# PERFORATED CYLINDRICAL GAS BURNERS FOR A NATURAL DRAFT, TOP-LIT UPDRAFT GASIFIER

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## SYNOPSIS

This informal brochure describes three attempts to introduce secondary air to burn gas produced from natural draft, top-lit updraft (ND-TLUD) gasifiers burning wood pellets. The overall hypothesis was that if secondary air is continually available up the height of a gas burner, then the burner will provide the gas flame with sufficient secondary air over a range of gasification rates. Three model burners were tested: (1) a simple perforated cylinder, (2) a perforated cylinder with a central gas wick, and (3) the burner from a commercial Kero-Sun Radiant 10 space heater.

Using a burner made from a simple perforated cylinder, a gas flame was supported from low and high gasification rates. However, as gasification rate increased, a tall yellow flame formed up the central axis of the cylinder, suggesting that any secondary air entering from the side walls of the burner was not efficiently mixing into the flame.

The second test added a gas wick up the center of a perforated cylinder to force the flame closer to the secondary air holes. The burner produced smoke at high gasification rates.

The third test using the burner from a Kero-Sun Radiant had produced gas rising in the annular space between two perforated cylinders. This burner appeared to burn very cleanly at low gasification rates, but could be overwhelmed moderate gasification rates, producing a great deal of soot.

In general, the results from these tests found the perforated burners were not satisfactory at medium to high power. Either there was insufficient mixing of gas and air, or the workable range of gasification rates was too narrow to properly turn up the power of the gasifier. Adding a gas wick or a nested perforated cylinder did not provide sufficient space for the flame reaction to proceed to completion before exiting the burner. There may be inefficient use of secondary air if at high rates, air is not properly incorporated into the flame, or at low gasification rates, air enters through holed above the flame.

The simple cylinder was able to sustain a stable flame at low gasification rates.

# A SIMPLE PERFORATED CYLINDER

**Figure 1.** From left to right: (a) burner shroud for pre-heating secondary air, (b) perforated cylinder with open top and perforated bottom, and (c) ND-TLUD reactor.

**Figure 2**. The assembled ND-TLUD ready for lighting. Secondary air enters though a gap between the top of the reactor, and the bottom of the burner shroud.

**Figure 3.** Low gasification rate: Small, stable flamelets formed at the bottom of the cylinder. This burner was able to support low turn-down of the gasification rate. It is possible that a substantive amount of unreacted air entered through the holes above the flame.

**Figure 4.** High gasification rate: A tall yellow gas flame forms up the central axis of the burner, and extended 0-10 cm above the top of the burner. Some soot was observed at the top of the flame, even if the flame was within the burner. The gas flame was forced away from the edges of the cylinder by entering secondary air. Entrainment of secondary air into the flame is imperfect, and a it is likely that a substantive quantity of the air exits the burner unreacted.

## PERFORATED CYLINDER WITH GAS WICK

**Figure 5**. Perforated cylinder (open top and bottom) containing a gas wick to position the flame close to the cylinder side walls.

**Figure 6.** At a high gasification rate, the flame exited the burner. The cooling flame above the burner emitted soot coming from the flame tips. Gas combustion may be complete if the burner was taller.

# KERO-SUN RADIANT 10 BURNER

The Kero-Sun Radiant 10 (Type K, L, M) Kerosene Heater has a chimney composed of two concentric, perforated cylinders that glow red hot when the heater is in operation. The burner works by drawing kerosene vapors up through an annular space between the two cylinders. Air from combustion is introduced into the annulus centripetally and centrifugally. This heater can be operated indoors in a room with some fresh air to supply oxygen. The CO emissions are low. The operator's manual can be found at www.toyotomiusa.com. This trial attempered to see if ND-TLUD produced gas could function in a similar way to kerosene, even though produced gas is on average less reactive.

**Figure 7**. Outer (hollow) (99 mm diameter) and inner cylinders (76 mm diameter, enclosed top and bottom)

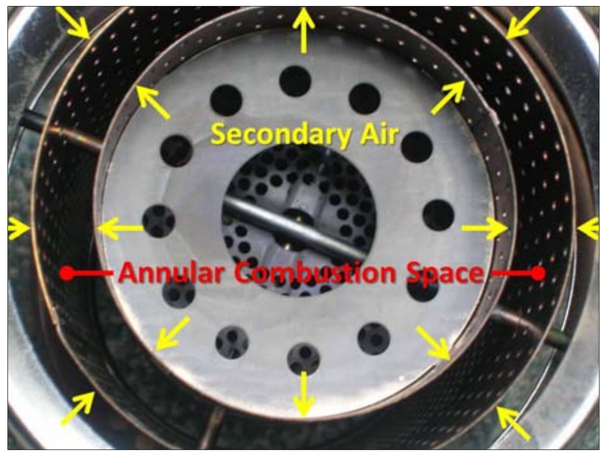


**Figure 8**. Inner cylinder nested inside the outer cylinder, forming an annular combustion space for produced gas.


**Figure 10**. ND-TLUD viewed from the top.

**Figure 9**. Intact Kero-Sun Radiant 10 burner on top of the ND-TLUD. The perforated cylinders are contained within a glass cylinder.

**Figure 11**. TLUD viewed from the top. A flange has been put on top of the secondary air pipe. The inner perforated cylinder sits on top of this flange. Produced gas is directed into the annular space between the inner and outer perforated cylinders, were it is burnt.

Secondary air is fed through a central pipe. A layer (2 pellets deep) of wood pellet fuel soaked in kerosene and alcohol is on top of the fuel bed.

There are no phonographs of the Kero-Sun burner working because tests were conducted at night.

The Kero-Sun burner worked for gas produced by a ND-TLUD, but only over a narrow range of low gasification rates. The bottom third of the cylinders glowed red hot. Above this range, the burner was overwhelmed, and a great deal of soot was formed requiring a lengthy clean-up.