

Differential Impedance Obstacle Detection for Horizontal Directional Drilling

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Program Objective

- **Develop a drill head mounted sensor that can detect and range obstacles in the drill path**

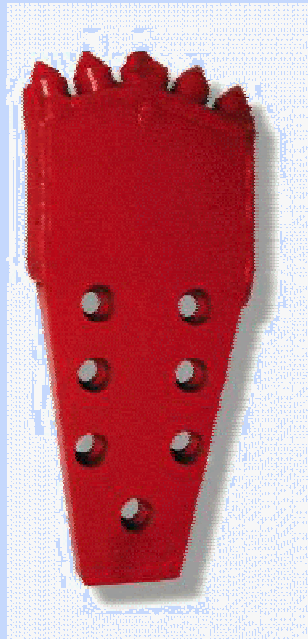
Typical Directional Drill Head



Key Technical Issues

- A sensing method that can detect plastic, ceramic, cement, or metal obstacles is needed.
- The environment and space limitations on the drill head are severe.
- The blade of the drill can be an obstruction to many sensing methods.

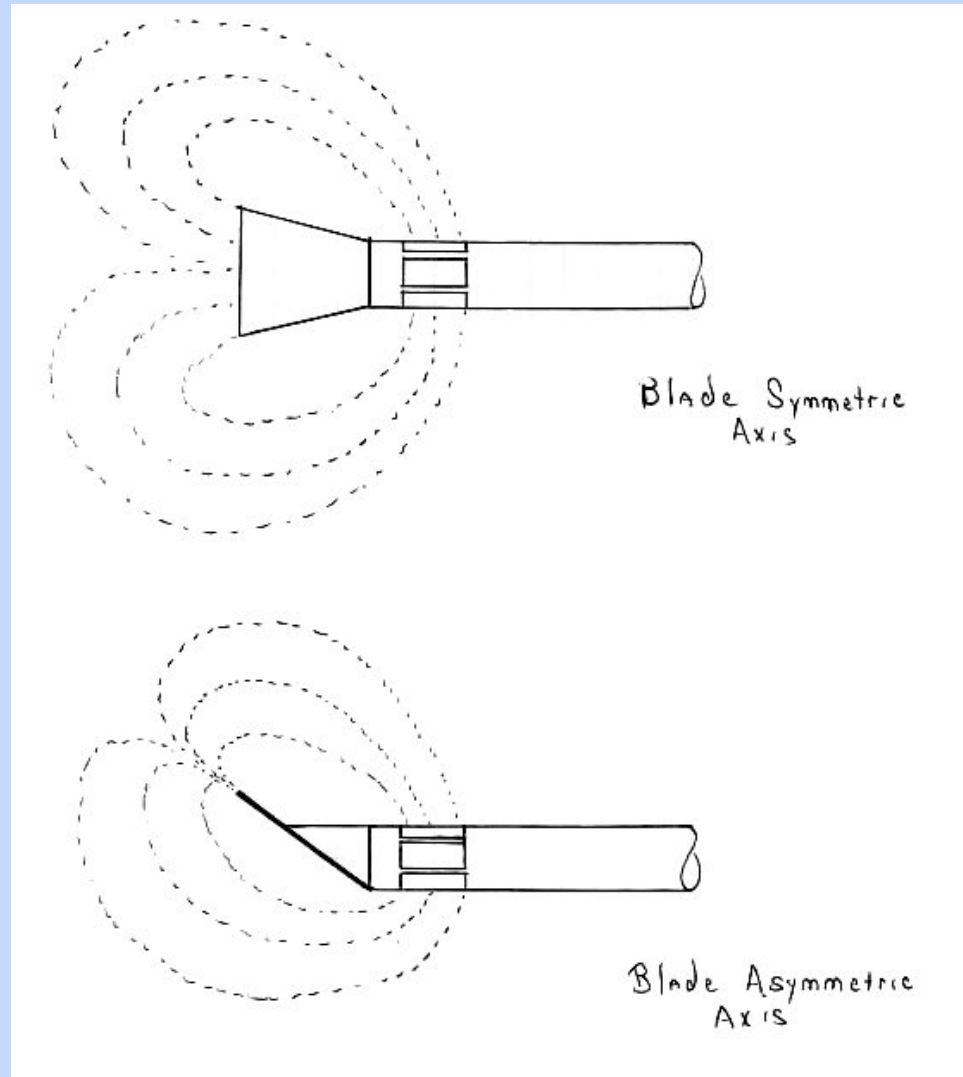
Drill Head Components



DI Obstacle Detection is Similar to CT

- **The objective for obstacle detection is detection and ranging rather than imaging.**
- **The rotary motion of the drill head provides scanning of the drill vicinity.**
- **The low-profile sensing plates can be easily integrated into the drill head.**
- **The blade, rather than being an obstruction, will be used as a signal injection point.**

Signal Flow around Drill Head



Scope of Work - Tasks

- **1. Research Management Plan**
- **2. Evaluate Sensor Concept**
- **3. Demonstrate Obstacle Detection in Ground**

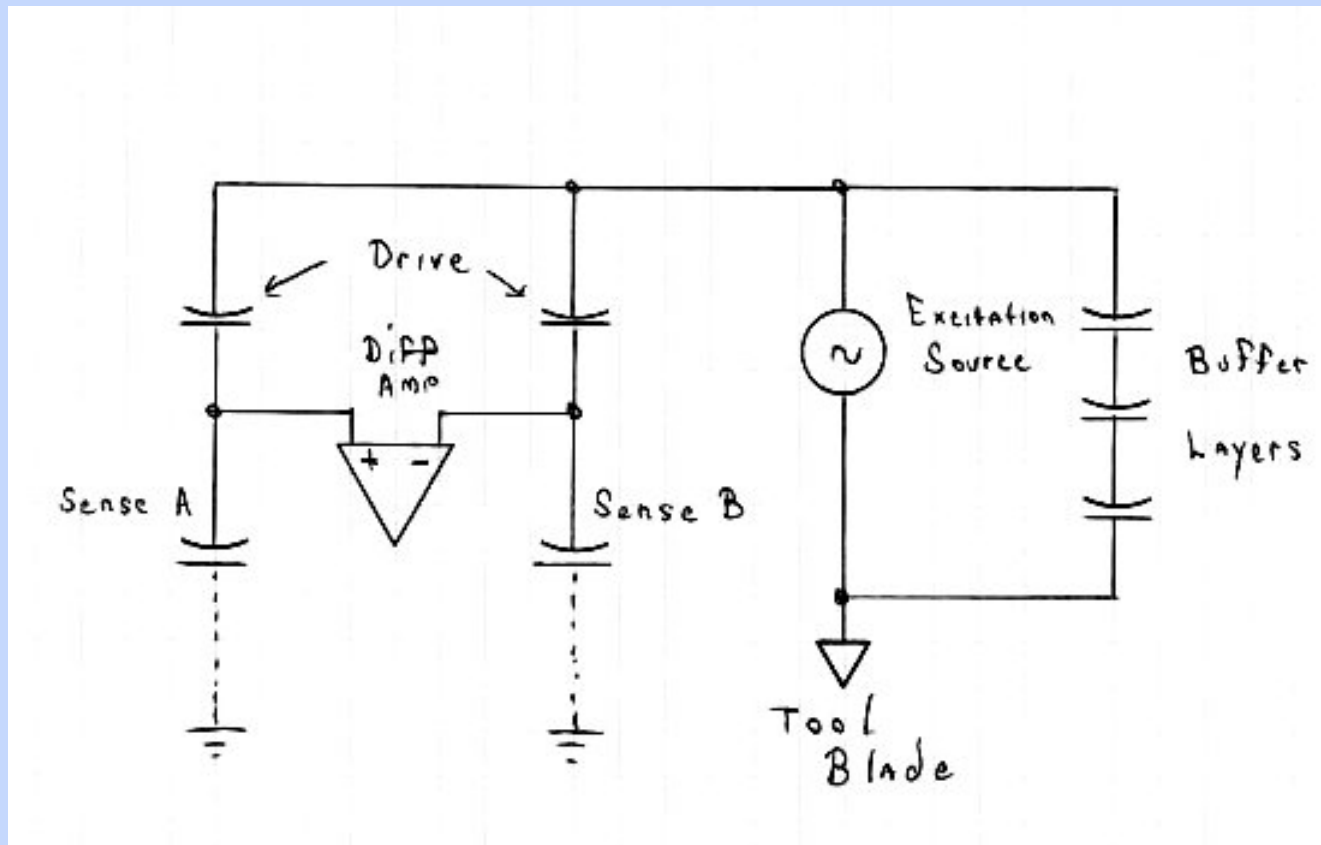
Task 1. Research Management Plan

- **Research Management Plan**
- **Kick-Off Meeting**
- **Technology Assessment**
- **Technical Reports & Presentation**

Task 2. Evaluate Sensor Concept

- Evaluate Dual Bridge Rotating Sensor
- Evaluate Soil Properties
- Construct Test Model of Sensor

Bridge Sensor Equivalent Circuit



Task 3. Demonstrate OD in Ground

- **Perform Passive Sensing Tests**
 - Of 60 Hz Sources
 - Of tracer signal
- **Perform Active Sensing Tests**
 - Using Excitation Signal from Drill Head
- **Demonstrate Obstacle Detection in Ground**

Task 1. Research Management Progress

- **The Detailed Work Plan has been prepared and submitted to NETL.**
- **The Kick-Off Meeting was held in May of 2002.**
- **The state-of-the-art for obstacle detection was compiled and submitted.**
- **The first Quarterly Technical Report has been submitted.**

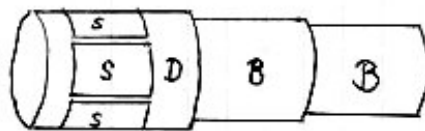
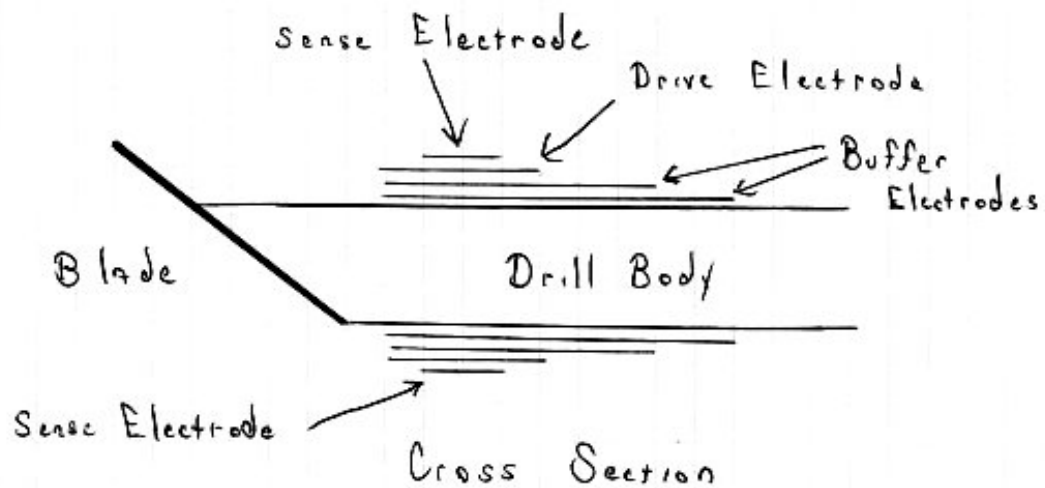
Some Subsurface Detection Methods Surveyed

- **Ground Penetrating Radar**
- **Seismic and Acoustic methods**
- **Microgravity variation surveys**
- **Magnetic Field disturbances**
- **Field emissions from active power lines and tracer wires**
- **AC and DC resistivity methods**

Task 2. Sensor Concept Progress

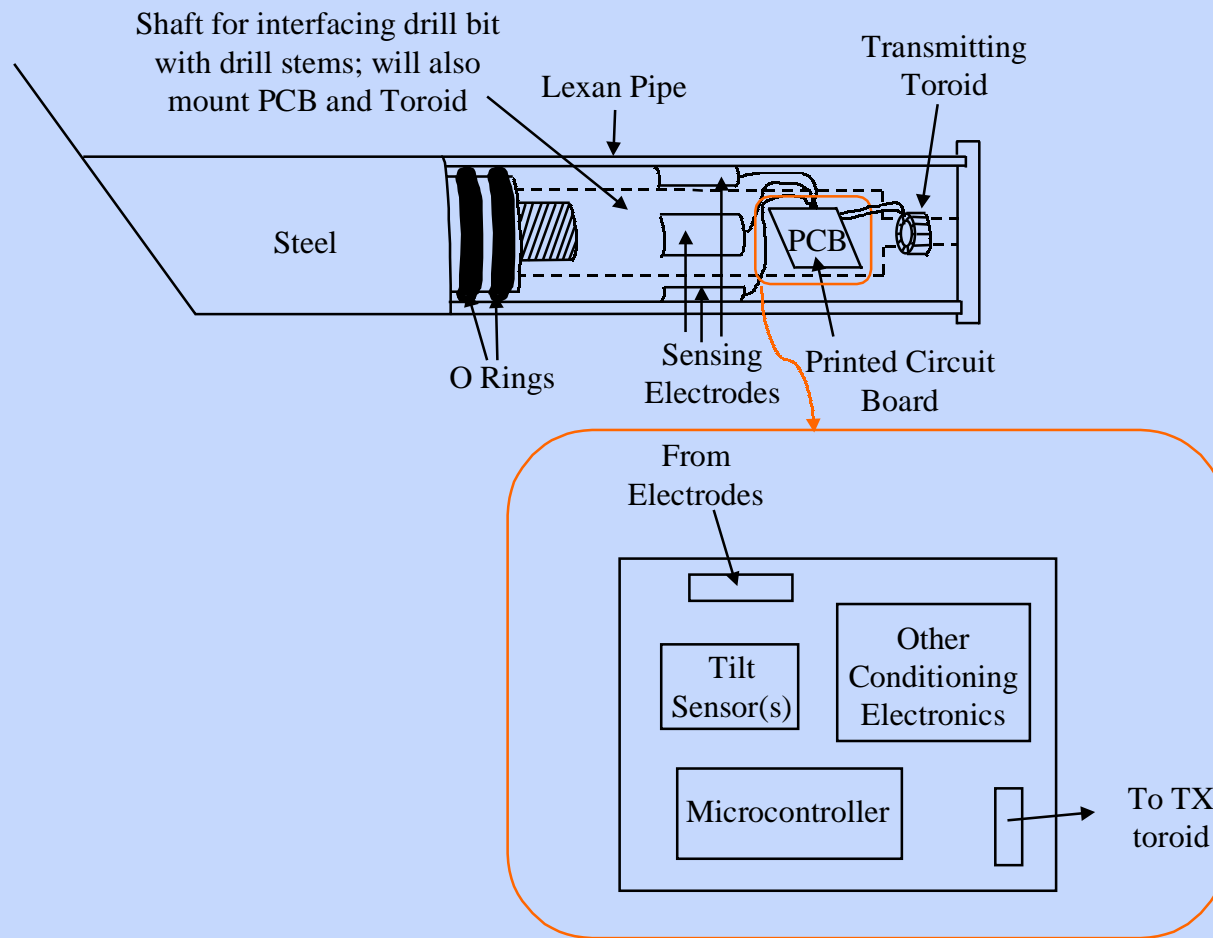
- Results of Capacitive Tomography project demonstrate that impedance techniques can detect plastic pipe in soil.
- GTI is also evaluating tilt and rotation sensors to capture the drill head attitude data.
- This must be correlated with impedance data to provide direction of obstacle.

Drill Head Sensor Concept



Electrodes Separated by Insulation
Separation Exaggerated for Clarity

Prototype Concept

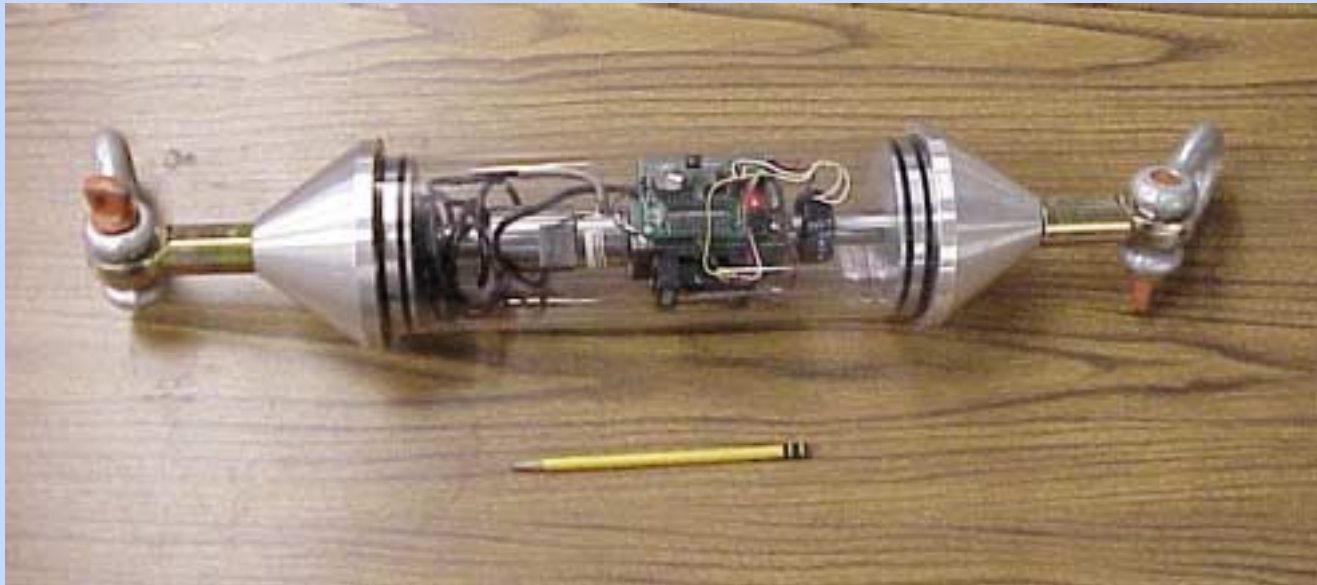


Reasonable Data Requirements

- **The rotation of the drill scans the immediate area, eliminating the need for multiplexers.**
- **A small number of data channels are required.**
 - Symmetric Drill Axis Impedance
 - Asymmetric Drill Axis Impedance
 - Drill Rotation and Tilt data

Delivering Data to the Operator

- **GTI developed a method of transmitting data through the drill rod for a tow tension monitoring application.**



Task 3. Demonstrate OD in Ground

- No work has yet been performed on this task.
- Scheduled for Spring of 2003

Summary

- **There is experimental proof that impedance techniques can detect plastics embedded in soil.**
- **The goal of performing obstacle detection and ranging can be realized in a small rugged package.**