

DFP 2000 DISAPPEARING FILAMENT

OPTICAL PYROMETER

**MANUAL FOR
OPERATION AND
MAINTENANCE**



HeatWave Labs, Inc.



This manual, Rev. 1 date 123002, covers DFP 2000 Pyrometers
with serial numbers greater than 21039

Where to Get More Information

This owner's manual represents the most current information at the time it was published;
for the latest information, please visit our website: www.cathode.com.

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1 Specifications

DFP 2000 Portable Disappearing Filament Optical Pyrometer	
Measurement Technology	Disappearing Filament
Measurement Ranges	Range 1 760°C to 1240°C/1400°F to 2264°F Range 2 1075°C to 1760°C/1967°F to 3200°F Range 3 1500°C to 2850°C/2732°F to 5162°F Range 4 1900°C to 4200°C/3452°F to 7592°F
Wavelength	0.65 microns (same as Leeds & Northrup optical pyrometers and the current N.I.S.T. standard)
Focal Range	Standard 7" to infinity Optional close up lens 2" to 6" Optional telephoto lens 24" to infinity
Small Target Capability	0.004" or smaller, depending on application
Accuracy	% of reading +/- 1 digit: Range 1-0.25%; Range 2-0.3%; Ranges 3 and 4-0.4% All under blackbody conditions
Ambient Temperature Range	0°C to 50°C/ 32°F to 122°F
Humidity	0 to 90% RH, non-condensing
Power	Rechargeable battery with "auto off" battery saver circuit
Display	Liquid Crystal [LCD] with 1° resolution, field changeable to °C or °F
Output	Analog, proportional to lamp current
Housing	Cast Aluminum
Tripod Mounting	1/4" x 20 thread
Weight	Approximately 1.6Kg/3.5 lbs.
Size	Approximately 6" W x 9" L x 2.75" H (15 x 23 x 7 cm)
Math Function	Averages up to 10 readings on demand
Battery Life	12 Hour continuous operation
Storage Temperature	-20°C/-4°F to 70°C/ 158°F

Due to continuing development and research, HeatWave Labs, Inc reserves the right to Change specifications without notice

Figure 1. DFP 2000 Pyrometer

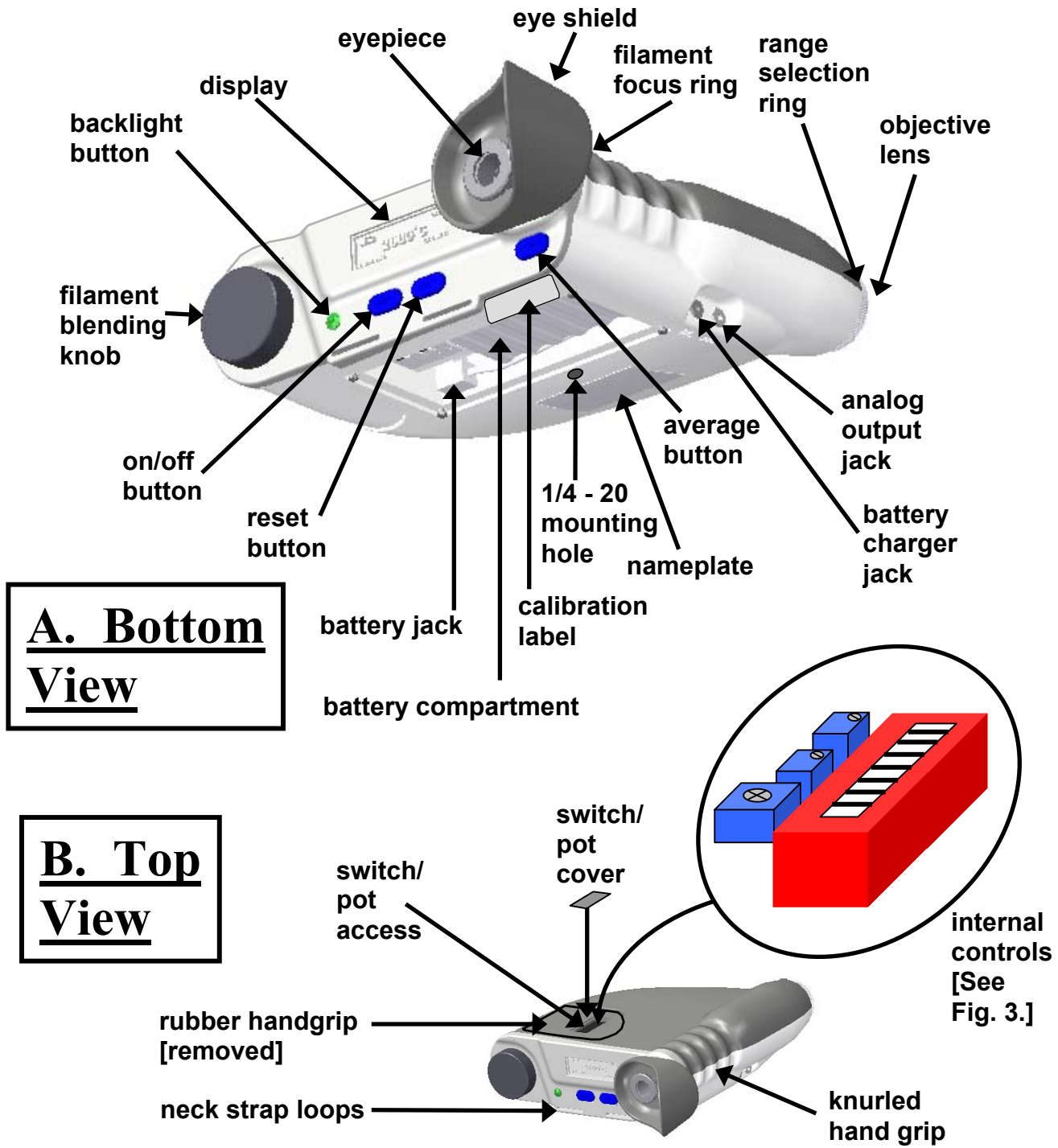
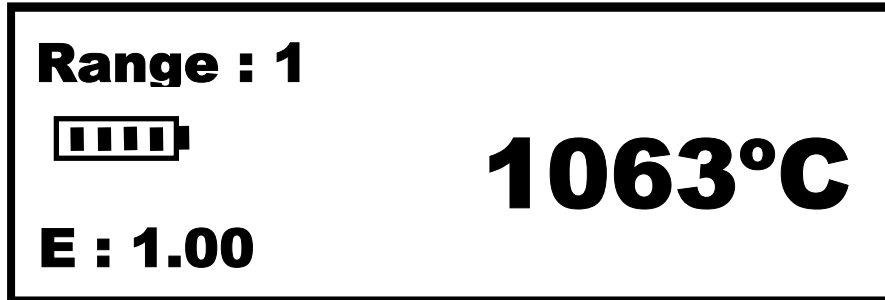


Figure 2. DFP 2000

A. Normal Mode

Temperature
Range Selection

Battery
Indicator

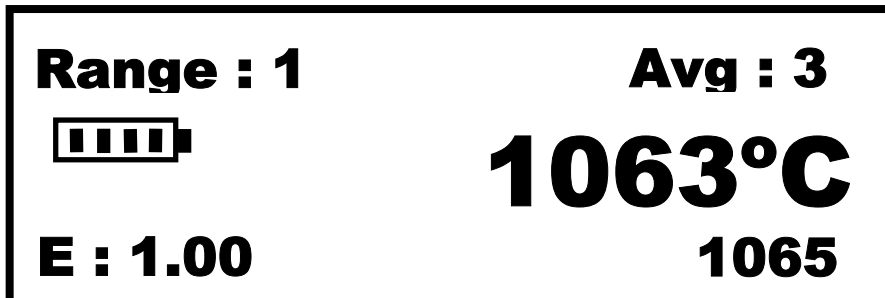


Emissivity
Selection

Temperature Value and Units

B. Averaging Mode

Number of
Measurements
in Present Average



The large characters display the present temperature. The smaller numerals in the lower right portion of the screen display the average of the measurements made while pushing the average button.

2 Introduction

The DFP 2000 optical pyrometer is a rugged, lightweight, state-of-the art instrument, designed to provide highly accurate measurements of incandescent target temperatures. It is based on the disappearing filament principle where a calibrated lamp filament is positioned within an optical viewing path and the brightness of a hot target is matched by the brightness of the lamp filament as it blends [i. e. disappears] into the glowing background of the target.

3 Unpacking

Before unpacking, note any damage to the shipping carton for which the carrier may be liable. After removing the molded carrying case from its shipping carton, carefully check its contents against the shipping list. If items are missing, contact HeatWave Labs immediately.

Standard items included with your unit are:

Molded polyethylene storage case

A DFP 2000 disappearing filament pyrometer with standard objective lens

Battery charger/AC adapter with cable
detachable neck strap

Optional items include

N. I. S. T. traceable report of calibration

Close up objective lens

telephoto objective lens

4 Operation

IMPORTANT - PLEASE READ BEFORE USING YOUR PYROMETER

- NOTE #1 The human eye may not adjust to the level necessary to make a successful reading on the first try. Therefore, several readings (3-6) should be taken until a repeatable result is achieved. If a repeatable result cannot be achieved, then an average of the readings taken should be used. See manual for automatic averaging procedure.
- NOTE #2 Depending on the characteristics of the individual lamp, the filament may not completely disappear. A thin dark border on top of and below the filament sometimes occurs making it impossible for a complete blend. Or, only a portion of the filament may disappear; in either case, the objective should be to match the color of the center of the filament to the target.
- NOTE #3 The filament and the target must be kept in sharp focus at all times and should be refocused to the vision requirements of each operator. **DO NOT BLUR** the focus of either in an attempt to cause the filament to disappear or an incorrect reading will result.
- NOTE #4 Disappearing filament pyrometers operate at .65 microns, which is in the red region of the visible spectrum. Using such a short wave length makes the DFP 2000 pyrometer less susceptible to changes in emissivity than infrared pyrometers which operate at wavelengths of about 1 micrometer or longer. The DFP 2000 pyrometer is, however, not immune to emissivity and a correction factor must be used to take a true temperature. However, in applications such as in the glass industry where emissivities are high (.93 or better), successful operating practices are often established without using true temperatures in which case the DFP 2000 pyrometer may be used with an emissivity of 1.0 See manual for a description of emissivity selection.

4.1 Preparing to make a measurement

4.1.1 Battery Check [REQUIRED]. Press the ON/OFF button and confirm that the LCD display appears and that the battery indicator on it is NOT flashing. If it is, see section 6. Powering the Instrument.

Caution: Never connect the battery charger without having batteries plugged into the battery jack within the battery compartment. Doing so can result in serious damage to the electronics of the instrument.

4.1.2 Temperature Units Check [REQUIRED]. Rotate the Filament Blending Knob until a temperature is displayed. Confirm that temperature is being reported in the desired units [$^{\circ}\text{F}$ or $^{\circ}\text{C}$]. If not, see 4.4 Temperature units selection, below.

4.1.3 Emissivity Check [REQUIRED]. Confirm that the emissivity indicated on the display is the emissivity desired for the application. See 4.5-emissivity selection below.

4.1.4 Eye Shield Adjustment [OPTIONAL]. The DFP2000 pyrometer is shipped configured for right eye viewing. The raised part of the eye shield is to rest on the right cheek. To prepare for left eye viewing, loosen knurled ring at the eyepiece, rotate the eyepiece such that the raised part of the eye shield will rest on the left cheek, and tighten the knurled ring.

4.1.5 Filament Focus [REQUIRED]. While sighting on a bright object, turn the filament focus behind the eye shield until the lamp filament [dark, horizontal line] is in sharp focus.

4.1.6 Choosing The Objective Lens [OPTIONAL]. Target distance and target size determine choice of objective lens. All DFP2000 pyrometers are shipped with a standard objective lens with a focal range of 7 inches to infinity. Recommended for closer targets is the optional close-up lens with a focal range of 2 inches to 6 inches. Recommended for distant targets small enough to make filament blending with the standard objective lens difficult is the optional telephoto lens with a focal range of 24 inches to infinity.

4.1.7 Changing The Objective Lens [OPTIONAL].

The objective lens assembly is removed by rotating it to its fullest extension out from the instrument case. The assembly is placed back into the instrument by screwing the threaded end [not the knurled end] into the hole at the front of the instrument.

4.1.8 Tripod Mount [OPTIONAL]. The DFP2000 pyrometer may be secured to a standard camera tripod using the $\frac{1}{4}$ "-20 hole threaded into the base of the aluminum case.

4.1.9 Range Selection [REQUIRED]. Because of the characteristics of the internal lamp and the nature of the human eye it is necessary to segment the full temperature scale of the DFP2000 pyrometer into four ranges.

The ranges available are:

Range 1 760 $^{\circ}\text{C}$ to 1240 $^{\circ}\text{C}$ /1400 $^{\circ}\text{F}$ to 2264 $^{\circ}\text{F}$

Range 2 1075 $^{\circ}\text{C}$ to 1760 $^{\circ}\text{C}$ /1967 $^{\circ}\text{F}$ to 3200 $^{\circ}\text{F}$

Range 3 1500 $^{\circ}\text{C}$ to 2850 $^{\circ}\text{C}$ /2732 $^{\circ}\text{F}$ to 5162 $^{\circ}\text{F}$

Range 4 1900 $^{\circ}\text{C}$ to 4200 $^{\circ}\text{C}$ /3452 $^{\circ}\text{F}$ to 7592 $^{\circ}\text{F}$

There are two methods of selecting the temperature range. One is used where the approximate temperature of the target is known. The other is used where the target temperature is initially unknown.

4.1.9.1 If the approximate target temperature is known,

1. Choose a range such that the anticipated target temperature lies as close to the middle of the range as possible.
2. Rotate the range selection ring behind the objective lens until the range indicated on the display is that chosen.

4.1.9.2 If the target temperature is initially unknown,

1. Rotate the range selection ring until the highest range [Range 4] is displayed.
2. Aim the DFP2000 pyrometer at the target and attempt to view it through the eyepiece.
3. If the target is visible, attempt to match its brightness with that of the lamp filament by rotating the filament-blending knob.
4. If the target is not visible or a brightness match is not possible with Range 4 selected, rotate the range selection barrel until the next-highest range [Range 3] is displayed on the LCD and repeat steps 2 and 3.
5. Continue repeating steps 2 and 3 on successively lower ranges until a brightness match may be achieved.

4.1.10 Display Backlight Control. [OPTIONAL]

4.1.10.1 Description of Backlight Control.

The bright display backlight enhances the readability of the display in low-light situations. However, it is sometimes desirable to have the display unlit during blending. This control allows the operator to choose whether to have the backlight on or off.

4.1.10.2 Operation of Backlight Control.

1. Press backlight pushbutton [See Fig. 1.] briefly to light the display.
2. Release the button quickly to turn the backlight back off.
3. To have the backlight on continuously, press the backlight button and hold for 5 seconds.
4. To turn the backlight off after step 3, press the backlight button briefly.

4.1.11 Time Out Control. [OPTIONAL]

4.1.11.1 Description of Time Out Feature

To minimize battery use, the DFP 2000 pyrometer is configured to turn off if the blending knob has not been moved for five minutes. However, it is sometimes desirable to keep the instrument on continuously. To disable or enable the Time Out Feature, see 4.6, Time Out Selection, below.

4.2 Making single measurements

1. Aim the DFP2000 pyrometer at the target and view it through the eyepiece observing the lamp filament [horizontal dark line] and the index [vertical line pointing up toward the center of the lamp filament]. See Figure 4-A.

2. Confirm that the lamp filament is in focus. If it is not, follow instructions under Filament Focus above.
3. Rotate the objective lens assembly until the target is in sharp focus.
4. Turn the DFP2000 pyrometer on, if necessary, by pressing the ON/OFF button.
5. Rotate the filament-blending knob until the brightness of the filament equals the brightness of the target in that portion of the filament nearest to the index.
6. Lower the DFP2000 pyrometer from the eye and read the temperature displayed. This is the measured target temperature.

4.3 Automatic averaging of multiple measurements

1. Press the RESET button to cancel any averaging in progress.
2. Make a measurement by completing steps 1-4 under "Making single measurements", above.
3. Press the AVERAGE button.
4. Make another measurement and press the AVERAGE button.
5. Continue steps 1-3 until the desired number of measurements for that average value is complete [up to 10 measurements]. The number of measurements contributing to the current running average is indicated in the display as "AVG number" on the display.

Note: When the average button is pushed the first time, the display changes and indicates: the present temperature reading in large characters, the average temperature in smaller numerals in the lower right portion of the screen and the number of measurements contributing to the average after "Avg:" in the upper right corner. See Figure 4-B.

Note, the maximum number of measurements that may be averaged is 10. When the tenth contribution to the average is entered, "Avg:10" will begin to flash in the upper portion of the display and the average of the ten readings will flash in the lower portion of the display. No more readings can contribute to the average. Pressing RESET will erase the flashing messages and prepare the instrument for another set of readings to be averaged.

4.4 Temperature Units Selection

Temperature may be displayed in degrees Celsius [$^{\circ}\text{C}$] or degrees Fahrenheit [$^{\circ}\text{F}$]. If the desired units are not being displayed, execute the following procedure..

1. Hold the instrument right-side-up as if about to make a measurement. Peel the rubber handgrip away from the top of the instrument, starting at its right edge, until the rectangular switch/pot access is exposed. The handgrip need not be completely removed. See Figure 1-B. The switch/pot cover usually sticks to the underside of the rubber handgrip.
2. Locate switch 1 on the red dipswitch. See Figure 3. Switch it off to display temperature in degrees Celsius and on for degrees Fahrenheit.
3. Unstick the switch/pot cover from the underside of the rubber handgrip.

4. Restick the rubber handgrip into place.
5. Peel the handgrip back again to expose the switch/pot access.
6. Place the switch/pot cover over the access.
7. Restick the rubber handgrip into place.

4.5 Emissivity Selection

Note. For a description of the purpose of emissivity selection, section 5.1.6 emissivity selection.

The DFP 2000 pyrometer is usually shipped configured with an emissivity value of 1.00. To change the emissivity applied to measurements, execute the following procedure:

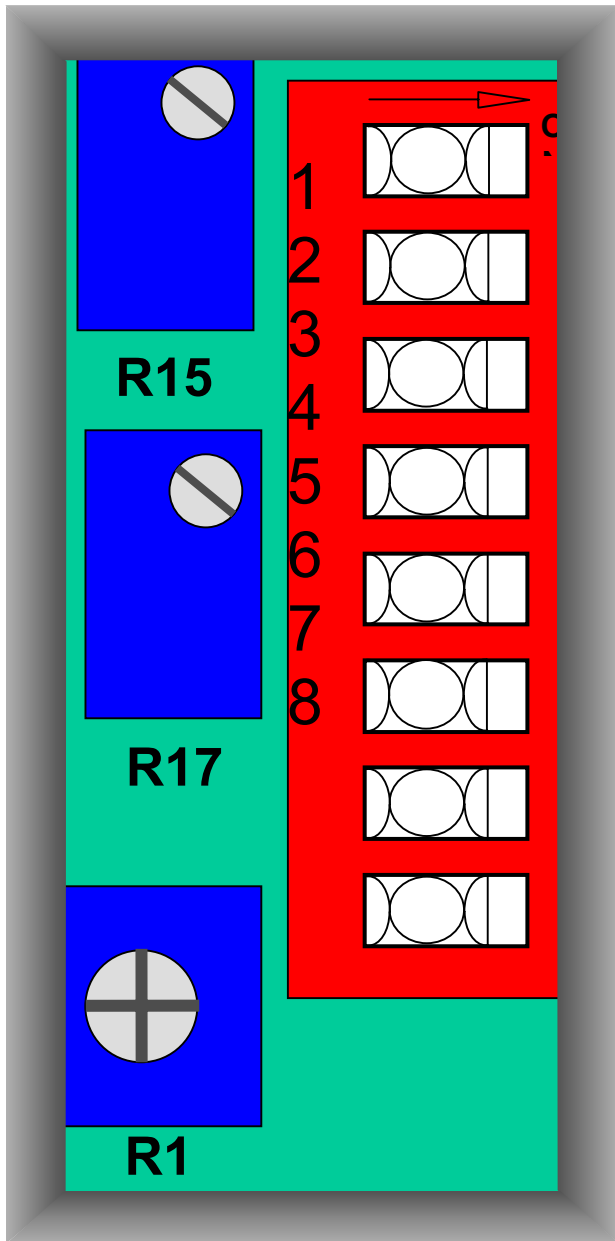
1. Hold the instrument right-side-up as if about to make a measurement. Peel the rubber handgrip away from the top of the instrument, starting at its right edge, until the rectangular switch/pot access is exposed. The handgrip need not be completely removed. See Figure 1-B. The switch/pot cover usually sticks to the underside of the rubber handgrip.
2. Locate switch 3 on the red dipswitch and switch it on. See Figure 3. The “E” in the lower left corner of the display changes to “Emis” and the emissivity value can be adjusted.
3. Press the average button to raise the emissivity and the reset button to lower the emissivity until the desired new emissivity value is displayed. Press the ON/OFF button to store the new emissivity value.
4. Turn switch 3 off.
5. Unstick the switch/pot cover from the underside of the rubber handgrip.
6. Restick the rubber handgrip into place.
7. Peel the handgrip back again to expose the switch/pot access.
8. Place the switch/pot cover over the access.
9. Restick the rubber handgrip into place.

4.6 Time Out Selection

1. Hold the instrument right-side-up as if about to make a measurement. Peel the rubber handgrip away from the top of the instrument, starting at its right edge, until the rectangular switch/pot access is exposed. The handgrip need not be completely removed. See Figure 1-B. The switch/pot cover usually sticks to the underside of the rubber handgrip.
2. Locate switch 7 on the red dipswitch. See Figure 3. Switch it on to disable the Time Out Feature and off to enable it.
3. Unstick the switch/pot cover from the underside of the rubber handgrip.
4. Restick the rubber handgrip into place.
5. Peel the handgrip back again to expose the switch/pot access.
6. Place the switch/pot cover over the access.

7. Restick the rubber handgrip into place.

Figure 3. Switch and Pot Access

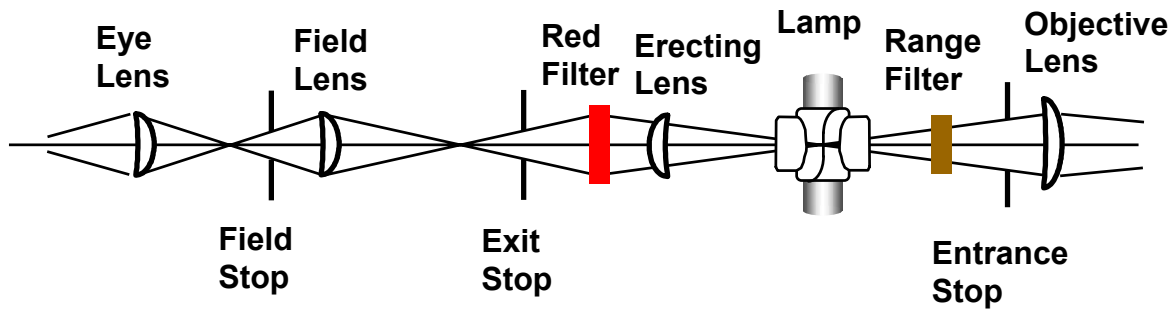


Dipswitch Functions

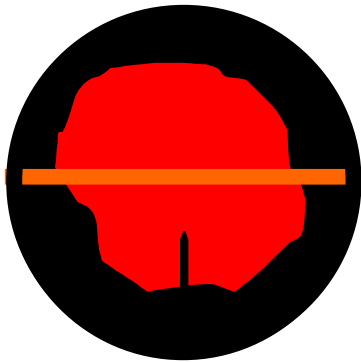
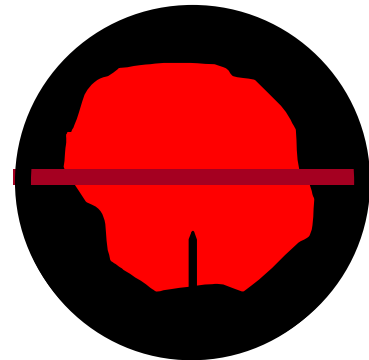
1. °C/°F selection
2. not used
3. emissivity adjust
4. not used
5. not used
6. not used
7. time-out selection
8. not used

Figure 4. The Disappearing Filament Principle.

A. An operator views a hot target through a small telescope containing a calibrated lamp filament in the image plane.

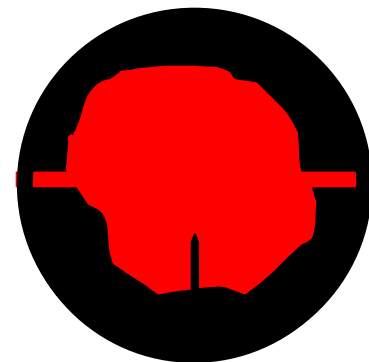


B. 1. The lamp filament is initially cooler than the target and appears dark before it.



B. 2. The lamp current is raised until the filament becomes hotter than the target and it appears brighter than the target.

B. 3. The lamp current is adjusted until the lamp temperature equals that of the target. The filament blends into the glowing background of the target.



5. Technical Information

5.1 Principle of Operation

As an object is heated to about 700°C, it begins to glow a deep red color. This indicates that the object is emitting enough energy in the visible portion of the spectrum for the eye to detect it. As the temperature increases, the object changes from red to orange to white, with concurrent dramatic increases in brightness.

While the eye can tell that an object is hot and an experienced observer might make a fairly good estimation of the object's temperature, to achieve accurate and reproducible measurements, it would be better if the eye could compare the object with one whose temperature is known. This is exactly the principle of *the disappearing filament optical pyrometer*. The hot "target" [so named because it is necessary to align or aim the pyrometer at it] is viewed through an optical system that contains a lamp filament whose brightness can be adjusted until it equals that of the target. The filament blends into the glowing background of the target. The temperature of the filament, and thus that of the target, is known from previously established calibration curves of current vs. filament temperature. See Figure 4.

Several requirements must be met to achieve filament blending and temperature determination.

5.1.1 Simultaneous Focussing. The first requirement is that the eye be able to focus on the target and on the lamp filament within the pyrometer simultaneously. This is achieved by providing dual focussing. The objective lens may be focussed to bring the target image into the plane of the filament. The eyepiece lens allows the eye to focus on the filament.

5.1.2 Red Filter. The brightness match is easier for the operator resulting in more accurate measurements if the filament blends into the incandescent target than if the filament is still discernable at equal brightnesses. The lamp filament is constructed of tungsten. If a target were to exhibit a wavelength dependence for emissivity [see the discussion on emissivity below] significantly different from that of tungsten, then true blending would not be possible at all wavelengths over a broad wavelength region. A brightness match would be possible but the filament would not "disappear" and reproducibility of measurements would be diminished.

However, if the measurement is constrained to a narrow wavelength region, the effects of wavelength-dependent emissivities are diminished. For this reason a red-transmitting filter is placed into the optical path to the eye. This eliminates light at short wavelengths. The rapid decrease in the sensitivity of the human eye eliminates light at long wavelengths. The measurement is thus constrained to a narrow wavelength region centered on about 0.65 microns [650 nanometers].

5.1.3 Range Filter. As heating targets approach 1300°C, they become too bright to be viewed by the eye, even through the red filter. However, if the light from the target is dimmed by an optical filter placed between the target and the filament, a filament blending of targets exceeding the 1300°C range becomes possible. The full temperature range of the DFP 2000 pyrometer is segmented into four [overlapping] ranges, with progressively less transmitting range filters used for progressively higher ranges.

5.1.4 Erecting Lens. While an erect image of the target is not necessary for filament blending, it does make sighting the instrument vastly easier. The erecting lens between the lamp and the red filter results in an erect image of the target and its background.

5.1.5 Current Measurement. Highly accurate filament current measurement is essential because the target temperature is determined from the filament current at the blending point based on the instrument's calibration of temperature vs. current. An internal reference voltage source is compared to the voltage developed by the lamp current passing through a precision resistor resulting in a precision measurement of the current.

5.1.6 Emissivity Selection. Different targets at identical temperatures may exhibit different brightnesses. The property that describes the brightness of a target at a given temperature is called the emissivity of the target. Targets with high values of emissivity will appear brighter than targets at the same temperature but with low emissivity values. Emissivity values are assigned relative to the theoretically perfect emitter—the so-called blackbody emitter. [The perfect emitter is called a blackbody because a perfect emitter must also be a perfect absorber and it would appear black at room temperature.] The perfect emitter is assigned the emissivity value of unity [1.00]. All real targets have emissivity values less than 1.00 although this value may be approached quite closely by a small hole in a large isothermal cavity—the so-called blackbody furnace.

If an emissivity of 1.00 is chosen to calculate the temperature of a target from the filament current, then the temperature displayed is the brightness temperature. Unless the emissivity of the target approaches 1.00, the true target temperature will exceed the brightness temperature. To compensate for deviations of target emissivity from unity, other choices are made available within the DFP2000 pyrometer software. For instance, molten iron often has an emissivity near 0.4 in value. If the instrument will be used to measure molten iron temperatures and true temperature [not brightness temperature] is the quantity to be reported, then the value of 0.40 is frequently selected for emissivity

5.1.7 Short Wavelength. Disappearing filament technology takes advantage of two characteristics of the human eye. The eye is very sensitive to changes in brightness and it is sensitive to short wavelengths.

Energy emitted by a hot body increases at all wavelengths with increases in temperature. However, the percentage increase is much greater at shorter wavelengths. In the disappearing filament optical pyrometer, this translates to a very rapid increase in brightness as target temperature increases. Since the eye is very sensitive to changes in brightness, this means that a distinction can be made between brightnesses corresponding

to temperatures very close together. The combination of the rapid change in brightness with temperature changes at short wavelengths with the eye's sensitivity to brightness changes leads to highly sensitive temperature determinations.

Small uncertainties in brightness produce smaller uncertainties in temperature where the brightness is changing rapidly with temperature [i. e. at short wavelengths] than where changes in brightness with changes in temperature are diminished [i. e. at long wavelengths]. Uncertainties in target emissivity or in absorption by intervening dust, smoke or spray are sources of brightness uncertainties.

In summary, the eye's excellent sensitivity to the short wavelengths used by the DFP 2000 disappearing filament optical pyrometer produce measurements which have:

1. high sensitivity to temperature changes
2. low sensitivity to emissivity uncertainties.
3. low sensitivity to intervening dust or smoke
4. low sensitivity to coating on windows of enclosed processes

5.1.8 User-defined targeting. In target definition, there are two distinctions between detector-based instruments and the disappearing filament optical pyrometer. First, for detector-based instruments, the target must fill the field of view of the instrument because it was calibrated on a target that filled its field of view. If, for instance, a target filled only $\frac{1}{2}$ of the field of view of the detector-based instrument, the resulting temperature error would be equivalent to that resulting from an uncompensated emissivity of 0.5. The disappearing filament optical pyrometer faces no such limitation. Although specified accuracy is achievable where the image of the target is at least three or four times thicker than the image of the filament, a meaningful measurement may be accomplished on any target where filament blending is possible.

A second distinction is that the operator knows exactly what portion of the target he is measuring because it is where the filament is blended. Detector-based instruments depend on the alignment of the light-gathering optics with an internal reticule, external sight, laser spot, etc. to assure that the signal reaches the detector from exactly the same area as that indicated by the sighting mechanism.

5.1.9 References.

5.1.9.1 General Pyrometry and Radiation Thermometry

Theory & Practice of Radiation Thermometry, D. P. DeWitt and Gene. D. Nutter, Eds. John Wiley & Sons, Inc., 1988

"Radiation Thermometry: Red Hot and Hotter," A. S. Tenney, *Mechanical Engineering*, 108, October, 1986, pp36-41

"How Do You Know How Hot It Really Is?" A. S. Tenney, *R&D*, Feb., 1987, pp122-126

"Applying Radiation Thermometers to Process and Lab Measurements, Albert S Tenney III, *InTech*, August 1988, pp49-53.

5.1.9.2 Optical Pyrometry

"Theory and Methods of Optical Pyrometry," H. J. Kostkowski and R. D. Lee, National Bureau of Standards Monograph 41, March 1, 1962 [available from National Institute of Standards and Technology [NIST] Gaithersburg, MD]

"Spectral-Band Radiation Thermometers," Gene D. Nutter, Chapter 5 in *Theory & Practice of Radiation Thermometry*, D. P. DeWitt and Gene. D. Nutter, Eds. John Wiley & Sons, Inc., 1988

5.2 Calibration

5.2.1 Report of Calibration and Use of Correction Data

A typical report of calibration provides the following data:

1. T_s , the temperature measured by a standard pyrometer or the temperature of a blackbody furnace
2. T_f , the corresponding temperature “as found” by the test pyrometer,
3. T_L , the corresponding temperature “as left” after test pyrometer calibration,
4. V_L , the test pyrometer variance “as left” at the corresponding temperature and
5. CL , the correction data “as left” at the corresponding temperature.

Note that T_f values may be of interest to those trying to analyze recent results from the pyrometer BEFORE IT WAS CALIBRATED, but have no bearing on applying corrections AFTER THE CALIBRATION. V_L and CL are of equal magnitude but opposite sign. Both are reported to avoid confusion in deciding whether to add or subtract the number from the pyrometer reading. The following procedure uses CL .

To use the Report of Calibration to correct pyrometer readings,

1. Select the T_s that is closest to the temperature measured by the test pyrometer.
2. Add to that value the corresponding CL

For example, if a pyrometer were reporting a temperature of 1110°C and its Report of Calibration had a CL of -2°C at 1000°C . The temperature to be reported would be:

$$1110^{\circ}\text{C} + [-2^{\circ}\text{C}] = 1108^{\circ}\text{C}$$

6. Powering the Instrument

The DFP 2000 pyrometer is shipped with a charged nickel-metal hydride battery pack plugged into the battery jack within the battery compartment. Unless the battery icon in the upper left corner of the display shows two or more solid, vertical lines indicating a nearly charged battery when the instrument is turned on, it is recommended that the battery be charged for several hours before using the instrument. The instrument may be used immediately with low charge in the battery by connecting the battery charger to the external battery charger jack on the lower right side of the instrument.

Caution: never plug the battery charger into a DFP 2000 pyrometer unless a battery pack is installed within the battery compartment and its cable is plugged into the battery jack within the compartment. Permanent damage to the electronics can result from doing so.

To charge the battery, plug the battery charger into 120VAC service and plug the jack on the end of the battery charger cable into the battery charger jack labeled DC on the lower

right side of the instrument. See Figure 1. Make sure that the plug is pushed all of the way into the jack. The instrument may be either on or off during charging but it will charge somewhat faster if it is turned off. The nickel-metal hydride battery is designed to heat up during charging. It is normal for the bottom of the case to become warm to the touch during charging. A thermistor mounted within the battery pack senses this temperature and controls the charging rate based on temperature.

Caution: Only the battery charger supplied with the DFP 2000 pyrometer may be used to charge the battery. Use of any other charger may damage the batteries and/or the instrument and will void all warranty.

7. Analog Output

An analog output jack is provided (See Fig. 1). This is a 30-60mV output proportional to the filament current and therefore proportional to the temperature reading. The user can generate a curve that calibrates the mV output to temperature or the user can have the factory provide this extra calibration curve.

Consult HeatWave Labs if a millivolts output proportional to lamp current is desired.

8. Service and Maintenance

8.1 Cleaning the instrument

Lightly dampen a soft cloth or paper towel and gently wipe any dirty portions of the external case. If necessary, isopropyl alcohol [isopropanol] may be used instead of water.

The objective lens and eyepiece may be cleaned with a lens tissue or soft cloth dampened with isopropyl alcohol.

8.2 Removal and replacement of the battery pack

The need to replace the battery is indicated when charging the battery fails to restore charge to the battery as indicated on the liquid crystal display. When this occurs,

1. Turn the instrument up-side-down and rotate it so that the display faces you and the objective lens is facing away.
2. Loosen the captured screws at the corners and carefully lift the plate out of the bottom of the case.
3. Unplug the short cable leading from the old battery to the battery jack next to it.
4. Remove the old battery, replace it with a new battery and plug new battery cable securely into the battery jack

8.3 Replacement parts list

Part	Part Number
Standard objective lens	A4006
Close-up lens	A4008
Telephoto lens	A4003
Eyepiece	consult factory
Rubber Eye Shield with mounting hardware	consult factory
Rubber handgrip	2005
Internal lamp	021951
Battery pack	consult factory
Battery charger/AC adapter with cable	051200
Detachable neck strap	consult factory

9. Warranty

HeatWave Labs, Inc. will repair or replace at its plant any parts or materials found defective, due to flaws in design or manufacture, when reported in writing within one year from date of sale. Instruments to be repaired under this warranty are to be returned to HeatWave Labs, postage pre-paid, by the user, who assumes all risk and cost of shipping to and from HeatWave Labs.

This warranty is void if the instrument is disassembled, tampered with, altered or otherwise damaged without prior consent of HeatWave Labs, or if considered by HeatWave Labs to be abused or used in abnormal conditions.

This warranty shall constitute the exclusive remedy available to the user and shall be considered a condition of sale and use.

HeatWave Labs, Inc. shall not be liable for any loss or damage, including loss of profits or consequential damage, resulting from, or attributed to the use of its product or resulting from a defect in design or manufacture of the product.

The user shall determine the particular use to which the product shall be applied and the seller excludes and disclaims any warranty that the product is fit for such a use.

10. Contacting HeatWave Labs

Where to Get More Information

This owner's manual represents the most current information at the time it was published; for the latest information, please visit our website: www.cathode.com.

We may also be reached in the following ways:

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Watsonville, CA 95076-2069

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