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LOFT REACTOR ADVANCED INSTRUMENTED CENTER FUEL BUNDLE

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SUMMARY

The program for designing and fabricating replacement fuel modules for LOFT provides a method for incorporating improvements in contemporary LPWR fuel design and in-reactor measurement techniques. Special development projects for measurement devices support the LOFT replacement fuel program.

LOFT Fuel Replacements

A fuel replacement program has been developed for the LOFT nuclear experiments which currently consist of six test series sets designated L2 through L7. The fuel replacement program during the L2 test series includes center fuel bundle replacements after tests initiated at 39.4 kw/m (75% power) peak fuel rod linear heat rate and entire core replacements after tests initiated at 52.5 kw/m (100% power). The replacement center fuel bundles will include expanded instrument features and one bundle will feature pre-pressurized fuel rods and zircaloy instead of stainless steel guide tubes.

Instrumentation Improvements

A comprehensive program is currently underway to develop, fabricate and install measurement devices for the following: (1) core inlet and outlet coolant void fraction, (2) core inlet coolant velocity, (3) fuel centerline temperature, (4) fuel rod length and (5) fuel rod internal plenum gas pressure and temperature. EG&G Idaho is developing the coolant measurement devices, Westinghouse Hanford Company is developing the fuel rod measurement devices, and Exxon Nuclear Company is developing the instrument attachment to the fuel bundles.

Redundant drag disc turbines (DTT) and ultrasonic density detectors (UDD) will be mounted in the center fuel bundle lower tie plates as shown in Figure 1. A redundant UDD will also be added to the center fuel bundle exit. These devices will measure coolant flow direction, velocity, and void fraction.

This UDD measurement is accomplished by the transmitter housing introducing an ultrasonic pulse to the acoustic transmission line. The pulse travels along the line to the UDD receiver housing. The ultrasonic pulse transmission time is dependent upon the density of fluid in the vicinity of the transmission line.

Two DTTs are mounted such that the instruments extend into the flow orifices of the reactor lower core support plate. Each instrument contains a turbine to measure coolant velocity and a drag disc which will measure coolant mass flux (ρV^2).

The new fuel rod measurement features will be added to the center fuel bundles only and current plans are to add 17 fuel centerline thermocouples, three linear variable differential transformers for fuel rod length measurement and 13 fuel rod plenum gas thermocouples and pressure transducers (prepressurized fuel rods only).

The centerline thermocouples have a tungsten-rhenium sheath of various lengths up to 43 inches. The tungsten-rhenium thermocouple is 1/16 inch in diameter and is installed into annular fuel pellets. The thermocouple tungsten-rhenium sheath is spliced to a stainless steel sheath extension cable in the fuel rod plenum area and exits through the fuel rod end cap. A special laser weld has been developed to seal the extension cable to the fuel rod end cap. A materials incompatibility between the stainless steel instrument housing and the zircaloy fuel rod is solved by the use of an extruded bond stainless steel to zircaloy transition joint. A special process for pressing and sintering pellets with a 0.073 inch diameter hole for the centerline thermocouple has been developed.

The plenum gas pressure is measured by an eddy current type pressure transducer which is installed into the plenum area of the fuel rod. An extruded bond stainless steel to zircaloy transition piece is welded to the end of the fuel rod. Attached to the transition piece is a stainless steel penetration coupling which allows the extension cable from plenum thermocouple to exit. A special laser seal weld has been developed to allow the plenum temperature stainless steel sheath thermocouple to exit from the penetration coupling. Welded to the penetration coupling is a segment of stainless steel cladding which houses the plenum pressure instrument. The stainless steel extension cable exits through the fuel rod end cap by the same type of laser seal weld identified for the plenum temperature extension cable. The plenum thermocouple and the plenum gas pressure instrument are mounted on the same fuel rods (see Figure 2).

There are three linear variable differential transformers (LVDTs) mounted on the orifice plate of the center fuel bundles. This instrument measures the actual growth of the fuel rod expected to occur during critical heat flux conditions (CHF). The sensing core of these instruments are attached to the fuel rod end caps while the lower fuel rod end caps are fixed to the lower tie plate.

Conclusion

The LOFT replacement fuel program has developed promising devices for loss-of-coolant experiment measurement of core inlet coolant conditions, centerline fuel temperature, fuel rod length and fuel rod internal gas conditions. The improved measurement features will be first included in the LOFT tests conducted in 1980.

Core Inlet Flow Instrumentation

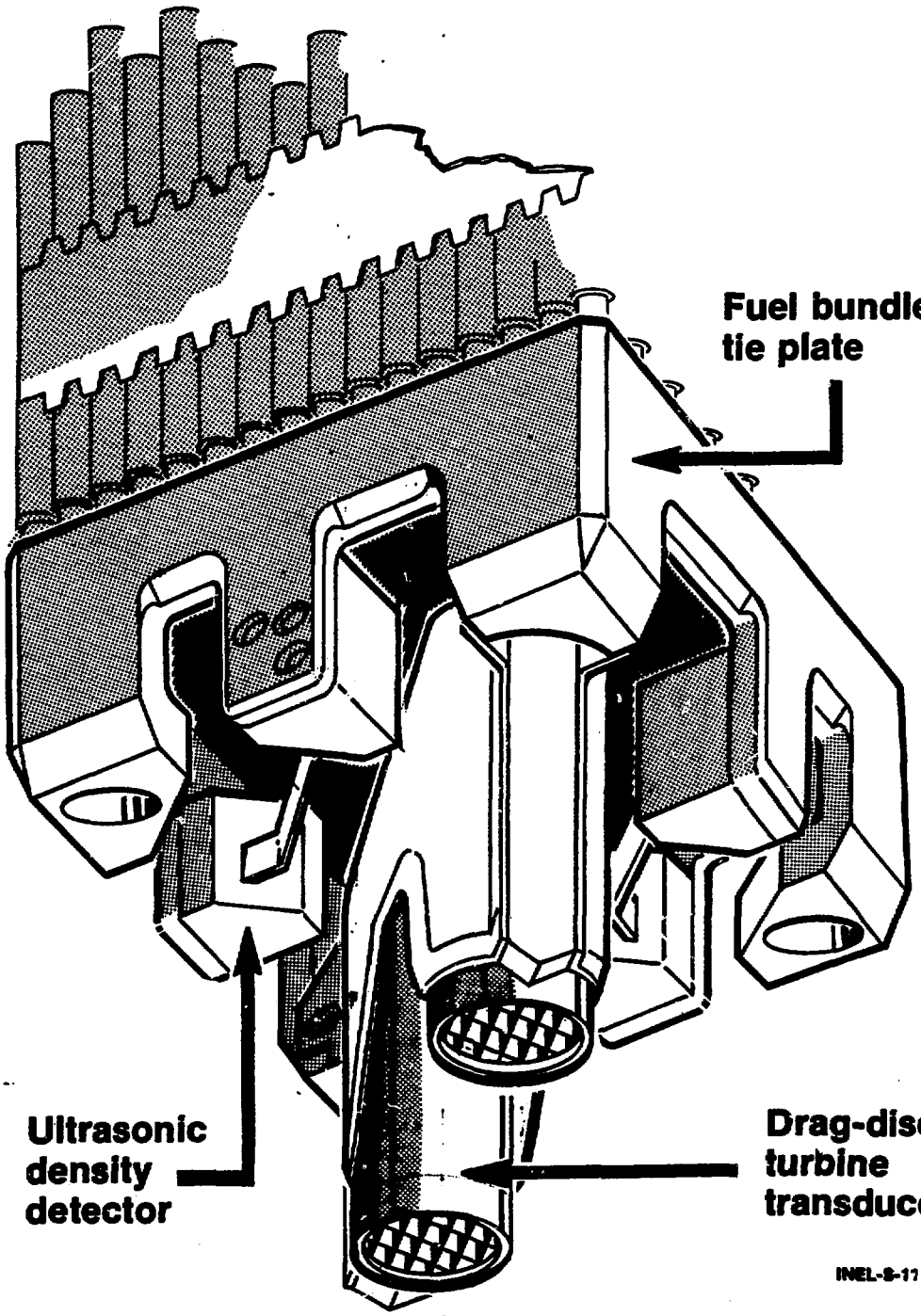


FIGURE 1

Plenum Pressure and Plenum Temperature Fuel Rod

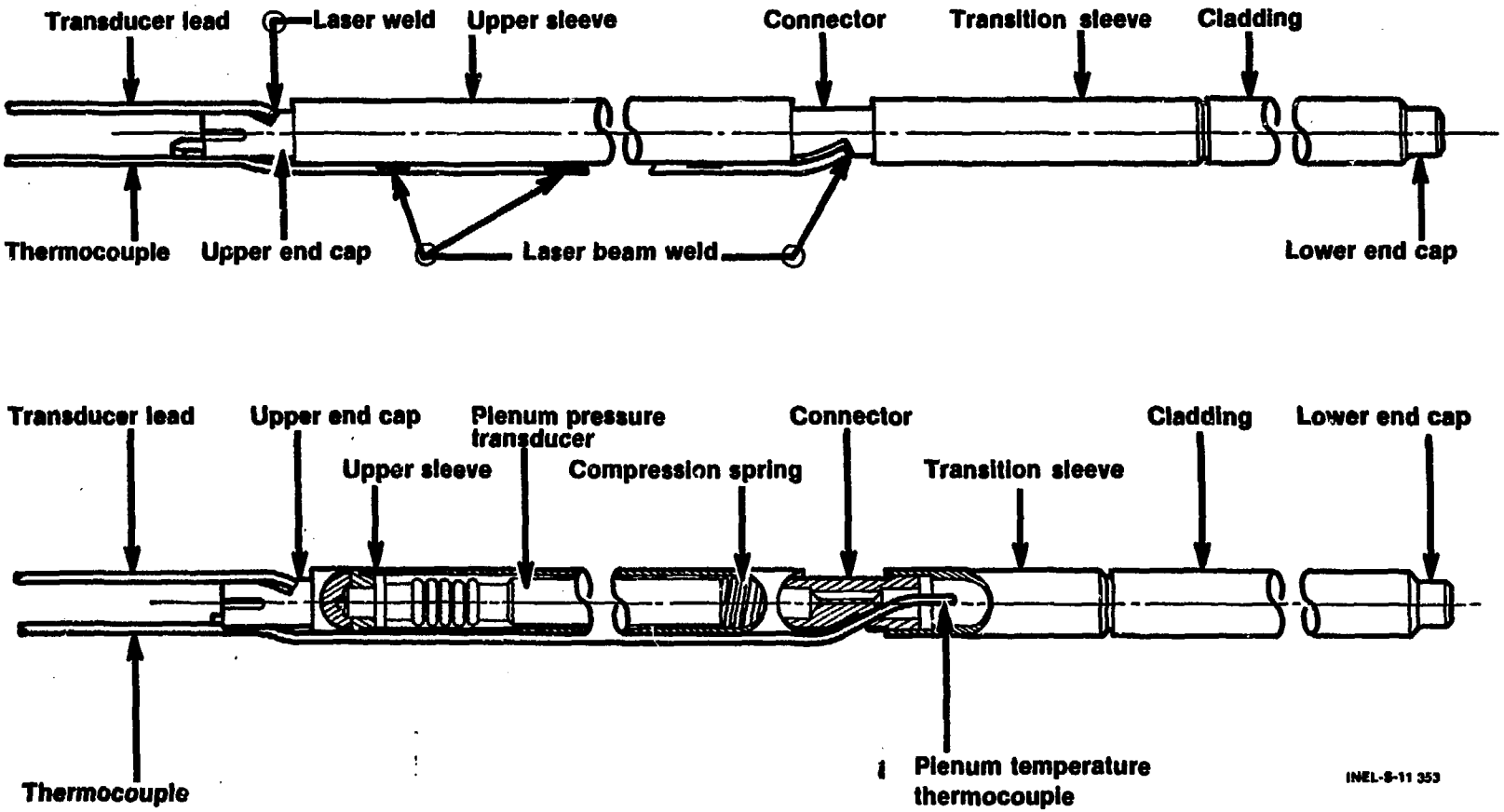
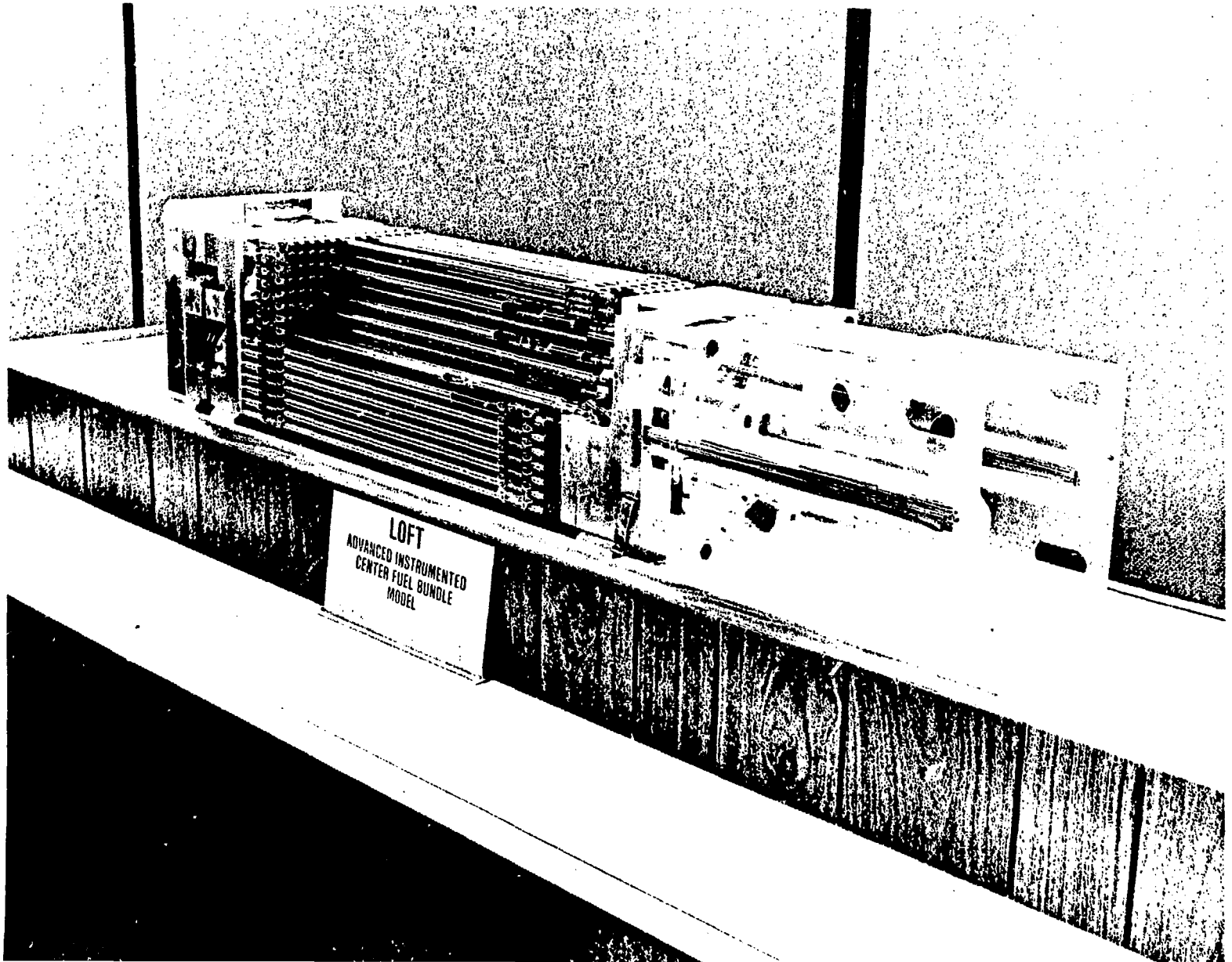


FIGURE 2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