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Declarations under Rule 4.17:

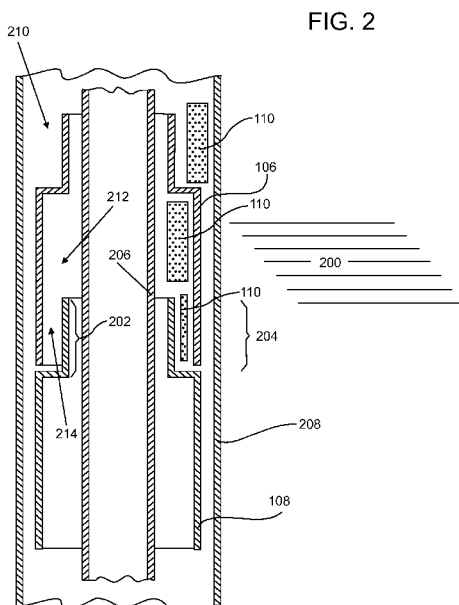
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

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[Continued on next page]

- (54) **Title:** DISTRIBUTED SENSORS TO MEASURE CEMENT STATE



(57) **Abstract:** A system for determining a curing state for cement disposed in a borehole penetrating the earth that includes a transceiver that includes a transmitting coil and that is configured to provide an input signal to the coil that sweeps through a frequency range and to measure the magnitude of the voltage across the coil. The system also includes a plurality of sensor nodes disposed in the concrete. The sensor nodes include a receiving coil and a capacitor coupled to the receiving coil to form a receiving circuit and that has a capacitance that changes as one of pressure or strain in the cement changes.



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AMENDED CLAIMS

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1. A system for determining a curing state for cement disposed in a borehole penetrating the earth, the system comprising:
 - a transceiver that includes a transmitting coil, the transceiver, during operation, providing an input signal to the coil that sweeps through a frequency range and measuring the magnitude of the voltage across the coil as the voltage is swept through the frequency range; and
 - a plurality of sensor nodes disposed in the concrete that includes:
 - a receiving coil; and
 - a capacitor coupled to the receiving coil to form a receiving circuit and that has a capacitance that changes as one of pressure or strain in the cement changes.
2. The system of claim 1, wherein the plurality of sensor nodes do not include a power source coupled to the receiving coil or capacitor.
3. The system of claim 1, further comprising:
 - a computing device that receives the magnitude of the voltage, determines the resonant frequency of the receiving circuit from the magnitude of the voltage and, from the resonant frequency determines the curing state.
4. A method of determining a curing state of cement disposed in a borehole penetrating the earth comprising:
 - disposing a plurality of sensor nodes that includes a receiving coil and a capacitor that form a receiving circuit in a cement slurry, the capacitor having a capacitance that changes based on one of a pressure or a strain;
 - disposing the cement slurry into the borehole;
 - lowering a transceiver into the borehole internal to the cement slurry, the transceiver including a transmitting coil;

providing a voltage to the transmitting coil as the transceiver is being lowered in the borehole;

sweeping a frequency of the a voltage applied to the transmitting coil over a frequency range as the transceiver is being lowered in the borehole;

measuring a magnitude of the voltage across the coil as the voltage is swept over the frequency range; and

determining the curing state based on dips in the measured magnitude.

5. The method of claim 4, wherein the dips occur at a frequency that match a resonant frequency of the receiving circuit.

6. A system for determining a property of cement disposed in a borehole penetrating the earth, the system comprising:

a transceiver that includes a transmitting coil, the transceiver, during operation, providing an input signal to the transmitting coil that sweeps through a frequency range and measuring the magnitude of the voltage across the coil as the voltage is swept through the frequency range; and

a plurality of sensor nodes disposed in the concrete, the sensors including:

a receiving coil; and

a capacitor coupled to the receiving coil to form a receiving circuit and that has a capacitance that changes as one of pressure or strain in the cement changes.

7. The system of claim 6, further comprising:

a computing device that receives the magnitude of the voltage, determines the resonant frequency of the receiving circuit from the magnitude of the voltage and, from the resonant frequency determines the property.

8. The system of claim 7, wherein the property is one of: curing state of the cement and the volumetric distribution of the cement.