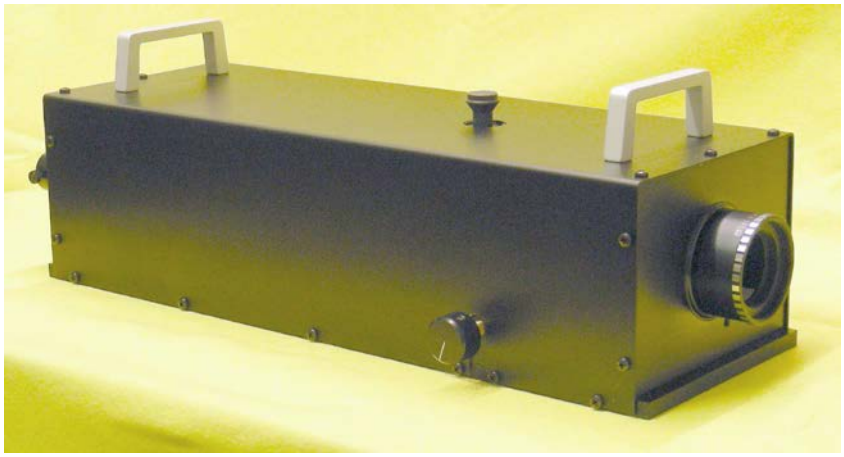
LINEARPYROMETER LP4

Technical Documentation KE 256-6.2007



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1. General Description

With the Linearpyrometer Type LP4 a measuring instrument has been made available for pyrometric and radiometric laboratory applications, whose design and construction allows highest requirements to be met.

At the new LP4 the opto-mechanical arrangement was conceived in most parts as well as the electronics. The main changes are:

- Replacement of the double achromate by an apochromate specially designed for the range 500 nm to 1700 nm.
- Replacement of the manually driven double filter wheel arrangement by a single wheel with integrated stepping motor drive. The digital motor drive electronics is optimised with regard to elimination of any disturbtance of the thermometric measurement by electro-magnetic interferences and thermal drift caused by the power electronics. An additional friction-free mechanical fine positioning is applied to ensure that the filter position has a very good reproducibility and long term stability.
- The photodiode and the filter wheel box are temperature-stabilised with a temperature of about 29 °C.
- The filter wheel with six places permits the selection of one of different spectral filters - if necessary combined with a neutral density filter - or for special application various aperture stops. This results in a high adaptability to special measurement demands:
- adaptation of centre wavelength and bandwidth, according to temperature range and actual measurement requirements (e.g. emissivity or transmittance bands of foils and gases),
- measurement of monochromatic and/or ratio radiance temperatures,
- application of multi-wavelengths evaluation and polarisation pyrometry,
- "in situ"-calibration of the effective wavelength of the interference filters.
- The target field stop and aperture stop are exchangeable, and different objectives can be used. Therefore distance target diameter and aperture angle can easily be adapted to the corresponding demands.

Measuring Principle and Construction

The outer as well as the inner photoelectric effect allows the construction of a radiance measuring instrument the output signal of which is highly proportional to the incident radiation flux. In the 'Linearpyrometer' which was designed and constructed by the IKE, this measuring principle developed by the PTB is applied in conjunction with a highly stable optical set-up which is particularly suitable for precision radiation thermometry. By the possibility of changing the objective lenses, spectral filters, neutral density filters and target field stop, high adaptability to a large variety of measuring tasks has been achieved.

For calibration, the comparison to only one suitable temperature fixed point (as, for example, the gold point) will suffice if the spectral transmittance of the interference filter is measured by means of a monochromator. Owing to the linearity, it will then be possible to define the temperature scale according to Planck's radiation law.

The instrument was tested for linearity, stability and resolution under various conditions. The errors detected kept each within a range of < 0.1 up to 0.5 % of the radiance, which corresponds to temperature errors of approx. 0.06 K up to 0.3 K at 1200 K, resp. up to 0.8 K at 2000 K measuring temperature. In individual measurements, at currents < $1 \cdot 10^{-12}$ A the relatively increased noise component exceeds the determined measuring uncertainty. With standard equipment of the instrument (silicon-detector, measuring field stop 0.25 mm ∅, interference filter 650 nm, 10 nm HBW) this corresponds to a temperature of 950 K.

2. Design and Operation

The measuring head comprises the optical system, the photodiode, and the complete measurement signal evaluation system. The arrangement is schematically shown in fig.1. The objective lens forms an image of the target in the measurement field stop plane. This can be observed through the adjusting telescope (intermediate lens and eyepiece). The circular aperture of the measurement field stop defines the measuring area. The radiation impinging on this area is rendered parallel by the collimator lens and falls on the photodiode after having passed through the spectral filter and, if necessary, through the neutral density filter. Directly before the spectral filter the aperture stop is arranged. An optical adapter consisting of 3 lenses and an adjustment system is used to focus the radiation onto the silicon detector.

The photodiode and the high-impedance electronic circuit including AD converter are incorporated in a measuring cell the temperature of which is thermostatically controlled (and also of the complete filter wheel box). The photocurrent measuring signal (unit ampere), the calculated radiance temperature or alternately the measuring cell temperature as well as the position of the filter wheels are displayed at the rear face plate, fig. 2.

The data-processing and -display together with the complete pyrometer control and the PC-Interface (RS-232C type) is accomplished by a microcontroller on the PCB which is mounted directly onto the rear face plate. At the rear face additionally arranged are the function keys for the manual control / stand-alone-operation of the instrument, the eye piece and the connectors to PC, power-supply and the optional high speed analog output signal.

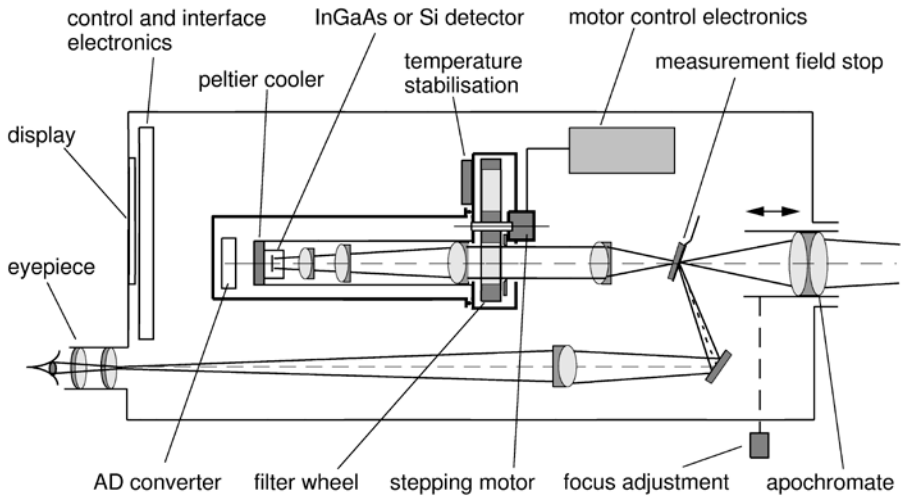


Fig. 1: Optical, mechanical, and electronic arrangement of the measuring head

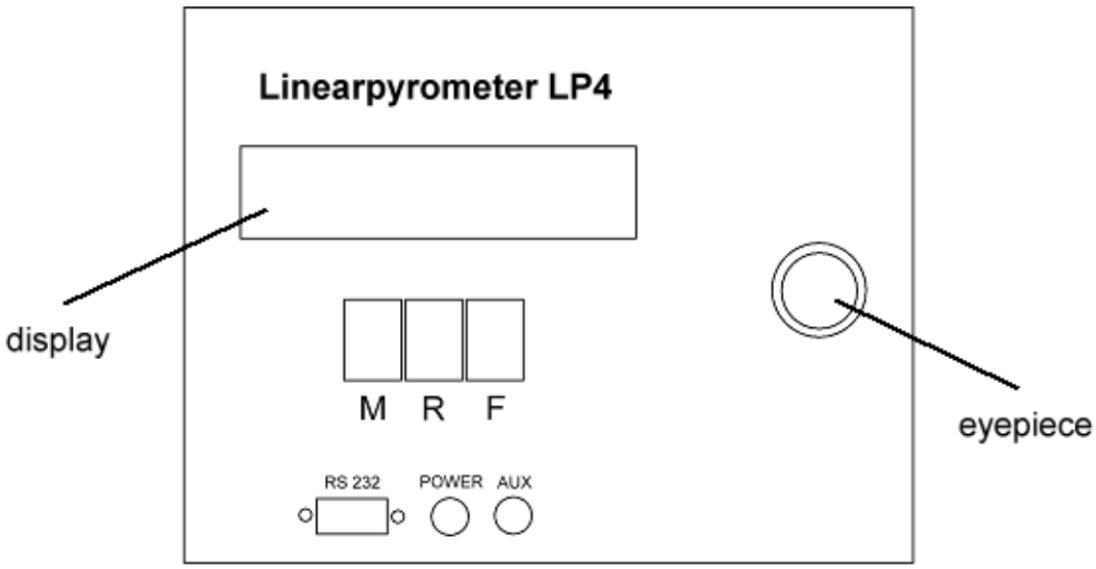


Fig. 2: Measuring head, rear face plate

Annex A

General Data of the Linearpyrometer LP4

The values given below are valid for standard equipment (actual values see Data Sheet for particular instrument):

Optics and filters

- front objective: f = 143 / 40 mm aperture, Apochromate f143
- target field stop: 0.25 mm diameter
- aperture stop: 9.0 mm diameter
- interference filter: 650 nm, 10 nm HBW

Measurement range

Photo current $1 \cdot 10^{-12}$ A to $8 \cdot 10^{-7}$ A

Temperature 950 K to 3000 K
- with ND-filter up to 3800 K

Target size

Distance front lens / target [mm]	600	2000
Aperture diameter [mm]	38	33
Target diameter [mm] *)	0.8	3.4

*) Size of source uncertainty: 0.04 % of measured photo current

Measurement uncertainty

Measured temperature	1200 K	1600 K	2000 K	2400 K	2800 K
Uncertainty U *(extension factor k = 2, confidence level 95 %)*	0.8	1.2 K	2.1 K	3.4 K	4.8 K
Long-term stability *(during 6 months, ambient temperature 22 °C ±3 °C, k = 1)*	0.25 K	0.5 K	0.9 K	1.5 K	2.4 K
Temperature drift between 22 °C and 28 °C ambient temperature (offset current subtracted)	$3 \cdot 10^{-4}\,K^{-1}$				

Settling time

Changing signal from 5 % to 98 % of the photocurrent:	0.4 s
Changing signal from overflow to 2 % deviation of the final value	0.8 s

Time constant

Increase to 90 % of final value	0.2 s

Analog Output (optional!)

Output voltage 0 to +7.2 V corresponding to 0 to 8nA (range R1) or 800nA (range R2)

Rise-time to 90% of change in all ranges	2 ms

On special demand even faster rise time is optionally available:

Rise-time to 90% of change in range R1 (8nA)	450 µs
Rise-time to 90% of change in range R2 (800nA)	75 µs

Permissible ambient conditions

Storage temperature:	15 °C to 30 °C
Working temperature range:	23 °C to 27 °C
Relative humidity:	10 % to 70 %

Adjusting facilities

adjustment telescope	free of parallax, brightness adjustable
adjustment lamp (option)	internal or external, green LED (light emitting diode)

Filter

One stepper motor driven filter wheel placed in the parallel path of rays with 6 places for filters (∅ 25 mm) or special aperture stops.

Displays

- Photo current: 799 999 counts,
- Calculated radiance temperature,
- Temperature of the measuring cell,
- Position of the filter wheel

Output/Input via RS232/V24 interface

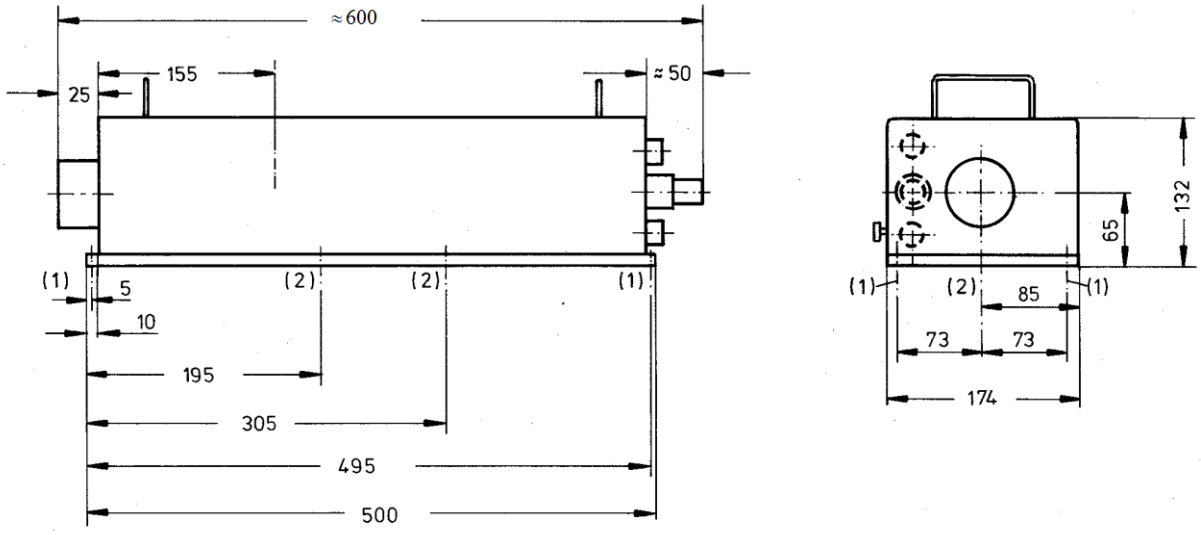
- output of the measured signal,
- output of the calculated temperature and position of filter wheels,
- output of temperature of measuring cell,
- input of calibration data.

Power supply (special equipment!)	**<u>115 V or 230V,</u>** 50 / 60 Hz
Power requirement	approx. 38 VA (55 VA max.)
Fuse :	2 x 0.5 A delay

Weights and outer dimensions

Measuring head	approx.: 12 kg; 600 mm x 178 mm x 140 mm
Power supply unit	approx.: 1 kg; 215 mm x 110 mm x 78 mm

Mounting dimensions of the measuring head



(1): 6 bolt holes, 4.5 mm diameter, 3 of which can be used for table mounting

(2): 2 blind tap holes M6 for screwing on a mounting plate from the lower side