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Hydrogen-Oxygen Torch Ignitor

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National Aeronautics and
Space Administration

HYDROGEN-OXYGEN TORCH IGNITOR

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SUMMARY

The Hydrogen-Oxygen Torch Ignitor described herein has been successfully used for many years at various NASA Lewis Research Center rocket test facilities to provide ignition for rocket engine research hardware. This ignitor is inexpensive, simple to operate, and has demonstrated very good reliability. It has been used as an ignition source for rocket engines that utilized a variety of propellant combinations; some of these engines developed up to 40 000 lb of thrust.

INTRODUCTION

This document describes the background, design, operation, and reliability of a hydrogen-oxygen torch ignitor being used at the NASA Lewis Research Center to provide an ignition source for a variety of rocket engine research test hardware.

BACKGROUND

In the early 1950's, personnel at NASA Lewis began testing small rocket engines at the Building 35 Rocket Laboratory and later at the larger Building 202 Rocket Engine Test Facility. Both facilities are in operation today and are used to support a variety of in-house rocket engine technology work as well as cooperative agreement testing for outside industry.

Originally, ignition for these research rocket engines was accomplished with spark plugs and/or electrical devices. Later, during the 1960's Apollo era, most of the test programs involved rocket engines that used nitrogen tetroxide and hydrazine propellant combinations which needed no ignition source since they were hypogolic. In the 1970's hydrogen/oxygen propellant combinations were the most frequently used and ignition was accomplished by injecting a small amount of fluorine with the hydrogen before the oxygen was introduced. Hydrogen and fluorine are also hypergolic. Unlike other rocket test centers, TEA (triethylaluminum) and similar compounds were never used at NASA Lewis due to the toxic nature of these chemicals.

When fluorine use at NASA Lewis was eliminated in the late 1970's, the hydrogen-oxygen torch ignitor described herein was designed to fill the gap. It was subsequently used as an ignition source on research rocket engines that ran at conventional oxygen/fuel (O/F) ratios using all possible combinations of liquid and gaseous hydrogen and oxygen. It was also used to ignite other propellant combinations like RP-1/LOX, carbon monoxide/GOX, methane/GOX, aluminum/GOX, and aluminized RP-1/GOX. In other instances, this ignition torch was used to ignite specialized engines which used gaseous hydrogen and oxygen propellants that operated at unconventional mixture ratios of 8 and 14.

DESIGN

Figure 1 (and Details A, B, and C) show a hydrogen-oxygen torch ignitor assembly. This consists of an upper flange containing a surface gap spark plug, a combustion chamber into which are introduced the

hydrogen-oxygen propellants, the torch injection tube which delivers the hot gases to the rocket engine, and a generic ignitor port which accepts the torch ignition tube. There are many different possible configurations for this ignitor port. One design is to insert the torch injection tube into a holder which is then installed into the side of a rocket engine combustion chamber as shown in figure 2. An exploded view of this assembly can be seen in figure 3. Other options are to install the torch injection tube directly into the rocket engine injector as shown in figure 4 or through a special port mounted into the side of a cooled acoustic resonator shown in figure 5. Still another option is to install the torch injection tube into a special ring which is sandwiched between the injector and the rocket engine as shown in figure 6. Gaseous hydrogen and gaseous oxygen, at ambient temperature, are introduced into the combustion chamber through two ports and ignited using the spark plug. A third port in the combustion chamber is used to monitor ignitor chamber pressure (IPC). The hydrogen flow is split with a calculated flow of 0.000625 lb/sec entering the combustion chamber and 0.00437 lb/sec flowing down along the outside of the torch injection tube to provide cooling. The oxygen flow is a calculated 0.025 lb/sec which makes the combustion chamber O/F equal to 40. This was chosen to create a combustion temperature of approximately 2050 K (3690 R). This lower temperature plus a short operating time eliminates the need to cool the torch combustion chamber. At the exit of the torch injection tube, the cooling hydrogen mixes with the products of combustion and the resulting O/F is 5. The flame produced is about 12 in. long and burns at a temperature of approximately 3100 K (5580 R) which is sufficient to vaporize and ignite the various propellant combinations involved.

OPERATION

Figure 7 shows the typical propellant line schematic used for ignition torch operation. Flow is controlled by setting pressures upstream of sharp edge choked orifices that are installed in the lines. These commercially available orifices are designed to be installed into tube assemblies using standard AN 37° flared tube fittings. Fine tuning the flows to make the ignition torch run at its precise operating condition requires initial cold flows and checkout firings as described below:

1. The oxygen regulator is first set at 1100 psig and the ignition torch is operated with only oxygen propellant. Ignitor chamber pressure (IPC) is set at 90 psig by adjusting the oxygen regulator pressure up and down from the starting 1100 psig setting. Since there are minor variations in the manufacture of each ignition torch, this procedure establishes the exact oxygen propellant flow required.

2. The hydrogen regulator is set at 700 psig but no cold flow is performed. The hydrogen flow is so small that the IPC will record only a negligible pressure.

3. The ignition torch is operated by a timing sequence of simultaneous oxygen flow and spark plug operation followed by the introduction of hydrogen flow (See timing chart, fig. 8). This can be done by an automatic timing device or by manually operating the spark plug and propellant valves. The ignition torch IPC should be approximately 135 psig during a hot firing. If IPC is higher or lower than this number due to manufacturing variations, the hydrogen regulator should be adjusted up or down from the initial starting 700 psig setting and the ignitor torch should be operated again until IPC is in the 130 to 140 psig range. This procedure establishes the exact hydrogen propellant flow required. This ignition torch is not a steady-state device and cannot be operated beyond 5 sec duration. In like manner, failure can occur if the IPC begins to approach 300 psig.

Once the initial checkout firings are complete, the torch is then set for main rocket engine operation. Using an automatic timing device, the ignition torch operation is set to commence just as the main rocket engine propellants enter the engine. IPC is monitored on an abort channel to verify torch operation and a purge (gaseous helium or nitrogen) is activated when torch operation is terminated. This purge is set at 60 psig above

the combustion chamber pressure and is designed to keep the ignition torch clear of main engine combustion gases. It stays on throughout the total firing test.

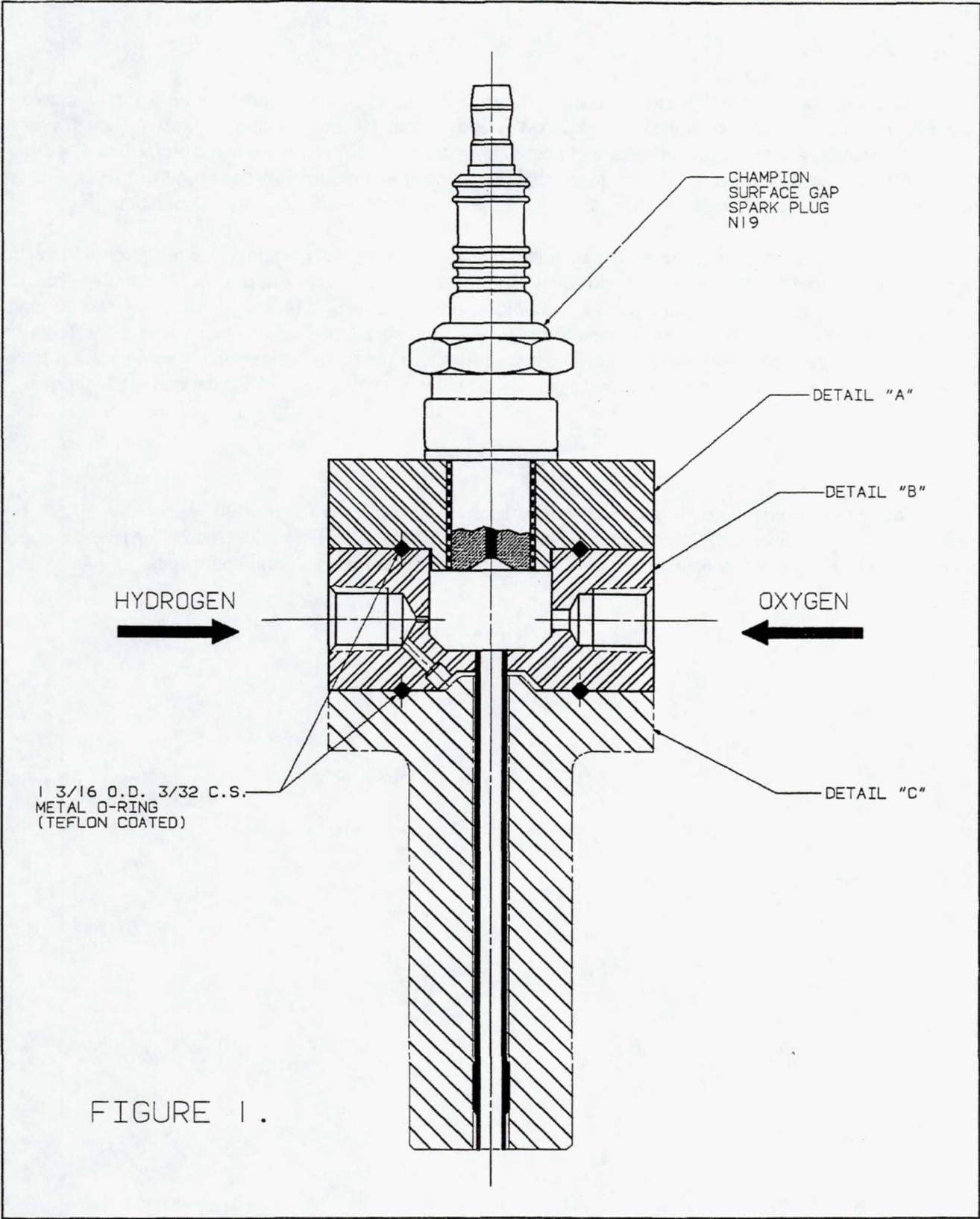
RELIABILITY

Many hydrogen-oxygen ignition torches of the type described in this report have been manufactured and operated at various NASA Lewis rocket engine test facilities from 1972 to the present time. Although each ignition torch eventually shows signs of wear and degradation after 100 firings, many have performed 400 firings before being replaced. They have shown great reliability as long as the torch purge is used to keep debris from entering the combustion chamber and flows are set properly at the start of each day of operation.

The torch ignition tube is the most vulnerable part of the design and original ignition torch designs used nickel as the material for this tube. This worked well but the nickel is very soft and could be easily bent. Later, a special Haynes 188 alloy was substituted for the nickel and it provided a bit longer life and was a stronger material. Assembly of the torch ignition tube to the combustion chamber must be done with E.B. welding or with a very high temperature furnace braze. The hole into which the torch ignitor tube is inserted must have the raised lip shown in figure 9 for proper operation; this provides a small manifold for the cooling hydrogen.

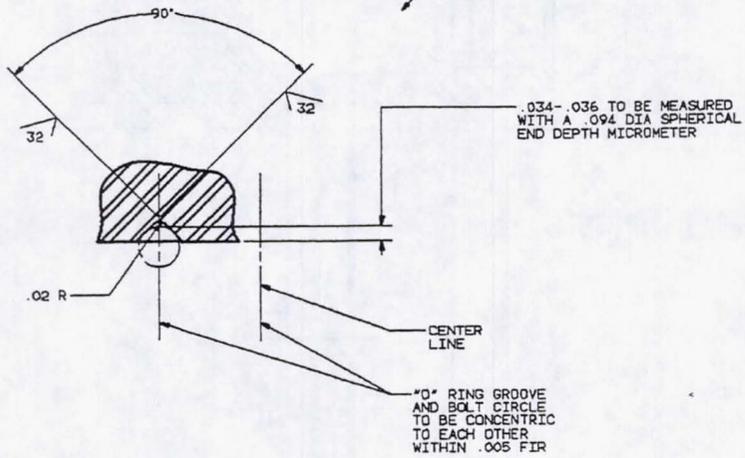
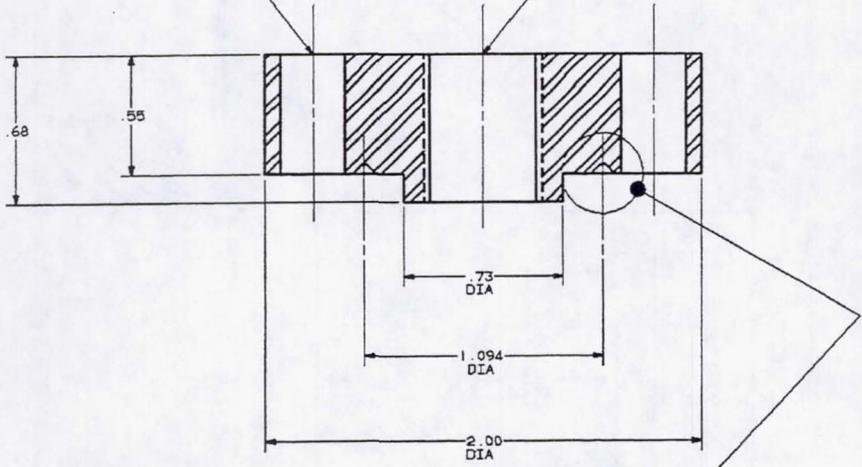
CONCLUSION

The hydrogen-oxygen torch ignitor described herein has been used for over 20 years at the NASA Lewis Research Center in Cleveland, Ohio to provide an inexpensive and reliable ignition source for research rocket engine testing. It is simple to operate and can be used in a multitude of ignition applications.

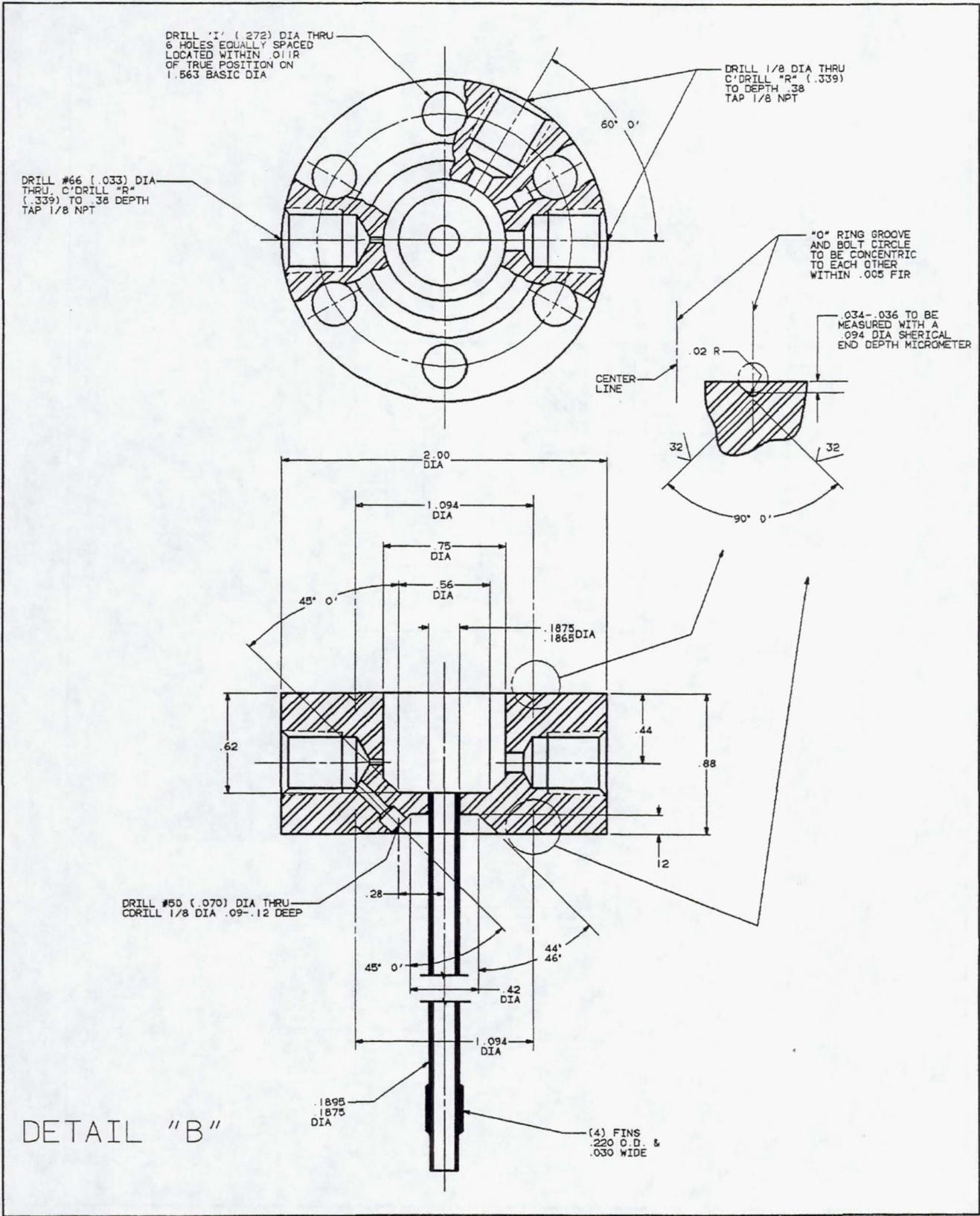


DRILL 'I' (.272) DIA THRU
6 HOLES EQUALLY SPACED
LOCATED WITHIN .01R
OF TRUE POSITION ON
1.563 BASIC DIA

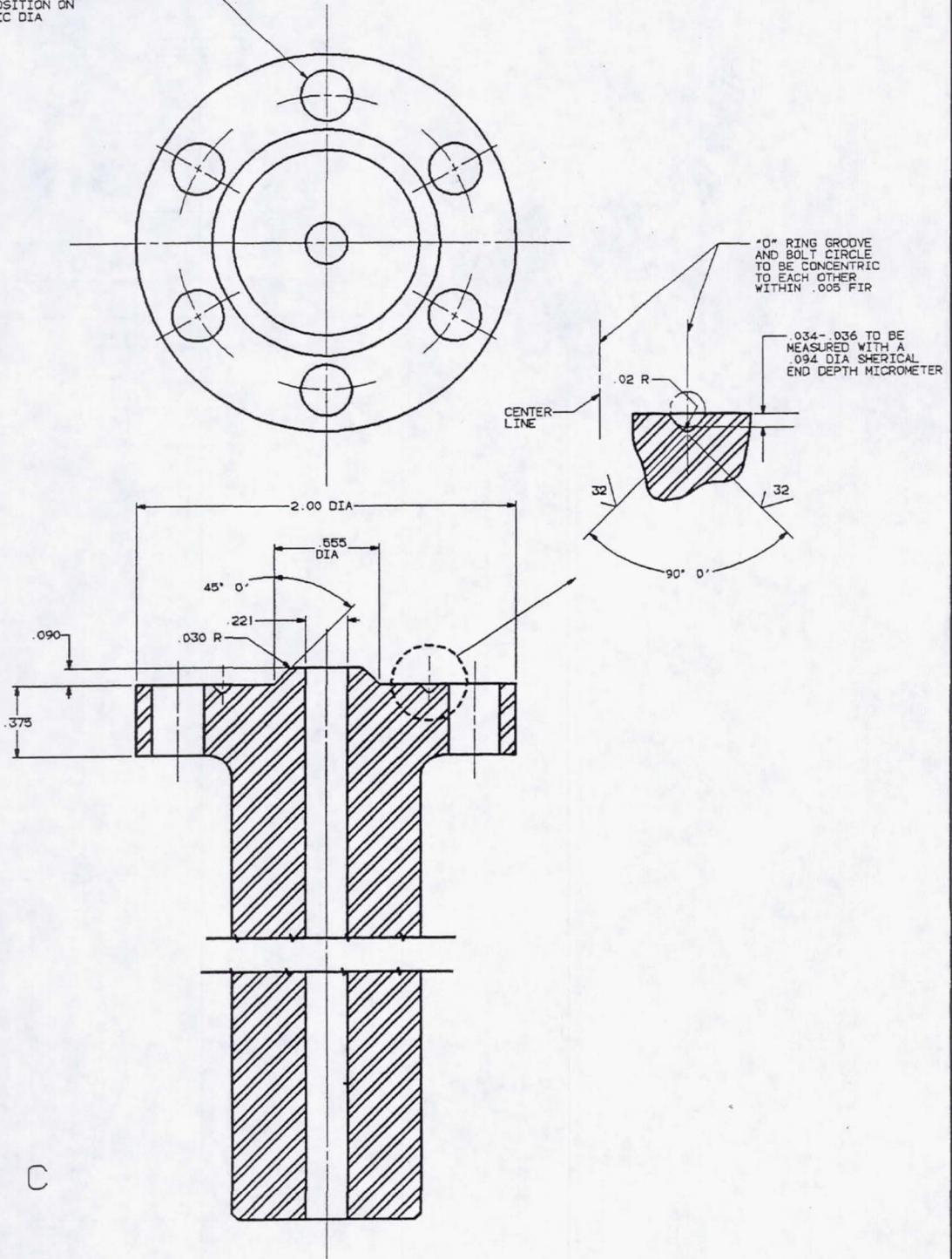
TAP M14 X 1.25 THRU



DETAIL "A"



DRILL 'I' (.272) DIA THRU
6 HOLES EQUALLY SPACED
LOCATED WITHIN .011R
OF TRUE POSITION ON
1.563 BASIC DIA



DETAIL C

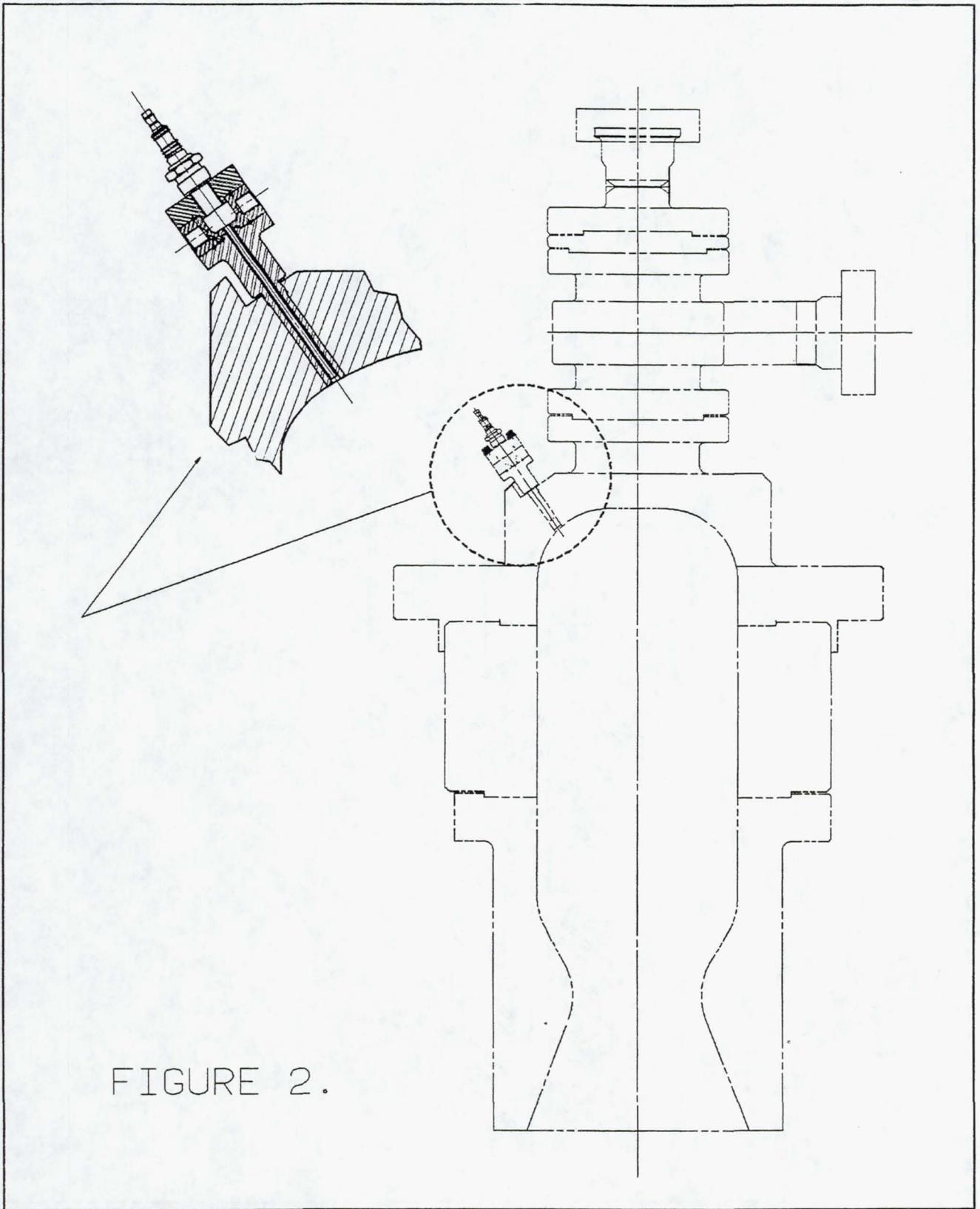


FIGURE 2.

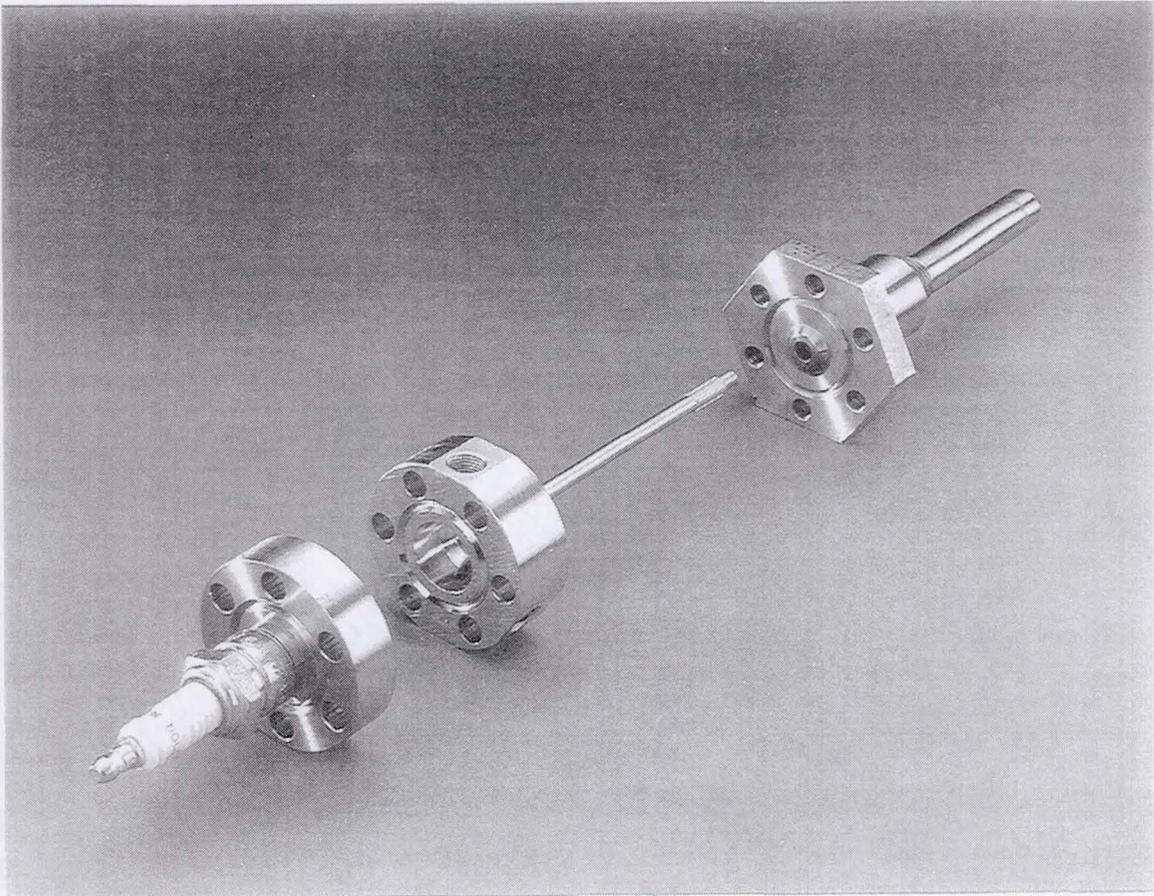


FIGURE 3

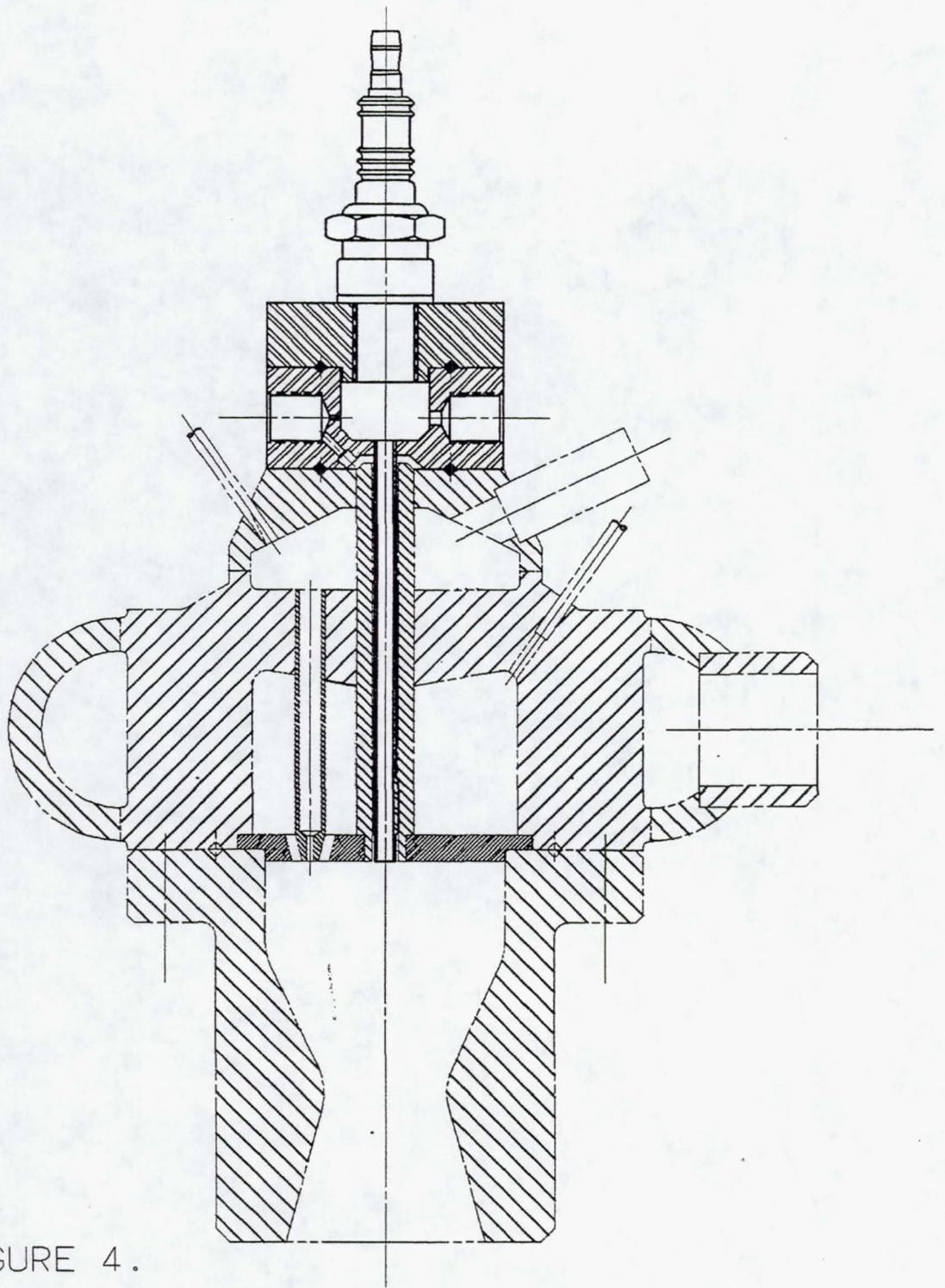


FIGURE 4.

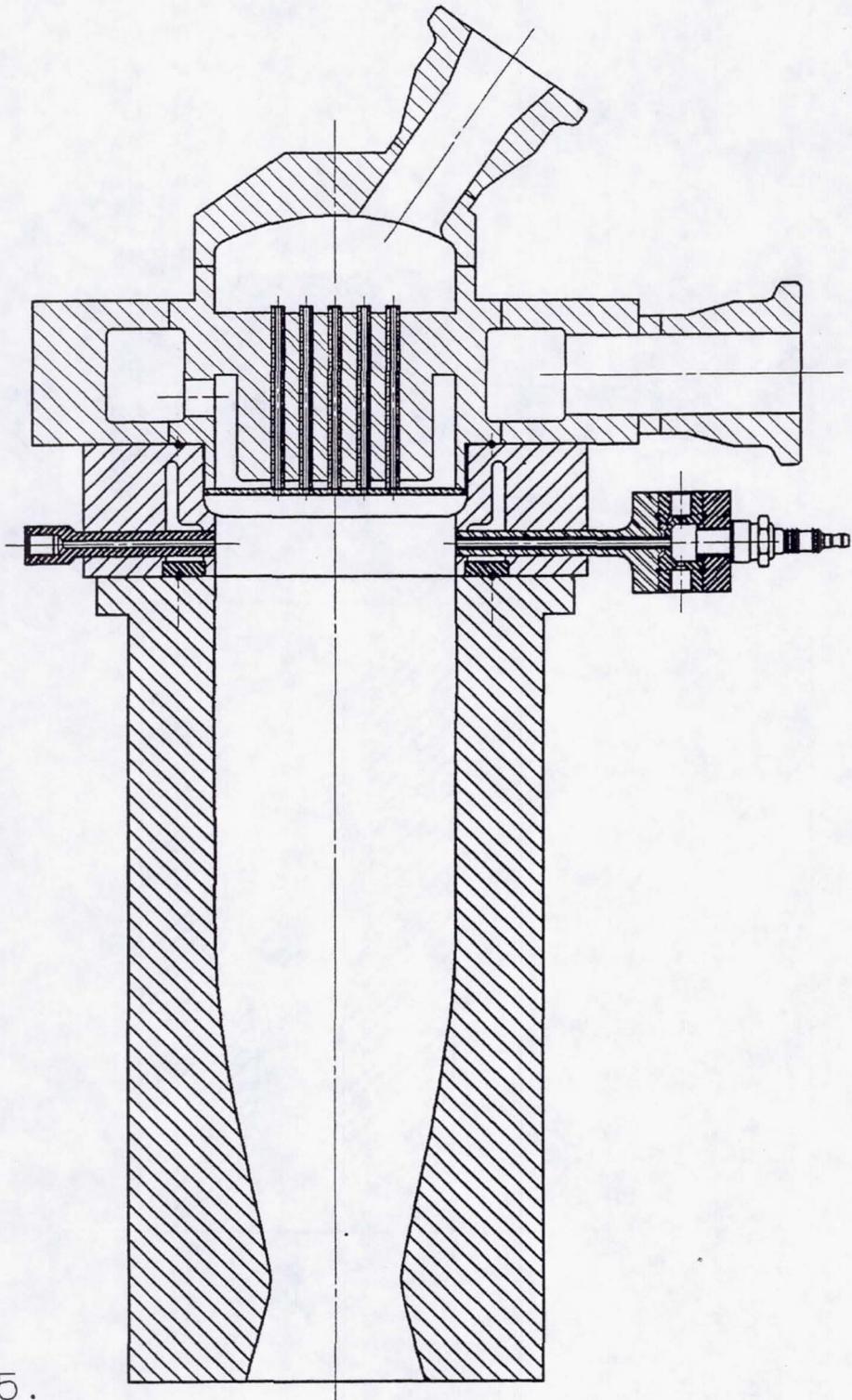


FIGURE 5.

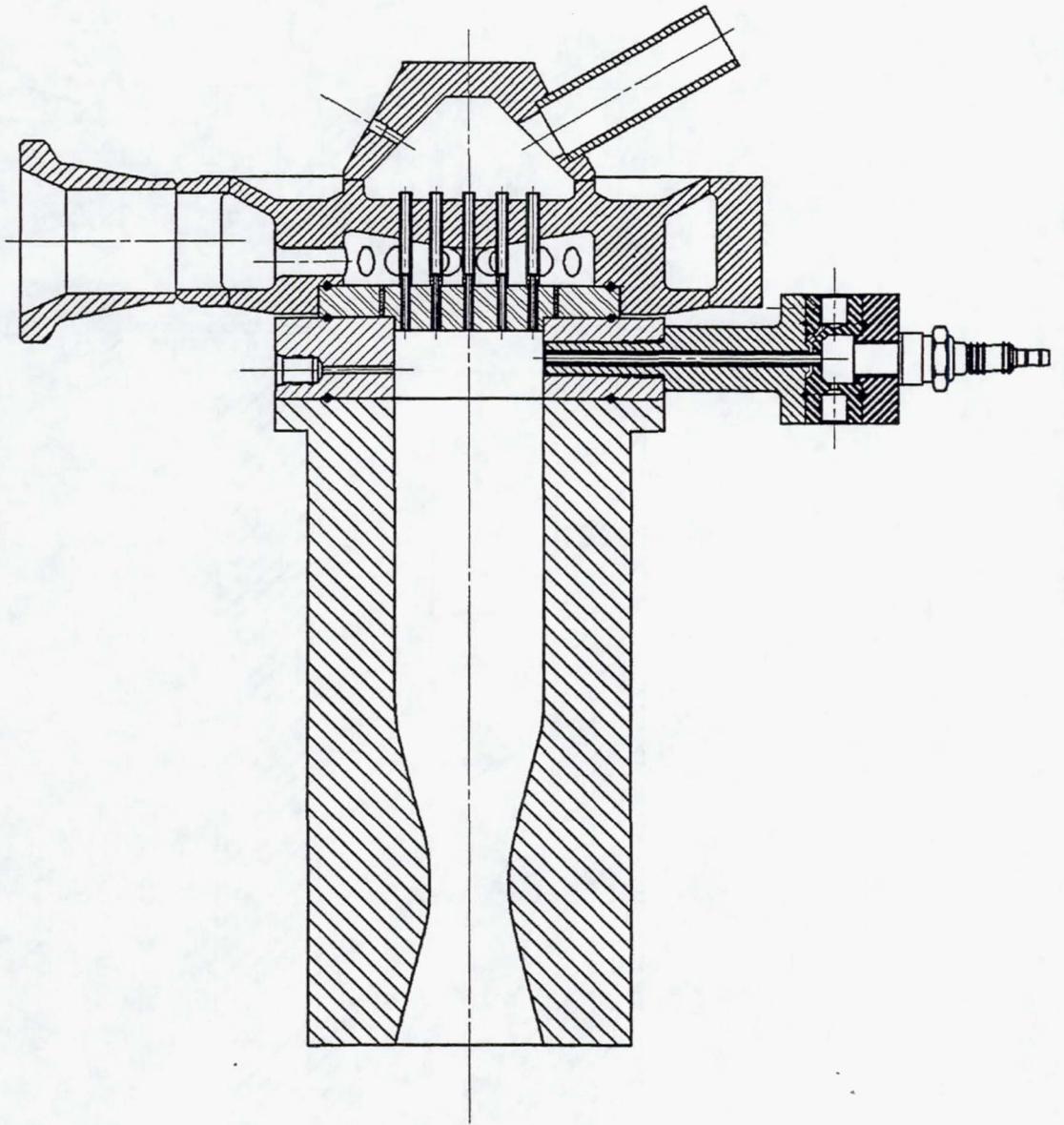


FIGURE 6.

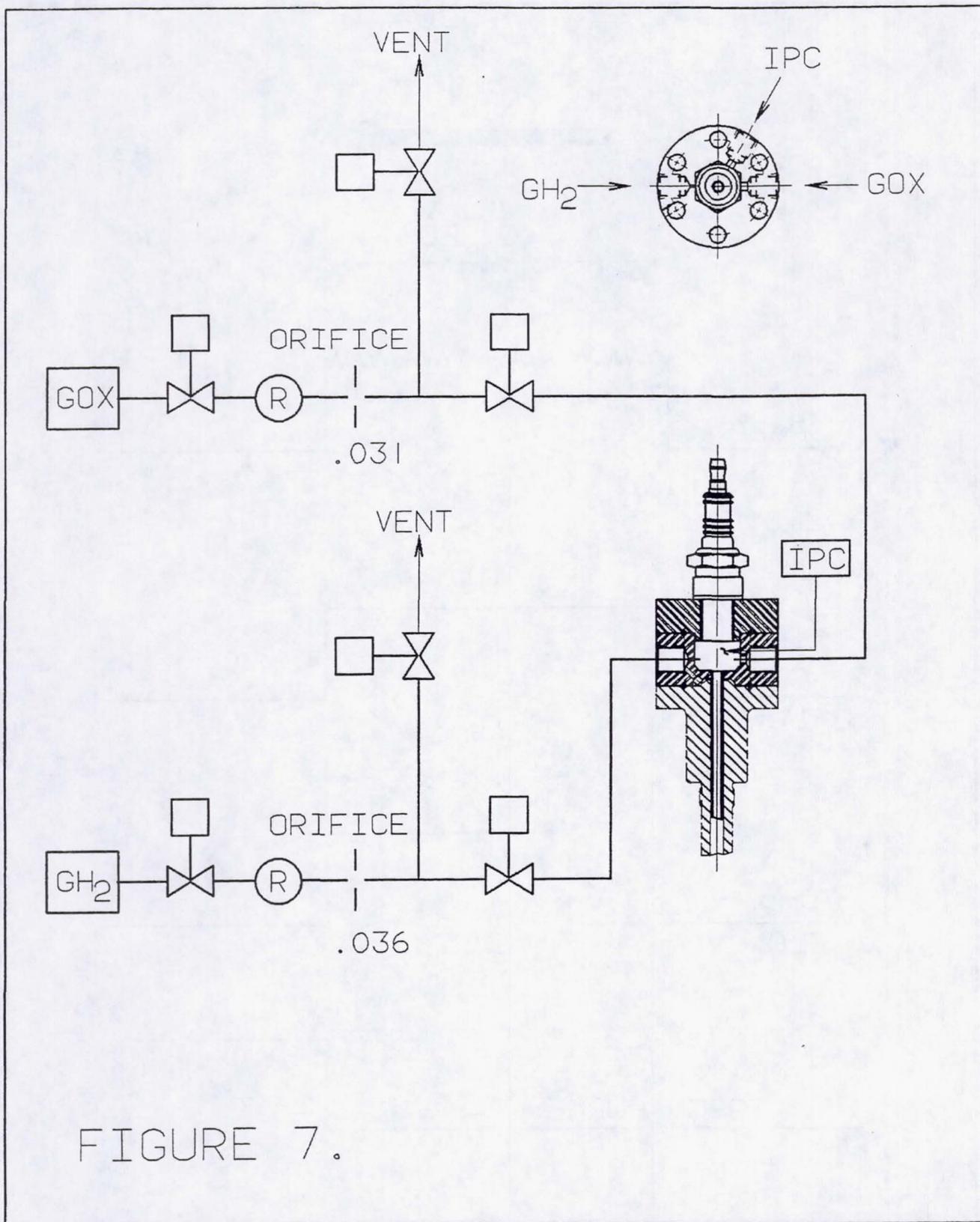
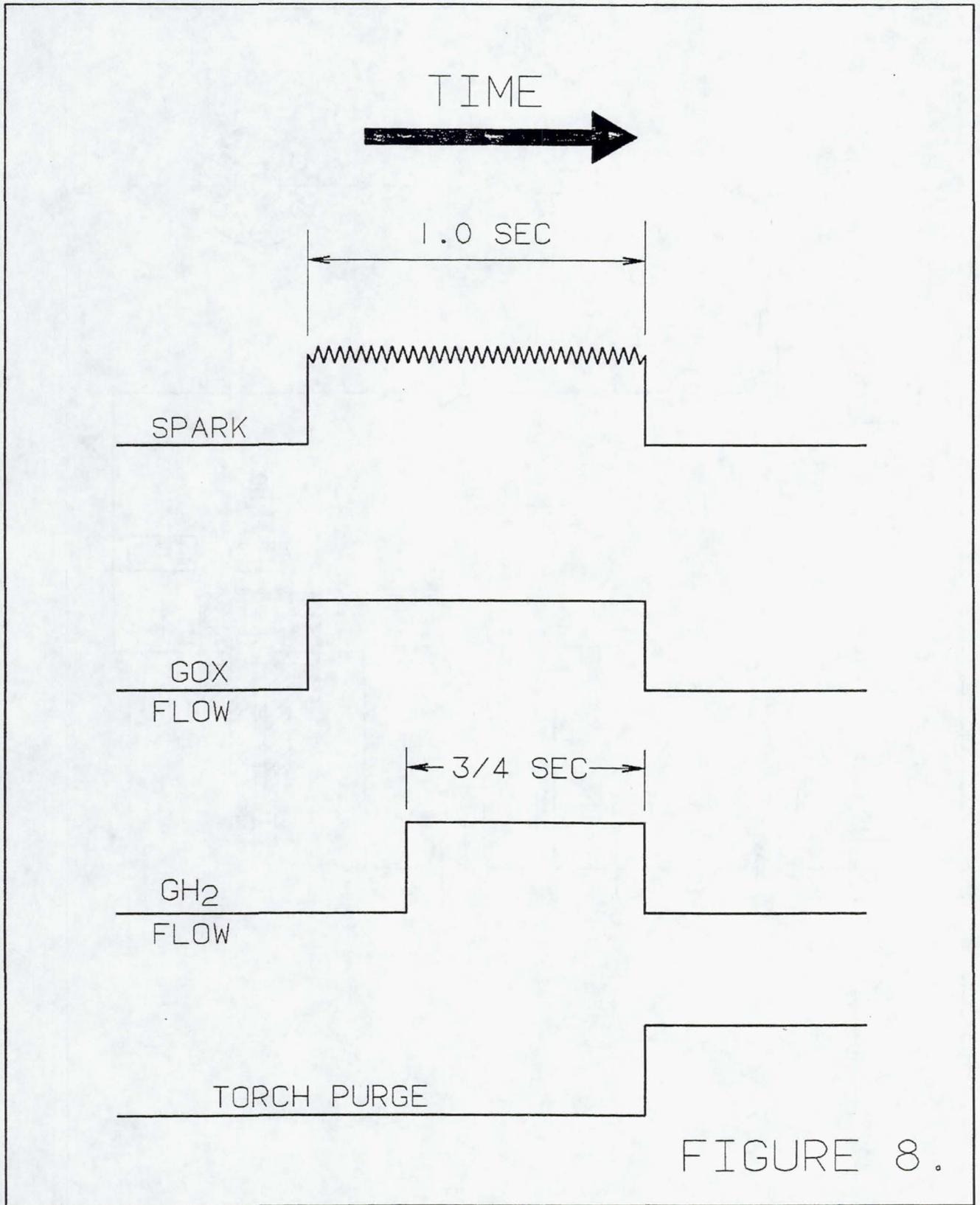


FIGURE 7.



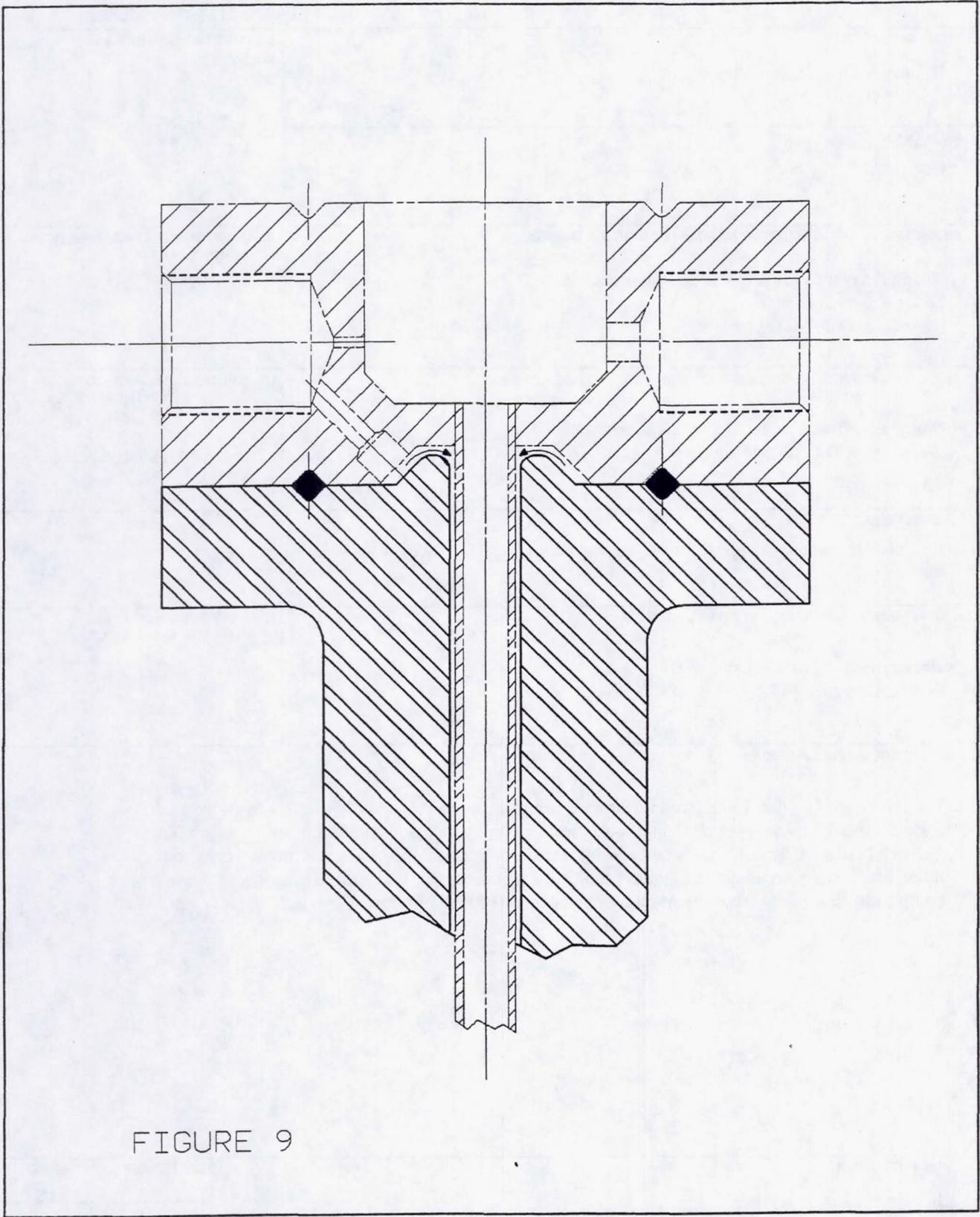


FIGURE 9

REPORT DOCUMENTATION PAGE

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