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CITATION:

Sasaki, Nobuji. A New Method for Surface Temperature Measurement. Memoirs of the College of Science, University of Kyoto. Series A 1947, 25(1): 37-39

ISSUE DATE:

1947-03-30

URL:

http://hdl.handle.net/2433/257310

MEMOIRS OF THE COLLEGE OF SCIENCE, UNIVERSITY OF KYOTO, SERIES A,
Vol. XXV, No. 1, Article 7, 1947.

A New Method for Surface Temperature Measurement

By

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(Received March 14, 1947)

The idea of the surface temperature is now gaining importance in science, industry and medicine. The method of measurement is varied and not well standardized[1]. The surface temperature is generally affected by emission and absorption of radiation, conduction and convection due to air and evaporation and condensation of vapours. Measuring instruments now in use, such as a thermoelement or a resistance thermometer, not only interfere with these factors, but also often give false results, i. e., the temperature beneath or over the surface. Radiation pyrometry requires the knowledge of emissivity.

In the new method here proposed use is made of a thermoelement[2], whose measuring junction may be heated or cooled to any temperature. A meter inserted in the element circuit naturally indicates the temperature of the junction itself[3], but can also give the temperature of a surface, if the junction temperature has been so adjusted, that no deflection occurs on the meter when the junction is brought into contact with the surface[4], because the absence of deflection means the absence of temperature difference

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1. F. C. Houghten and H. T. Olson: 'Measurement of Surface Temperatures', *Temperature*, American Institute of Physics, New York, (1941), pp. 855—861.

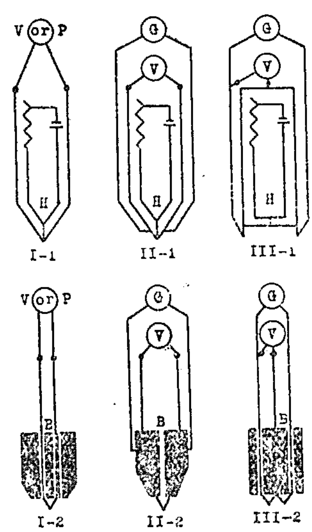
2. In principle a resistance thermometer or even a liquid-in-glass thermometer can be used as well.

3. Judged from the mode of heating, the temperature distribution inside the junction is possibly not so uniform in actual use as when calibrated in a bath with uniform temperature. Error due to this effect may, however, be very small. The surface of a silver or copper block maintained at a definite temperature may serve as a conventional surface of standard temperature, especially when used in the same inclination as the actual surface and just in front of it.

4. For a wet or a liquid surface a non-wetting junction should be used.

between them. The measuring junction may conveniently be kept constant at any temperature by metallic conduction from an electrically heated wire H (type 1), or given a smoothly changing temperature by varying the heating current or by means of a previously heated or cooled metal block B, in which the leads near the junction have been embedded with suitable electrical insulation (type 2), or else heated by radiation (type 3).

Exact results may be obtained, if the temperature jump which occurs in the junction when it touches the surface, is large for a given temperature difference between them. Such will be the case, if the surface has a high thermal conductivity and a heat capacity far exceeding that of the junction, and further if the junction has a large contact surface, a small heat capacity and a small heat loss due to conduction, convection and radiation, though some of these latter conditions are contradictory among themselves and also with the requirement for the junction to have sufficient mechanical robustness and material connection[1] with a heat source. As to the meter to be inserted in the thermoelement circuit we may use a millivoltmeter V (less exact) or a potentiometer P (more exact but awkward) (I), but exactitude and convenience can both be achieved with a millivoltmeter V in the full *emf* circuit and a zero instrument such as a sensitive short period galvanometer G either in a circuit in which the *emf* is partly compensated by the reference junctions maintained nearly at the same temperature as the measuring junction (II), or in a circuit with *emf* almost completely compensated by a symmetrically connected secondary thermoelement (III). These electrical circuits with each of the two types 1 and 2 of measuring junction are given in the figures.



To measure the surface temperature with a measuring junction type 1 we proceed thus: first, adjustment of the junction to a certain proba-

1. Such is unnecessary for the junction type 3.

ble temperature, secondly, a brief contact with the surface, thirdly, a suitable adjustment according to the magnitude and the direction of deflection; this process is repeated until no deflection occurs. The junction temperature finally adjusted is the surface temperature. To make measurement with a measuring junction type 2 it is brought to a suitable initial temperature and left to change smoothly. Brief contacts are then repeated regularly. At first the deflection will decrease and pass through zero to increase again in the opposite direction. The junction temperature corresponding to zero deflection is the surface temperature. To be precise, the temperature of junction type 1, which has been adjusted to T at some distance from the surface, will always change to $T+\Delta T$ just before the contact is made[1]. $T+\Delta T$ is then obviously equal to the surface temperature if no deflection occurs. To minimize this inconvenient ΔT the junction should be adjusted at a point as near the surface as it does not sensibly affect the surface temperature.

The validity of the new method has been roughly tested by measuring surface temperatures along a steam-fed tube with varying thickness (with conical bore), using an iron-constantan element and a millivoltmeter. The value extrapolated to zero thickness was found to be 100 ± 1°C. An automatic rapid performance of the instrument is in view.

The present investigation was carried out by the Education Ministry grant for natural science.

1. This is due to the temperature gradient in the ambient air and to the radiation from the surface, apart from irregular air draughts. ΔT depends on the speed of approach and apparently also on the quickness of response on the part of the meter.