New Sensor Principle for Determining the Condition of Roads

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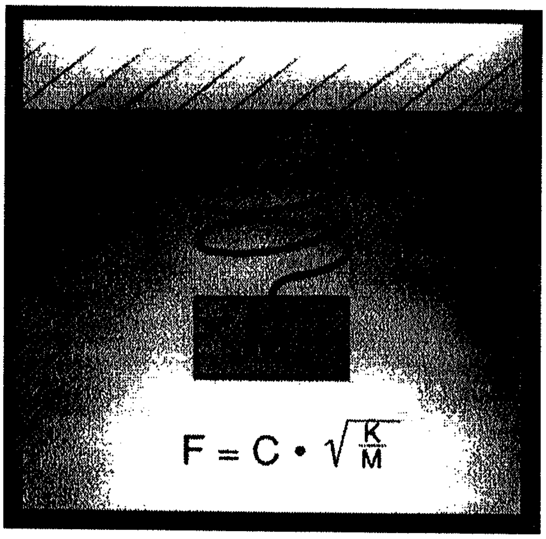
The idea of getting away from the electrochemical conductance method for the determination of the condition of roads using ground probes has been there for some time. There have been thoroughly hopeful results with infra red or microwave scanning of the road surface. The industrial breakthrough of these methods however has still not developed yet for various reasons.

In the following a new physical principle is introduced, namely mechanical vibrations for the quantative measurement of the thickness of water film and for the determination of the quantity of residue salt on roads. In the sector of detection of water film and ice on the bearing surfaces of aircraft the measuring principle of the vibrating membrane has proved itself well in practical use. Hence it is likely that this principle will also be used with modified sensors for the determination of wet and salt residue on streets and runways.

1. Determination of the Quantitative Thickness of Water Film

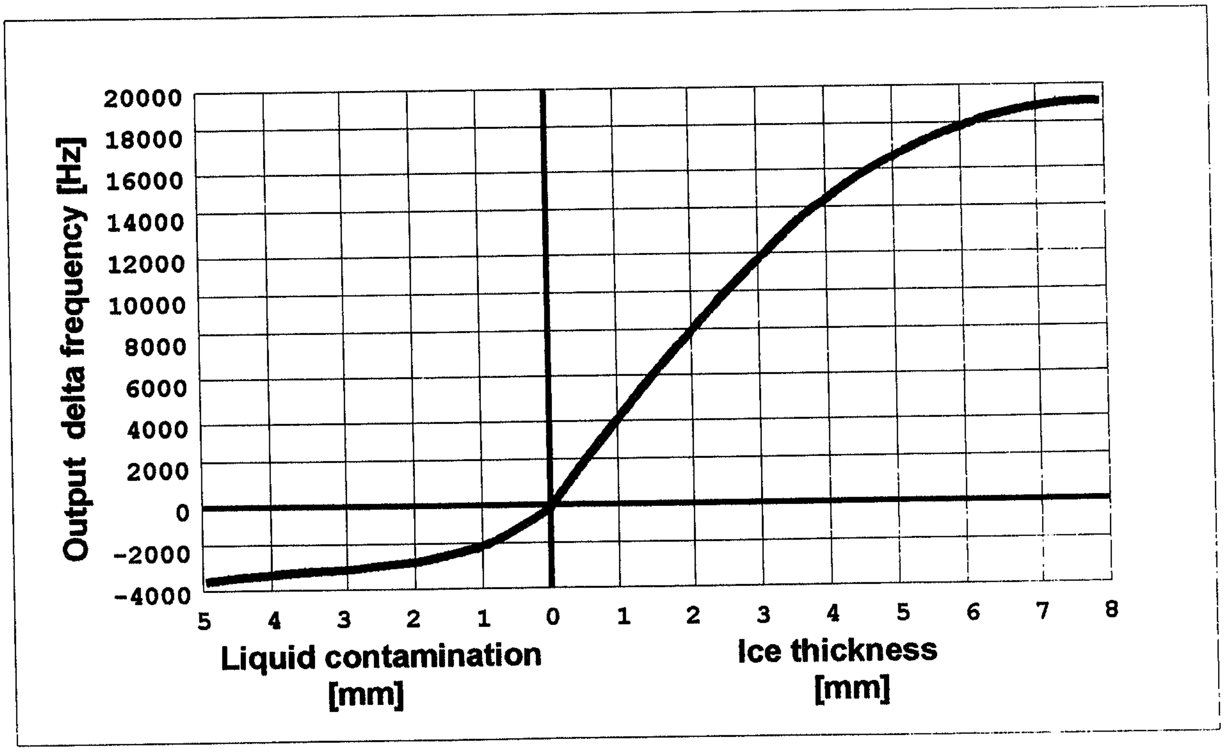
A metal membrane is vibrated using piezo-crystals and kept in the frequency of resonance by means of an active control circuit. The spring/mass vibration system constructed in this way vibrates at about 45 kHz. As with any such vibrating system the frequency of resonance depends on the mass which is moved and the rigidity of the spring. An increase in the vibrating mass leads to a reduction, an increase in rigidity of the spring brings about an increase in the specific frequency of the vibration system.



If this vibrating metal membrane is now introduced as a surface sensor on a road, then a film of water will reduce the specific frequency as the mass increases.

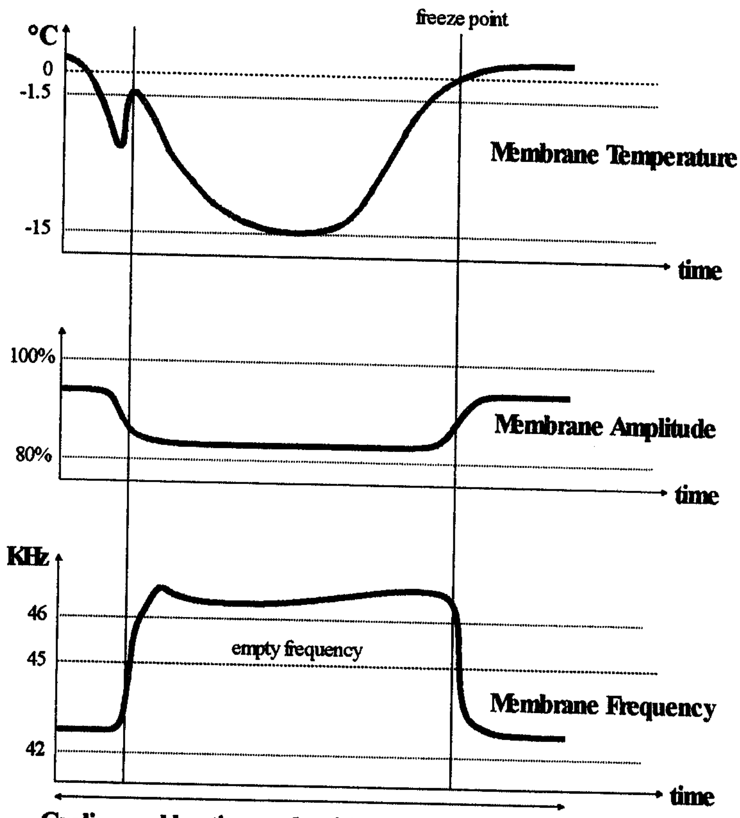
It should be noted that each street surface presents different wetting characteristics. A 1mm column of water in concrete does not correspond to the same quantity of water as a 1mm column of water in draining asphalt. The surface sensor with the vibrating membrane adapts to these local relationships without any problem, both the zero point (dead frequency) and the reduction in frequency can be freely adapted to certain thicknesses of water film. A basic advantage of the measuring method presented here as opposed to previous road probes is that the thickness of water film can be determined quantitatively.

A layer of ice stiffens the membrane, therefore increases the spring constant and brings about an increase in the specific frequency of the vibration system. The vibrating membrane, without hesitation, responds to the thinnest layer of ice and thus allows its thickness to be detected quite simply.



2. Determination of the Freeze Point Temperature of Surface Liquid

The sensitive measuring method of the vibrating membrane provides further important information with regard to the condition of the roads, as the temperature cycles go through. For this purpose a Peltier element is fitted under the membrane, which can effect a Δt of 15°C of the membrane. To also obtain stable frequency responses with a cooling/heating cycle a costly temperature compensation is necessary.



Cooling and heating cycle with water aprox. 90 sec

If the membrane is now cooled, the liquid lying on it solidifies. This is reflected by the vibration system with an increase in frequency. As any liquid can be undercooled, this solidification temperature does not however correspond to the temperature sought after. The freeze point temperature sought after, at which solid and fluid phases are in the same balance, can only be detected with a melt-on process. So the membrane is heated up. When the freeze point temperature is reached the frozen substance lifts free of the membrane. The vibration system records this moment with a drop in specific frequency. The membrane temperature measured at the same time corresponds to the freeze point temperature sought after.

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