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# Hydrogen-Air Ignition Torch



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# HYDROGEN-AIR IGNITION TORCH

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## SUMMARY

The hydrogen-air ignition torch described in this report has been successfully used for many years to burn off excess hydrogen that accumulates in the scrubber exhaust ducts of two rocket engine test facilities. The torch is simple to operate, inexpensive, and has demonstrated very good reliability. Burning off excess hydrogen has proven to be more economical than the carbon dioxide inertion technique that was used at these facilities in previous years.

## INTRODUCTION

This document describes the background, application, and operation of a hydrogen-air ignition torch being used at the NASA Lewis Research Center in rocket engine exhaust ducts to burn off excess hydrogen which accumulates during hot firing tests.

## BACKGROUND

In the late 1950's and early 1960's, personnel at the Lewis Research Center began testing hydrogen-oxygen rocket engines. Initial testing was done at the Combustion Research Laboratory (CRL) and later at the larger Rocket Engine Test Facility (RETF). Both facilities, which are still in operation today, have a scrubber duct into which the rocket engines exhaust. Since all hydrogen-oxygen rocket engines operate at less than a stoichiometric mixture ratio, the products of combustion contain excess hydrogen which can accumulate in the scrubber duct and detonate. To prevent an explosion of this excess hydrogen, CRL personnel initially inerted their scrubber duct with large amounts of carbon dioxide. Although it was difficult to keep the carbon dioxide in the duct, this technique worked reasonably well and was the standard operating procedure for many years. When testing began at RETF in the early 1960's, this same inertion technique was used but it proved to be expensive and too cumbersome for the accelerated test schedule of the facility, so a new technique was developed. A hydrogen-air ignition torch was designed in 1968 and installed at several places in the scrubber duct. The plan was to provide multiple ignition sources throughout the duct to burn off the excess hydrogen before it could accumulate and detonate. This technique worked quite well and is still being used today at both the CRL and RETF facilities.

## APPLICATION

At the Rocket Engine Test Facility, which is described in (ref. 1), rocket engines being tested fire vertically downward into a scrubber duct which muffles the engine noise, cools the exhaust products, and exhausts them to the atmosphere (fig. 1). This duct contains water spray bars just downstream of the rocket engine as well as in the horizontal and vertical sections and it has a total of seven hydrogen-air ignition torches installed to burn off the excess hydrogen. At the Combustion Research Laboratory, which is described in (ref. 2), rocket engines being tested fire horizontally into a similar duct (fig. 2). Due to the smaller thrust level of rocket engines being tested at this facility, no cooling water is used and only three hydrogen-air ignition torches are installed to burn off the excess hydrogen.

## TEST FACILITY OPERATION

At both facilities, the hydrogen-air ignition torches are lit at the start of the test firing day and stay lit until all testing is complete. Their operation is constantly monitored by facility personnel. The number of torches used and their placement in the scrubber duct was a function of the specific application. Direct impingement on the water spray was avoided and the torches were placed where it was assumed the hydrogen was most likely to accumulate. If minor detonations were experienced during a test firing, efforts were made to determine where they took place and additional torches were installed to eliminate the problem. The torches have demonstrated very good reliability. The original set of torches operated for 15 years before they were replaced with a new set and there were only three or four occasions during this time period when a torch went out and had to be relit during a test firing day.

## ECONOMIC CONSIDERATIONS

The Rocket Engine Test Facility has averaged over three test firing days per week since this facility became operational. When the carbon dioxide inertion technique was being used, it was not unusual to use over 12 tons of carbon dioxide in one test firing day at a cost of $128 per ton. It took over an hour to inert the scrubber exhaust duct at the start of the test firing day, re-inertion was required during testing, and an hour was required to blow out the carbon dioxide at the end of the day. When the hydrogen-air ignition torches were installed, RETF personnel could turn them on and off in a matter of minutes and the cost of the hydrogen and air used during a test firing day was negligible.

## HYDROGEN-AIR IGNITION TORCH DESCRIPTION

The schematic shown in Figure 3 shows the basic operation of this torch. A central compressed air source is regulated down to 50 psig and introduced into the 1-in. diameter tube through the 0.062 in.-diameter orifice to provide a flow rate of 0.0037 lb/s. Gaseous hydrogen is regulated down to 40 psig and is introduced into the 1/4-in. diameter tube through the 0.052-in. diameter orifice to provide a flow rate of 0.0006 lb/s. The compressed air and

gaseous hydrogen come from facility storage vessels exposed to outside temperatures and no attempt is made to condition the temperature of these gases. An 18MM spark plug is threaded into the boss on the side of the torch to provide the ignition spark. It is excited by a simple ignition transformer, 120 V rms secondary, constant duty. The spark plug is excited only long enough to achieve ignition and then is turned off. To give constant assurance that the torch is lit, two Type K, open ball, Chromel-Alumel thermocouples are spot-welded to the exit end of the torch to monitor the air temperature near the flame. The torch operates at a mixture ratio of 6.1 and the flame exits the torch at subsonic velocities. Construction of the torch is shown in figure 4. Since the torch is subjected to an outside environment, the material used is 304 stainless steel. A double-tube design was chosen to allow the compressed air to cool the inner tube before mixing with the gaseous hydrogen. The welded design utilized low-cost and readily-available tube, rod, and plate. Figure 5 shows a picture of the torch with the thermocouples installed.

## CONCLUSION

The hydrogen-air ignition torch has been used for 18 years at the Combustion Research Laboratory and Rocket Engine Test Facility to safely burn off excess hydrogen accumulation in the exhaust scrubber ducts. The torch is simple to operate, inexpensive, and has demonstrated very good reliability. The use of these torches to burn off the excess hydrogen has proven to be more economical than the carbon dioxide inertion technique originally used at these facilities.

## REFERENCES


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2. Gordon, Larry H.: 6670 Newton Attitude-Control Thruster Using Hydrogen-Oxygen Propellant. NASA TM X-3523, 1977.

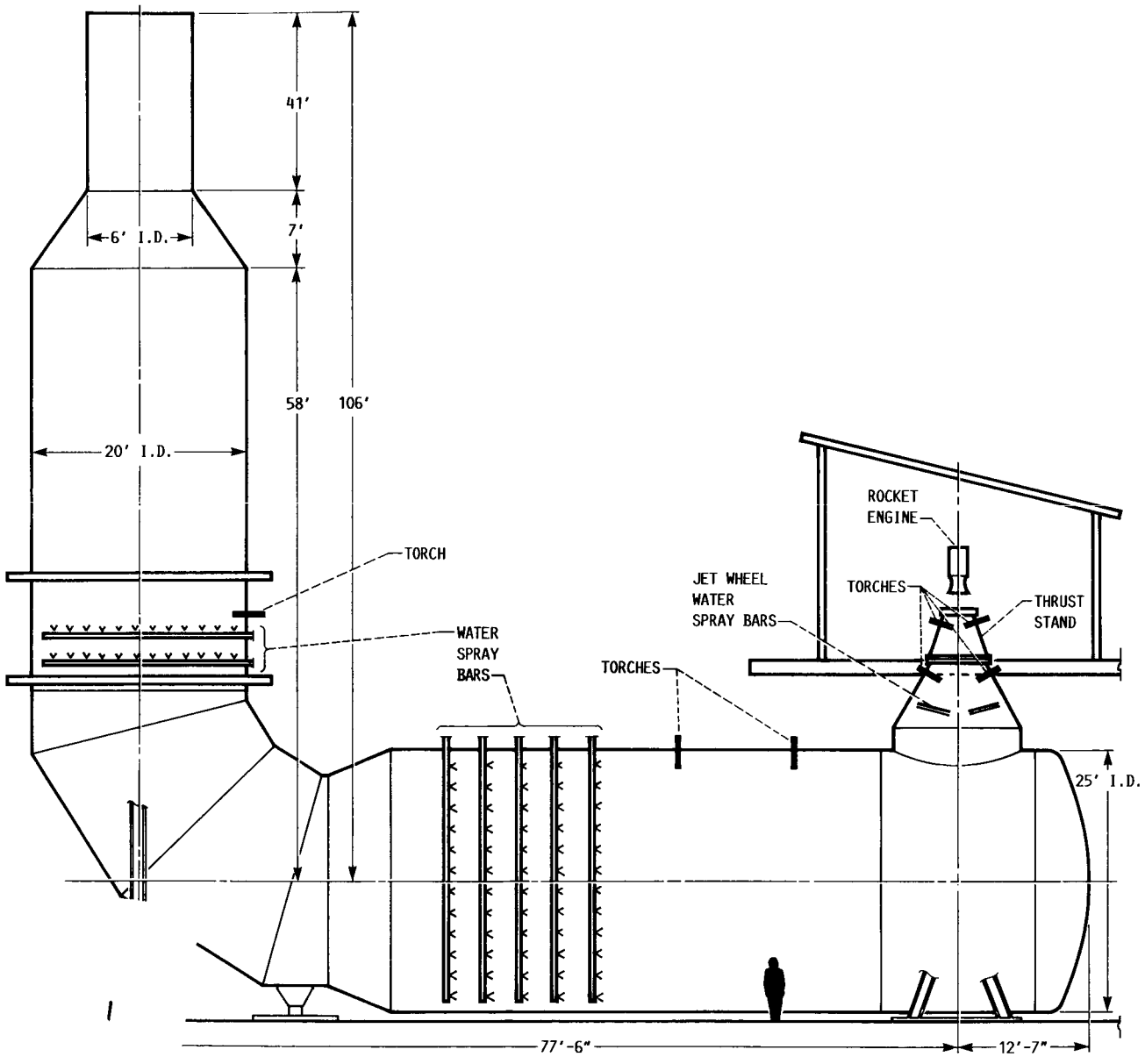


FIGURE 1.- ROCKET ENGINE TEST FACILITY SCRUBBER EXHAUST DUCT.

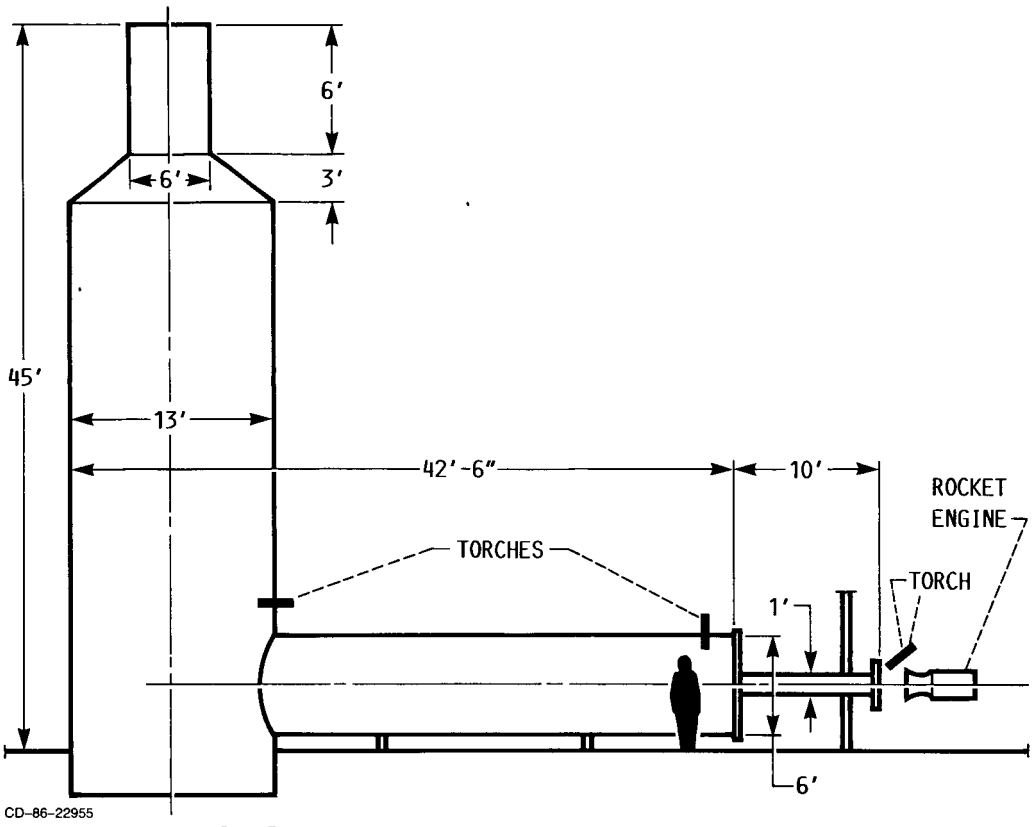


FIGURE 2.- ROCKET COMBUSTION LABORATORY SCRUBBER EXHAUST DUCT.

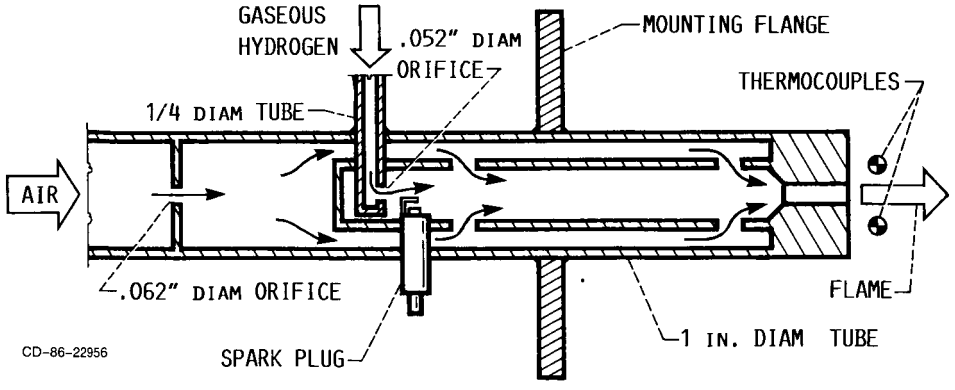


FIGURE 3. - HYDROGEN-AIR TORCH SCHEMATIC.

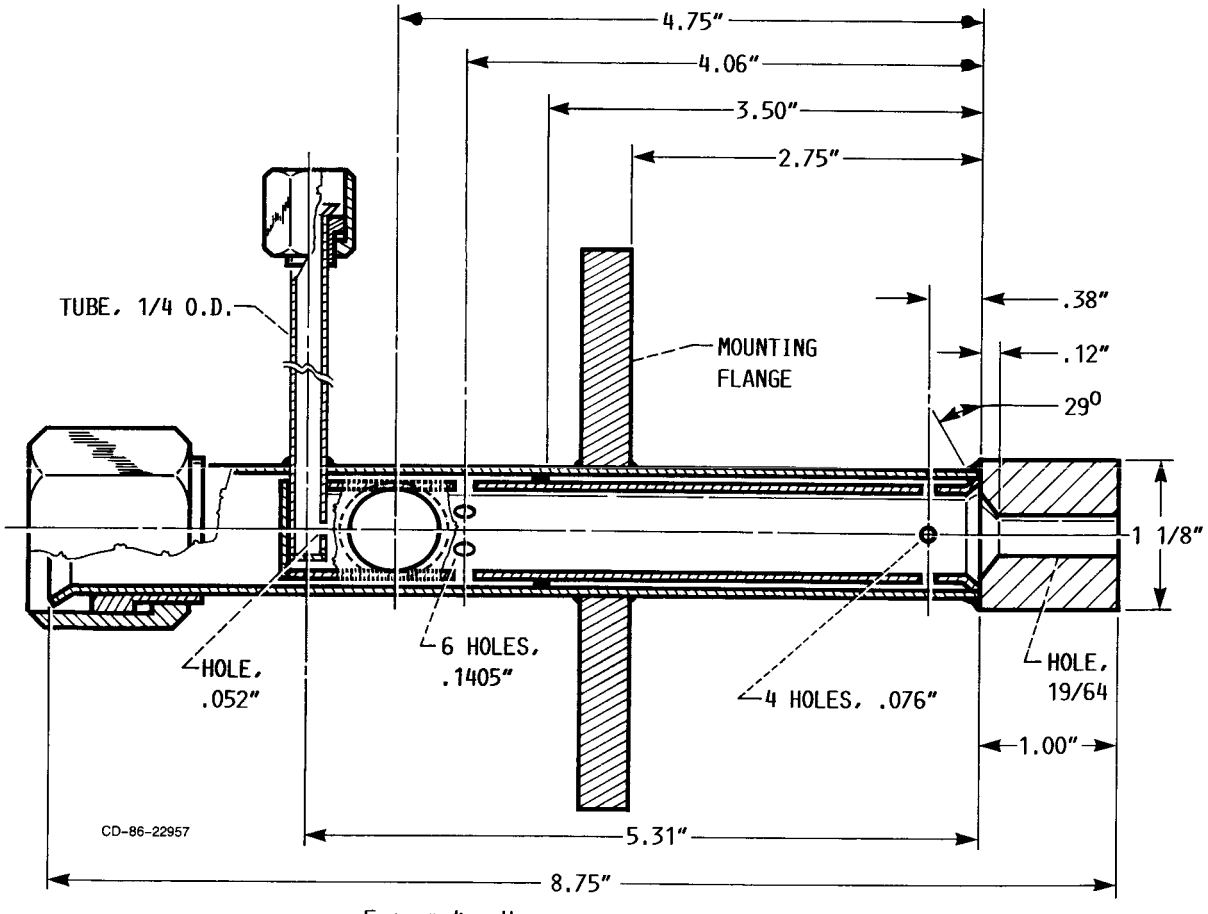


FIGURE 4.- HYDROGEN-AIR TORCH ASSEMBLY.

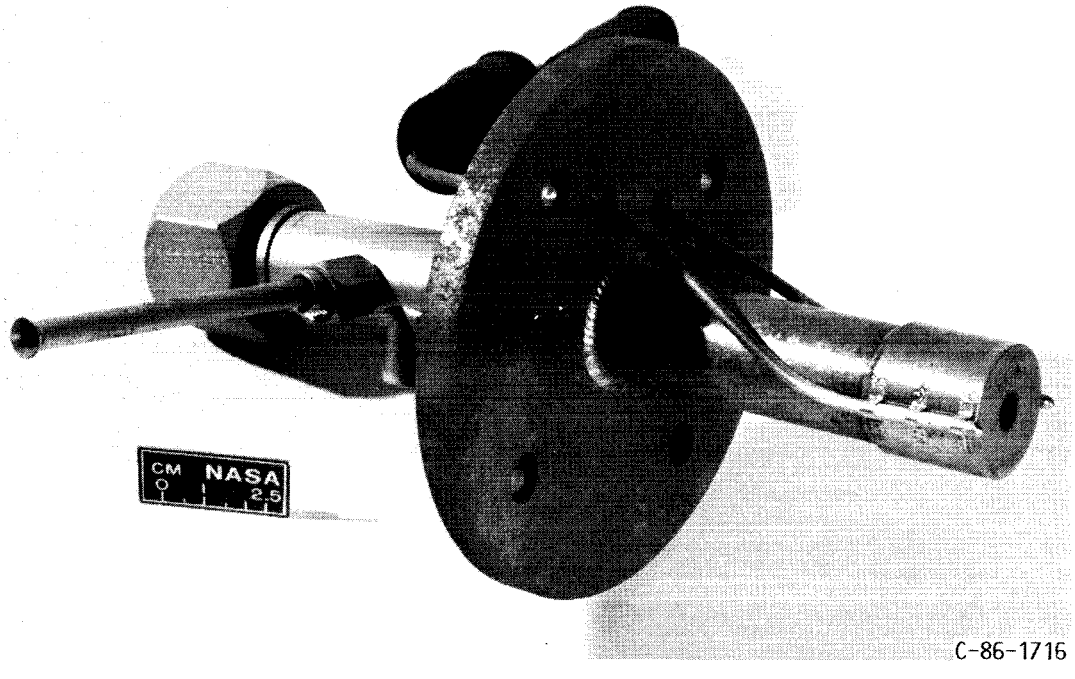


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FIGURE 5. - HYDROGEN-AIR IGNITION TORCH.

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15. Supplementary Notes

16. Abstract

This report describes the design and operation of a hydrogen-air ignition torch presently being used to burn off excess hydrogen that accumulates in the scrubber exhaust ducts of two rocket engine test facilities at the NASA Lewis Research Center in Cleveland, Ohio.

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