UNCLASSIFIED

AD 667 704

THERMOELECTRIC HEAT-FLUX MEASURING ELEMENTS

O. A. Gerashchenko, et al

Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

15 August 1967

AD 667704

FTD-HT-23-689-67

FOREIGN TECHNOLOGY DIVISION

THERMOELECTRIC HEAT-FLUX MEASURING ELEMENTS

by

O. A. Gerashchenko and V. G. Fedorov

50 YEARS

1917 1967

GOLDEN ANNIVERSARY

FOREIGN TECHNOLOGY DIVISION

APR 22 1968

Distribution of this document is unlimited. It may be released to the Clearinghouse, Department of Commerce, for sale to the general public.

10

This translation was made to provide the users with the basic essentials of the original document in the shortest possible time. It has not been edited to refine or improve the grammatical accuracy, syntax or technical terminology.

FTD-HT-23-689-67

UNEDITED ROUGH DRAFT TRANSLATION

THERMOELECTRIC HEAT-FLUX MEASURING ELEMENTS

By: O. A. Gerashchenko and V. G. Fedorov

English pages: 6

SOURCE: AN SSSR. Sibirskoye Otdeleniye. Institut Avtomatiki i Elektrometrii. Trudy. (Academy of Sciences of the USSR. Siberian Branch. Institute of Automation and Electrometry. Transactions), Vol. 2, 1966, pp. 207-210.

Translated by: F. Dion/TDBXT

TT7001032

ITIS INDEX CONTROL FORM

01 Acc Nr	68 Translation Nr	65 X Ref Acc Nr	76 Reel/Frame Nr
TT7001032	FTD-HT-23-689-67	AT6011939	1881 1245

97 Header Clas	63 Clas	64 Control Markings	94 Expansion	40 Ctry Info
UNCL	UNCL, 0	0		UR

02 Ctry	03 Ref	04 Yr	05 Vol	06 Iss	07 B. Pg.	45 E. Pg.	10 Date
UR	3005	66	002	000	0207	0210	NONE

Transliterated Title
TERMOELEKTRICHESKIYE IZMERITEL'NYYE ELEMENTY TEPLOVOGO POTOKA

09 English Title
THERMOELECTRIC HEAT-FLUX MEASURING ELEMENTS

43 Source
AN SSSR. SIBIRSKOYE OTDELENIYE. INSTITUT AVTOMATIKI I ELEKTROMETRII. TRUDY. (RUSSIAN)

42 Author	98 Document Location
GERASHCHENKO, O. A.	
16 Co-Author	**47 Subject Codes**
FEDOROV, V. G.	20, 07
16 Co-Author	**39 Topic Tags:**
NONE	thermocouple, conductive heat transfer, intensive heat transfer, flow measurement
16 Co-Author	
NONE	
16 Co-Author	
NONE	

ABSTRACT: The knowledge of the local value of the heat flux is very important information for the understanding of processes in devices based on heat exchange. In the past no instruments were available for the measurements of heat transfer through very small surfaces in objects of arbitrary configuration. Consequently, the present authors developed universal, highly accurate and stable devices which do not generate distortions of the original physical process. The units are based on differential thermocouples using thermoelectrode materials as auxiliary walls generating a temperature difference proportional to the heat flux. The existing devices can measure local heat fluxes up to 140,000 WaH/m^2, and single sensors are 8 mm in diameter and 1 mm high. More complicated geometrical arrangements can gather 100 single sensors within a d = 25 mm, h = 1.5 mm disk, or 1,000 sensors within a d = 10 mm, h = 1.2 mm space. Work is in progress on a 1,000,000 W/m^2 unit. The maximum operating temperature is 1,500C. When the sensor is built along an isothermal surface, then the distortion of the original field may be completely neglected and the operating temperature raised up to 6,000C. Orig. art. has: 2 figures. English Translation: 6 pages.

THERMOELECTRIC HEAT-FLUX MEASURING ELEMENTS

O. A. Gerashchenko and V. G. Fedorov

(Kiev)

The local value of the heat flux gives very important information about processes and equipment based on heat exchange. Its intensity can be very diverse, from fractions to tens of millions of W/m^2; the processes of heat exchange realized by thermal conductivity, convection, radiation or their combination are also different. It is especially necessary to localize the measurements of heat fluxes in physiological investigations, when equipment is being developed for a new technology, in automatic control systems and in the regulation of technological processes.

There is not yet a heat-measuring instrument that would allow us to measure the quantity of heat passing through sufficiently small sections of the heat-exchange surface at any point on a body of any configuration. Through some degree the present work fills that gap. The basic requirements presented to heat-flux sensors were universality, high accuracy and stability of measurements, and the absence of distortions of the physical picture of the process during their application.

A differential thermocouple using the material of its thermoelectrodes as an additional wall to obtain a temperature difference proportional to the heat flux is the basis of the heat-flux measuring elements we developed [1, 2]. This combination of the functions of an additional wall and sensing elements allows us to obtain small-size low-inertia sensors.

A single heat-flux sensor (Fig. 1, a) is a triple-layered wall of metallic thermoelectrode materials. The temperature difference to be recorded arises on the faces of the middle layer when a heat flux passes through the sensor. A temf proportional to the heat flux arises on these faces in the couple with the material of the edge layers. Leads that are thermoelectrically similar to the edge layers are welded to them; the signal from the sensor is fed along these leads to the recording instrument.

Instruments for measuring local heat fluxes up to 140,000 W/m^2 with single sensors (d = 8 mm, h = 1 mm) have been developed and put into practice at certain enterprises and scientific establishments.

The use of platinum or copper as the edge layers and the current-carrying leads, and of constantan as the middle layer, allows an operating temperature of the sensors up to 1000 and 700 C respectively. The middle layer can be made from certain ceramic materials, in particular, silicon carbide, which increases the temperature up to 1500 C and the signal of the element by one order. Instruments for heat fluxes up to 1,000,000 W/m^2 are now being developed.

When the sensor is built into or applied on an isothermal surface, in view of the low thermal resistance of the sensor it takes on the temperature of this surface and in most practical cases we can disregard the distortion of the physical picture of the process.

Therefore, the temperature of the surrounding medium does not limit application of the sensor and in one of the developed variants of heat-measuring equipment this temperature reaches 6000 C.

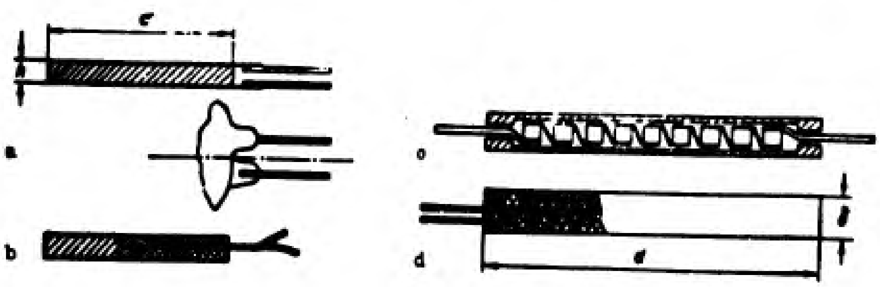

Fig. 1. Types of heat-flux measuring elements: a and b) single sensors with peripheral or central exit of the thermoelectrode; c) battery sensor of the "dry cell type"; d) battery sensor of the "spiral" type.

The electrical signal of a single sensor is very weak (1-2 μV for 1000 W/m^2); therefore, even for large heat fluxes M-195 or F-18 universal galvanometers are used as the secondary instrument. For small heat fluxes, up to 10,000 W/m^2, their application is hampered by the diverse nature of the noises. To remove this deficiency, we developed battery heat-flux sensors (see Fig. 1, c, d). The "dry cell" sensor (see Fig. 1, c) is a battery of serially connected small-size single elements inclosed in a metallic skin or ceramic tablet. "Dry cell" sensors are made by welding constantan blocks and copper foil connectors. The battery is insulated from the skin with mica plates about 0.01 mm thick. A battery of 100 single sensors will fit into a disc with d = 25 mm and h = 1.5 mm.

"Spiral" sensors (see Fig. 1, d) allow fitting up to 1000 elementary sensors in a d = 10 mm and h = 1.2 mm disc. A flat spiral tape of thermoelectrode material is electrolitically covered on one side with another material. The tape is insulated with lacquer and turned such that the points of transition from a "double" to a "single" electrode are on the faces of the obtained disc. The disc is encapsulated in epoxy resin or a high-temperature lacquer (in this case the disc is inclosed in a metal skin), or baked in a porcelain tablet.

The battery sensors have a rather high signal, which allows them to be used with a rough secondary instrument of the dial millivoltmeter type; this also allows us to recommend their use in investigating the local heat exchange in rotating installations, while the high sensitivity of the sensors allows them to record small thermal fluxes (on the order of 10^{-2} W/m^2) with high accuracy, which is especially important in measuring radiative heat fluxes and temperatures.

The calibrated graphs of battery sensors in a wide interval of heat fluxes are straight (Fig. 2) or weakly curved lines.

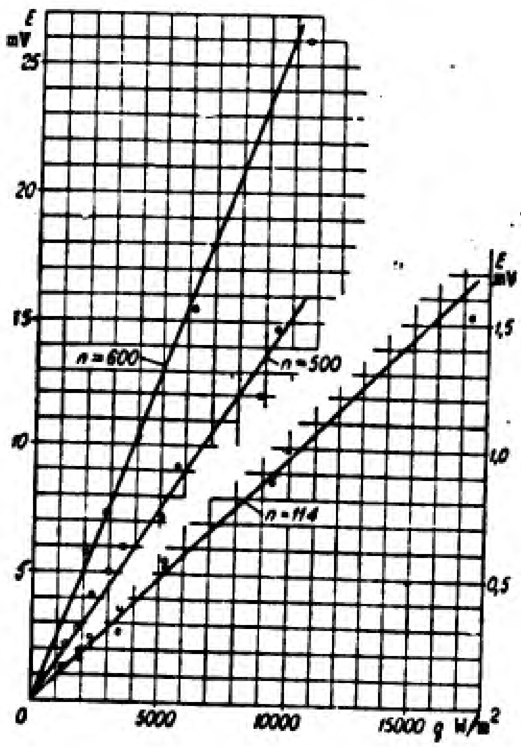

Fig. 2. Typical calibrated graphs of battery heat-flux measuring elements (n is the number of elementary sensors).

All the types of sensors are calibrated on a special stand consisting of a low-inertia emitter of powerful heat fluxes and radiometric devices [3, 4]. The possib..ty of developing and absolutely measuring stable fluxes of beam energy in a wide range of intensities (10^2-3 · 19^5 W/m^2) allows us to speak about the error in measuring heat fluxes by calibrated sensors not exceeding 3-6% of the measured magnitude. The sensor readings are sufficiently stable, which is supported by repeated calibrations after the sensors have operated in different conditions, including at their maximal temperature.

Sensors produced in small lots are already finding application in industry and research establishments to measure local heat losses through high-temperature insulation, to check out different heat-exchange apparatuses, etc.

The high sensitivity of battery sensors allowed us to construct a simple and compact instrument for rapid determination of the thermophysical constants of different materials by the block method and to find the temperature dependence of the thermal conductivity of samples of new heat-resistant insulation, Stal'fol', Penosil and glass Textolite.

By placing a filter of the test material in the path of the energy flux to the sensor it is rather simple to determine the coefficient of passage of beam energy. An experimental determination of the integral coefficient of heat passage for several substances showed good agreement with the calculated data.

Based on these sensors we have developed equipment for controlling different technological processes, growing refractory crystals in crystallization furnaces, thermal processes in the tuyere zone of blast furnaces and in molten-salt electrolyzers.

The large specific signal of the battery sensor (per unit of the surface perceiving the flux) allows it to successfully compete with the known instruments for measuring high temperatures by noncontacc methods based on the principle of a thermocolumn or a bolometer. One significant difference of this sensor is the practical independence of the instrument's operation from the conditions of its cooling. In particular, with these sensors we can solve the problem of measuring the temperature of semitransparent highly-heated gases by the method proposed by G. Shmidt in 1909. The effect of the rear wall, the background, must be precluded by measuring three magnitudes: the incident energy from the hot background, the incident energy from the cold background and the temperature of the hot background. Attempts to realize this method were usually not successful due to errors in measuring the incident flux of beam energy.

These sensitive elements can find wide application in automatic control systems utilizing regulation with respect to the thermal flux, temperature or temperature deri ative.

Literature

1. Gerashchenko, O. A. and V. G. Fedorov. Pribor dlya izmereniya lokal'nykh teplovykh potokov. (An Instrument for Measuring Local Heat Fluxes), Teploenergetika, No. 6, 1958.

2. Gerashchenko, O. A. and V. G. Fedorov. Datchik teplovogo potoka. (A Heat-Flux Sensor), Izv-vo VINITI, No. P-58-80/8, 1958.

3. Gerashchenko, O. A. and V. G. Fedorov. Maloinertsionnyy izluchatel' moshchnykh teplovykh potokov. (A Low-Inertia Emitter of Powerful Heat Fluxes), Avtomatika i priborostroyeniye. Kiev, No. 2, 1962.

4. Gerashchenko, O. A. and V. G. Fedorov. Pribor dlya izmereniya luchistykh potokov bol'shoy intensivnosti. (An Instrument for Measuring High-Intensity Beam Fluxes), Izd-vo GOSINTI, No. P-62-45/6, 1962.