 0.9 gal/hr of waste oil

TABLE I

Burner # 1 Combustion Data

Nozzle Air - psi	Oil Use gal/hr	(-.05" W.G. [†] Draft at Stack)			Burner Efficiency	Over-fire Damper Position	Net Heat Output - BTU/hr
		*Smoke #	%CO ₂	Temp. (°F)			
20	0.33	1	6	660	64%	¼ open	29,570
30	0.48	1	6.5	700	65%	½ open	43,680
40	0.65	2	8	770	66%	¾ open	60,060
50	0.73	2	10	850	68%	¾ open	69,496
60	0.82	3	12	900	68%	full open	78,064
70	0.92	4	13	940	69%	full open	90,800

* The smoke number is assessed on the Bachrach scale of 1 to 10, wherein a standardized test produces at 1 a barely perceptible trace on filter paper, at 10 an opaque black smear. A smoke number of 6 is the maximum permitted for a gravity-feed space heater.

† W.G. = "Water Gauge", in reference to a standard scale (related to water movement in a device partially evacuated by the draft to be measured).

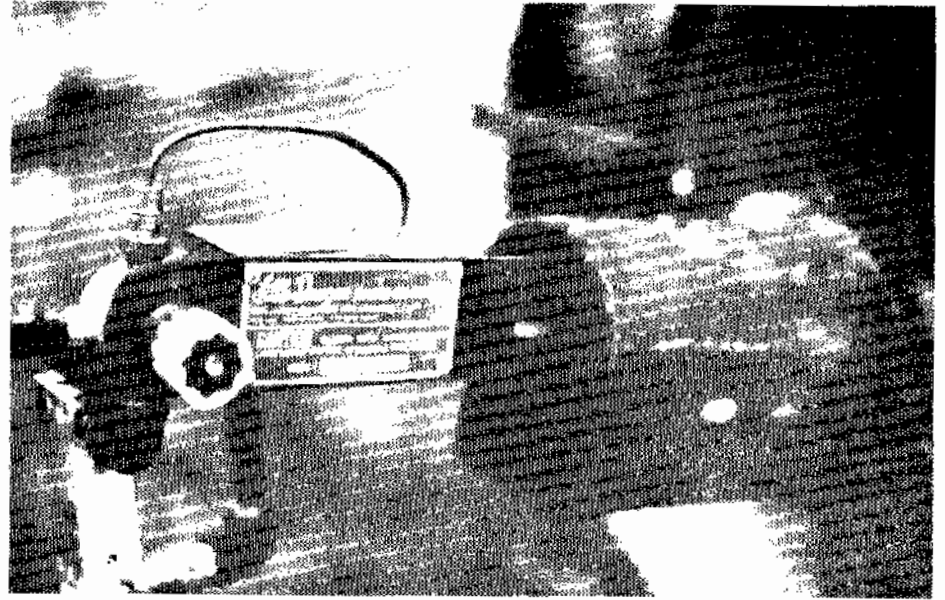
efficiently with no visible smoke emissions. Operation showed CO₂ levels between 6% and 13% at the stack, indicating good fuel air mixing at a minimum excess air ratio of 30%. Burner heating efficiencies range from 64% up, as measured by a Dwyer test kit monograph, which is nearly equivalent to a conventional residential fuel oil fired furnace.

In Fairbanks, Alaska, an average home requires about 30 BTU of heating per square foot (ft²) of floor space to meet the winter's maximum heating demand (-50°F outside and maintaining +70°F inside). Burner # 1 could satisfy the heating requirements of a 3000 ft² home or easily provide supplemental heating in small buildings such as workshops.

The burner should not be operated unattended primarily because of the fouling characteristic of used oils. If the flame goes out, the burner nozzle continues to spray oil into the barrel. This is a hazardous condition which could result in an explosion, should the accumulated oil re-ignite. So the final stove design calls for a flame detector and automatic oil shutoff valve system to be installed for protection. These systems are common to all approved fuel-oil fired furnaces. Parts used for this safety system cost approximately \$125 (Fairbanks, Alaska 1980). The system supervises the burner's operation and will prevent flooding of the combustion chamber if the flame goes out. With the system installed, the burner is operated as follows:

Startup Procedure

- 1) The lighted torch is placed near the burner as before, air and oil adjusted as normal and flame detector reset button pushed to open oil shutoff valve.
- 2) The oil shutoff valve will remain open for about 45 seconds or stay open once the detector senses flame at the burner.
- 3) As long as flame is present, the detector will keep the fuel oil shutoff valve energized and open.
- 4) If the flame goes out, the detector will de-energize the fuel oil solenoid valve within 45 seconds and oil will stop flowing to the nozzle.
- 5) The controller limit switch must be reset manually to reopen the fuel oil solenoid valve.



Close-up view of Burner # 1.

The flame detector is mounted onto the barrel so it can detect the light of the burner's flame. The controller reset allows the stove sufficient time after flameout to vent the hot gases inside the barrel before re-ignition. This detection system is recommended for all installations, since waste oil is variable in viscosity and tends to foul control valves and cause flameouts. It was noted during performance tests that oil flow to the nozzle always declined over a period of time, even with the air pressure constant at the nozzle. This required the control valve to be adjusted periodically to avoid flameouts. Apparently, the small foreign particles in the used oil were bridging at the control valve seat and restricting the gravity-fed oil supply. For this reason, the oil line should be run through a felt-type oil filter to trap most of these contaminants and improve the burner's reliability.

BURNER # 2

This unit has been designed to dispose of large quantities of waste oil (up to 10 gal/hr) with little effort made to utilize the fuel's heat release. The incinerator is composed of standard 55-gallon steel drums mounted vertically to form a smokestack. The bottom two barrels are lined with an insulating castable refractory, forming the unit's com-

bustion chamber. The barrels are separate and stackable using guides that are brazed along the barrel bottom rim to keep the rims aligned and the stack straight. If the incinerator does not need to be portable, the barrels can be permanently joined. The burner is installed at the bottom side of the first barrel through a 6" diameter air intake port. The burner is constructed from a standard model used on any residential oil-fired furnace (typical fuel range of 1-2 gal/hr). However, its fuel nozzle is replaced with a "Sonic Nozzle" designed to atomize waste oil. Approximate cost of materials is \$1025 (Fairbanks, Alaska 1980).

Operation

This burner operates similar to a standard fuel oil burner; it has an electric squirrel cage fan and high-pressure oil pump for combustion, using a high voltage transformer and spaced igniters at the nozzle. The main difference is that its nozzle uses air pressure at the tip to atomize the heavier used oils to a fine mist that can be ignited by the arc from the burner's igniters.

The size of the stack and air intake areas are designed to provide sufficient draft and over-fire air mixing or turbulence to promote complete combustion and acceptable limits to visible emissions. The bottom barrel has a smoke collar at its top, which reduces the inside outlet to

a 19" diameter. This 2"-wide ring aids combustion by stabilizing air flow at ignition and helps to funnel the exhaust gases toward the center of the stack as they travel upward. The ring compresses the gases to increase velocity and turbulence at the location where over-fire air is injected. Four over-fire air ports (2" x 5") are spaced equally around the bottom edge of the second barrel, just above the smoke collar. As the burner increases its fuel burning rate, the incinerator's stack temperature goes up and the resulting draft increases. This draft differential pressure naturally encourages primary and over-fire air into the gas stream.

Initial testing of the burner showed that additional primary air was needed at the burner inlet for complete combustion at 10 gal/hr, so the burner was shifted outward to allow more air to enter around the burner throat. The best position is with the burner throat end flush with the barrel's side. A small residential burn-

Burner # 2 set up for use.

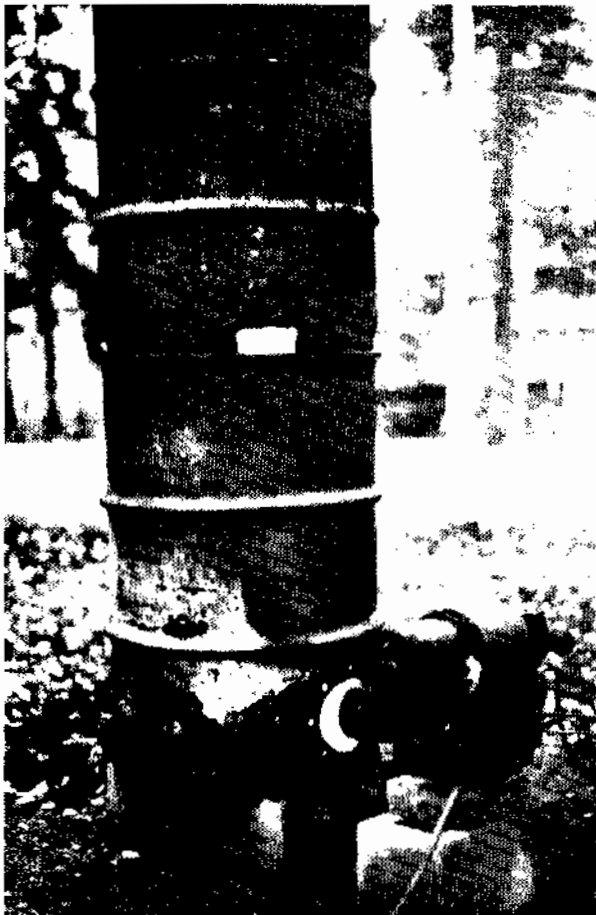


TABLE II
Burner # 2 Combustion Data

Nozzle Air	Pressure Oil	Oil Use gal/hr	Stack Conditions (at -.15" W.G. Draft) Smoke #	%CO ₂
25	4	2.0	0	3
25	5	4.0	1	6
25	8	8.0	2	12
40	10	6.0	2	10
40	12	8.0	2	11
40	16	10.0	3	12
40	18	12.0	5	13

er is not designed to provide sufficient air from its fan to burn 10 gal/hr.

The inlet fuel filter was not adequate for the 10 gal/hr continuous flow; the filter was increased in size to a General model # 2A-200A, which is similar in construction but rated over 30 gal/hr for # 2 fuel oil. With this filter, the pump could deliver the 10 gal/hr flow rate under pressure.

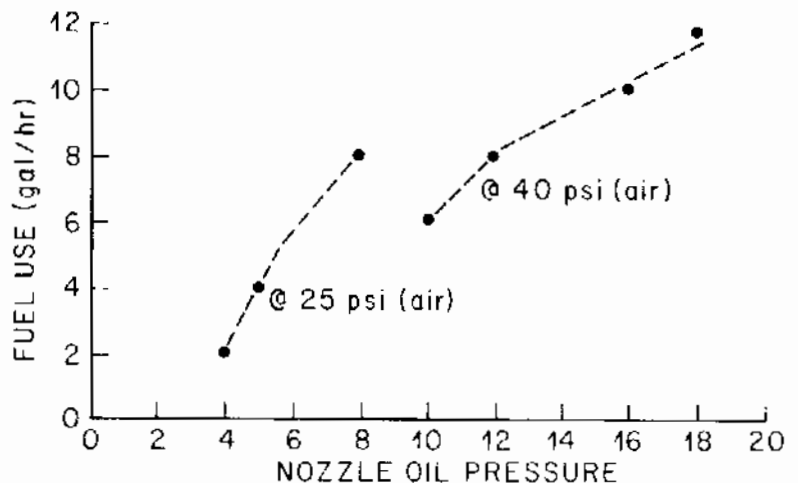
Table II gives the final test results on the incinerator. The air pressure to the nozzle changes the burner's range of operation. It needs at least 20 psi to atomize the oil effectively and 40 psi to attain 10 gal/hr at good combustion. A disadvantage is that the oil supply

must be at least 50°F to atomize properly; colder oil will not ignite with the electric arc in the burner.

The accompanying graph shows the incinerator's oil burning rate vs. nozzle pressure. The flames begin entering the second barrel when it is fired over 6 gal/hr. Smoke conditions never exceed 20% opacity; the present Alaska standard for commercial incinerators is 30%. Inside stack temperatures exceed 1000°F, which require the barrels to be lined with the castable refractory to protect the barrel metal from overheating and also to reduce radiant heating near the burner. Otherwise the barrel life will be marginal and the burner motor will operate at overload temperatures and fail quickly.

The burner can also operate outside the incinerator combustion chamber. The flame is stable and will maintain ignition

Fuel use curve of Burner # 2.



without the firebrick or draft from a combustion chamber, so it would be suitable as an ignition source for a commercial refuse incinerator in remote Alaskan communities, where approved land fills are not available.

Burner # 2's ability of self-ignition of the waste oil is a real advantage over Burner # 1. It can be set up for intermittent service to satisfy a temperature demand or control device, such as in a commercial refuse incinerator. Standard flame detector systems on the burner provide adequate safety for flameouts; however, with constant ignition from the electric igniters, the possibility of a flameout is remote compared to Burner # 1's operation. In summary, Burner # 2 can provide a safe and simple means for disposing of waste oil at its source quickly and effectively. The unit is designed for quick setup and minimal maintenance, using parts that are easily obtainable in Alaska and are familiar to anyone who has worked with standard fuel oil-fired furnaces.

BEYOND DISPOSAL

In Europe, waste oil has been utilized as a reliable source of heat, both residentially and commercially, for the past ten years. Some countries have nation-wide waste oil distribution systems and a full range of furnaces available to burn waste oil safely. The results of my experiments prove how simple and easy waste oil is to burn. It is a resource which should be more studied — and more used.

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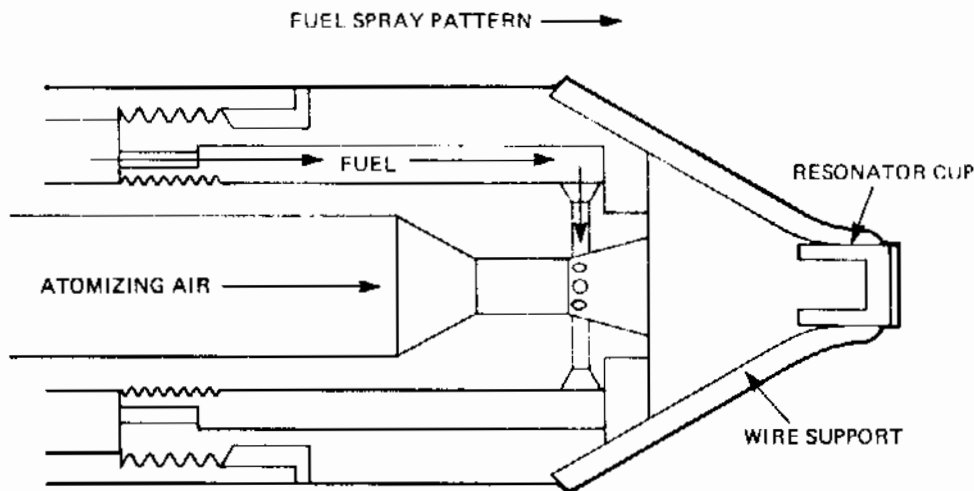
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Author Abegg is willing to help readers with the details of waste oil burners to the extent his experiments have given him information. We will forward to him correspondence received here in our office. ♦



Burner # 2 in operation. Notice absence of smoke at top of burner.



Interior view of "Sonic Nozzle": Resonator cup forms a shock wave that breaks up the fuel entering.