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

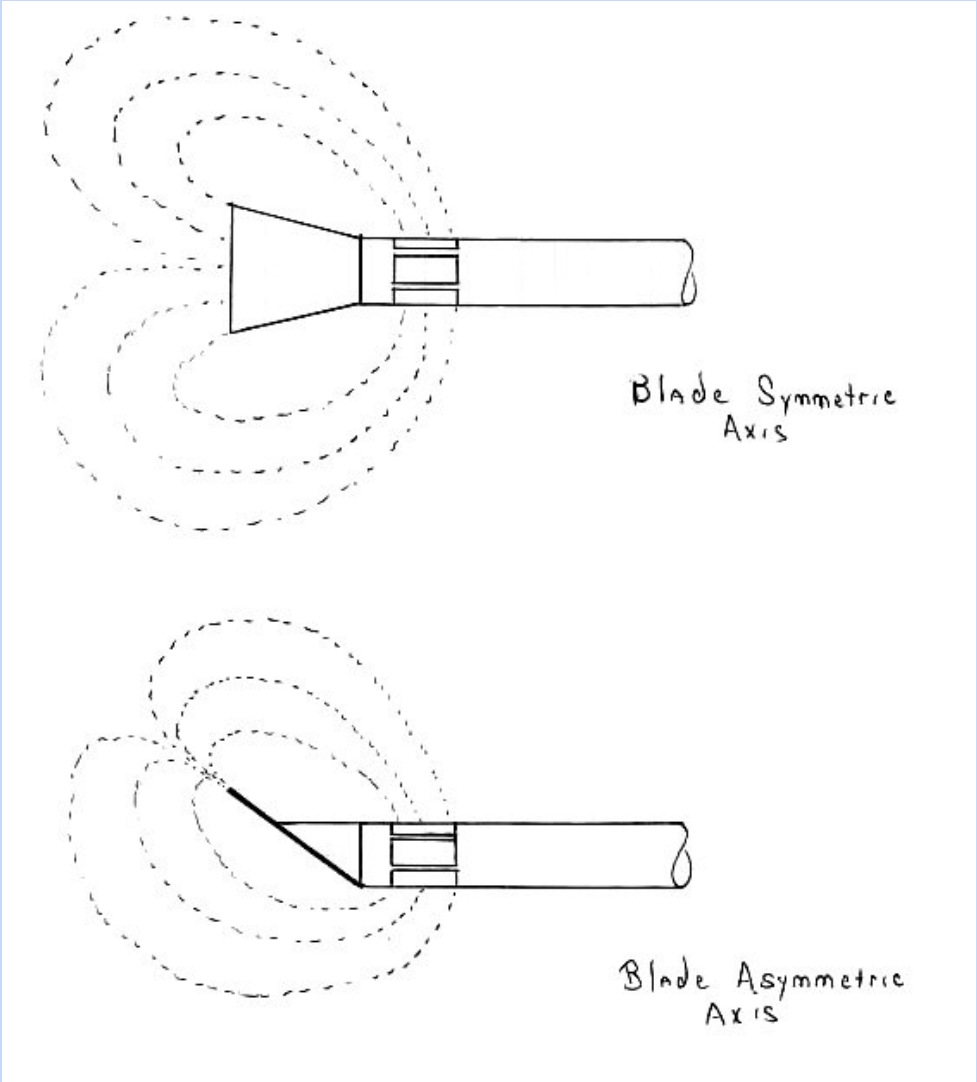
- A sensing method that can detect plastic, ceramic, cement, or metal obstacles is needed.
- The environment and space limitations on the drill head are severe.
- The blade of the drill can be an obstruction to many sensing methods.

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

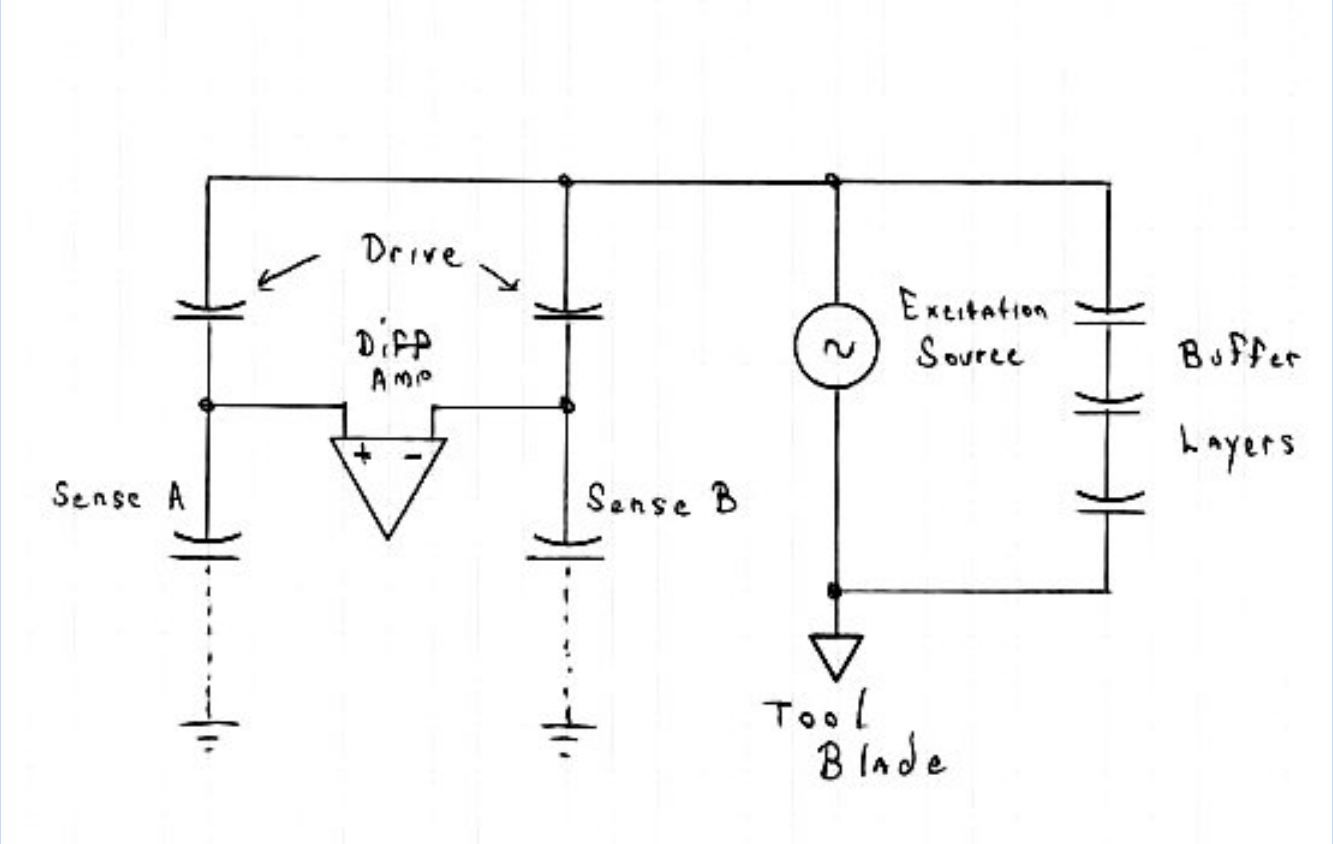
Task 1. Research Management Plan

- 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.

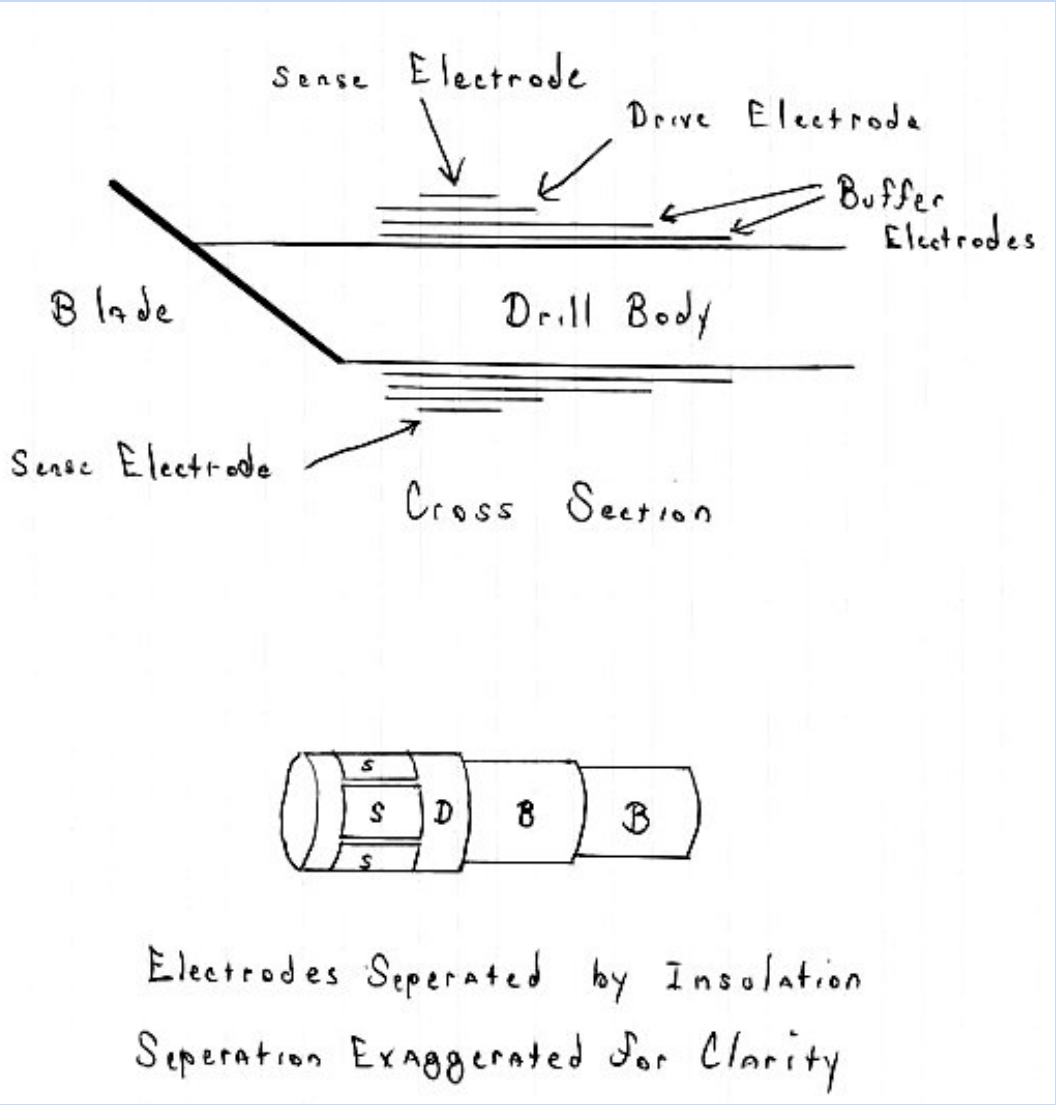
Some Subsurface Detection Methods Surveyed

- 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

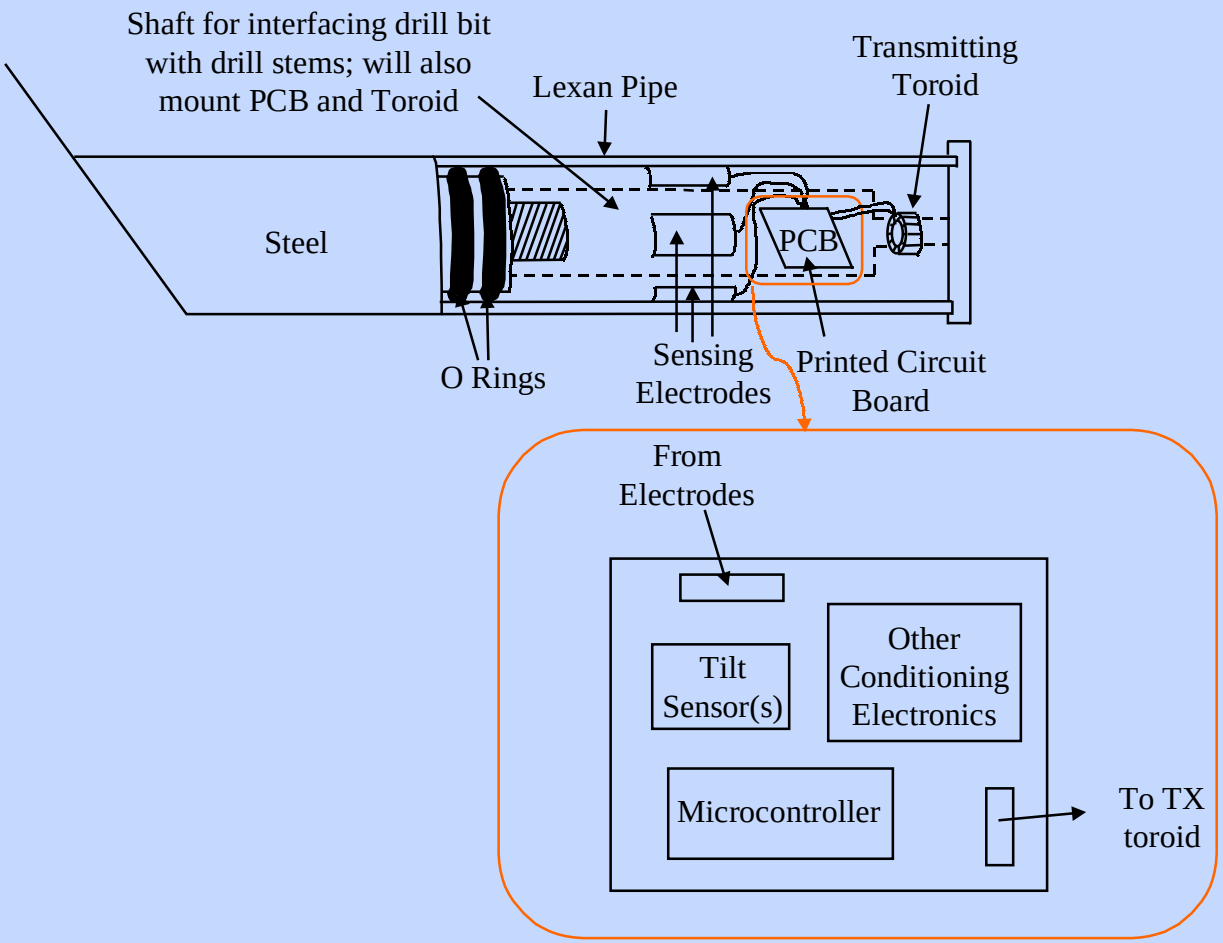
Task 2. Sensor Concept Progress

- 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



Prototype Concept

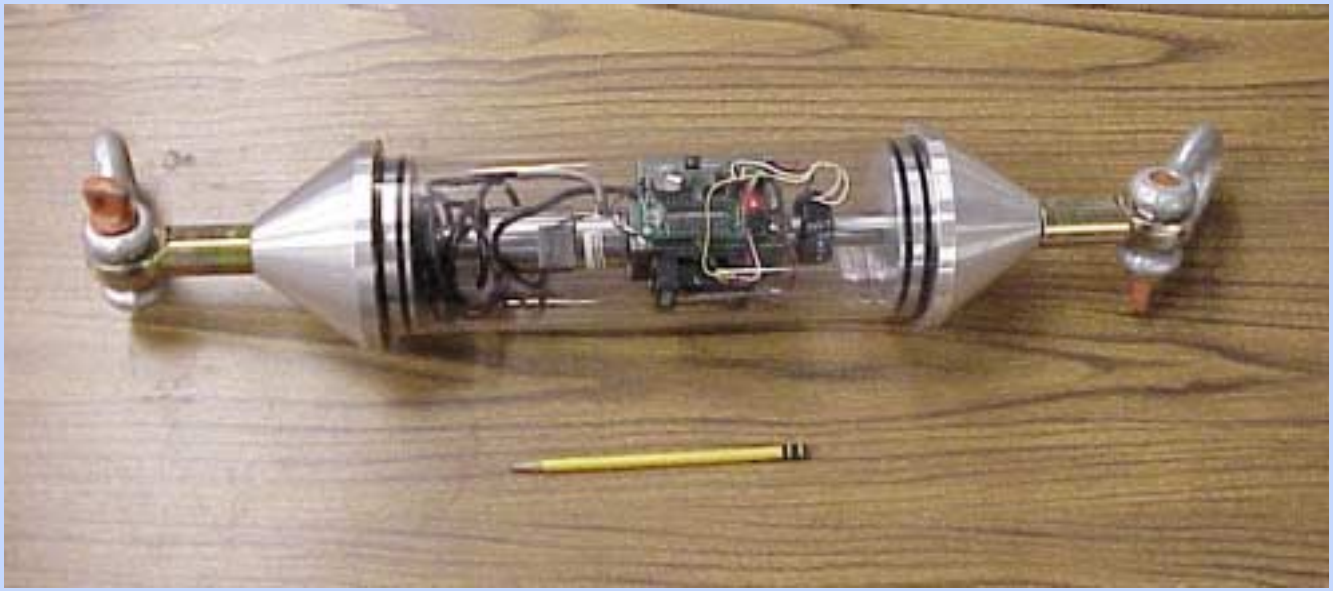


Reasonable Data Requirements

- **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.