Heat Spy Digital Infrared Thermometer

INSTRUCTION
MANUAL

MODELS DHS24X, DHS24XL, DHS24L
DHS26X, DHS26XL, DHS26XT, DHS26L
DHS28X, DHS28XL, DHS28XT, DHS 29XT, DHS 35XT
And all DHSA Models

W2111
06/04/13 Rev B

Wahl

HEAT SPY WARRANTY

WAHL warrants all its products to be free from defects in workmanship and material under normal use and service.

If any of our products is believed to be defective as to workmanship and/or material under normal use and service and if the same is returned to the Company, freight prepaid, within 12 months after date of purchase is found by the Company's inspection to be defective in workmanship and/or material under normal use and service, it will be repaired or replaced free of charge and shipped, freight prepaid, to any point in the United States. If inspection by the Company of any such product does not disclose any defect in workmanship and/or material under normal use and service, the Company's regular charges will apply. This warranty shall not apply to (1) ordinary wear and tear nor (2) any product which has been opened or modified or repaired or altered by a purchaser, (3) to any product which has been subjected to misuse, negligence or accident. The Company's obligation, under its warranty or otherwise, relative to product defects is limited to the above paragraph.

Warranty Card must be filled in and returned for above warranty to be valid.

WARRANTY and CALIBRATION REGISTRATION at

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Registration is fast and easy. In about a minute you can have your product automatically registered for Warranty Protection and our Calibration Reminder service. Let Palmer Wahl help you protect your investment, and maintain product accuracy and compliance with ISO and other quality standards.

Questions? Call Customer Service at 1-800-421-2853 or 828-658-3131
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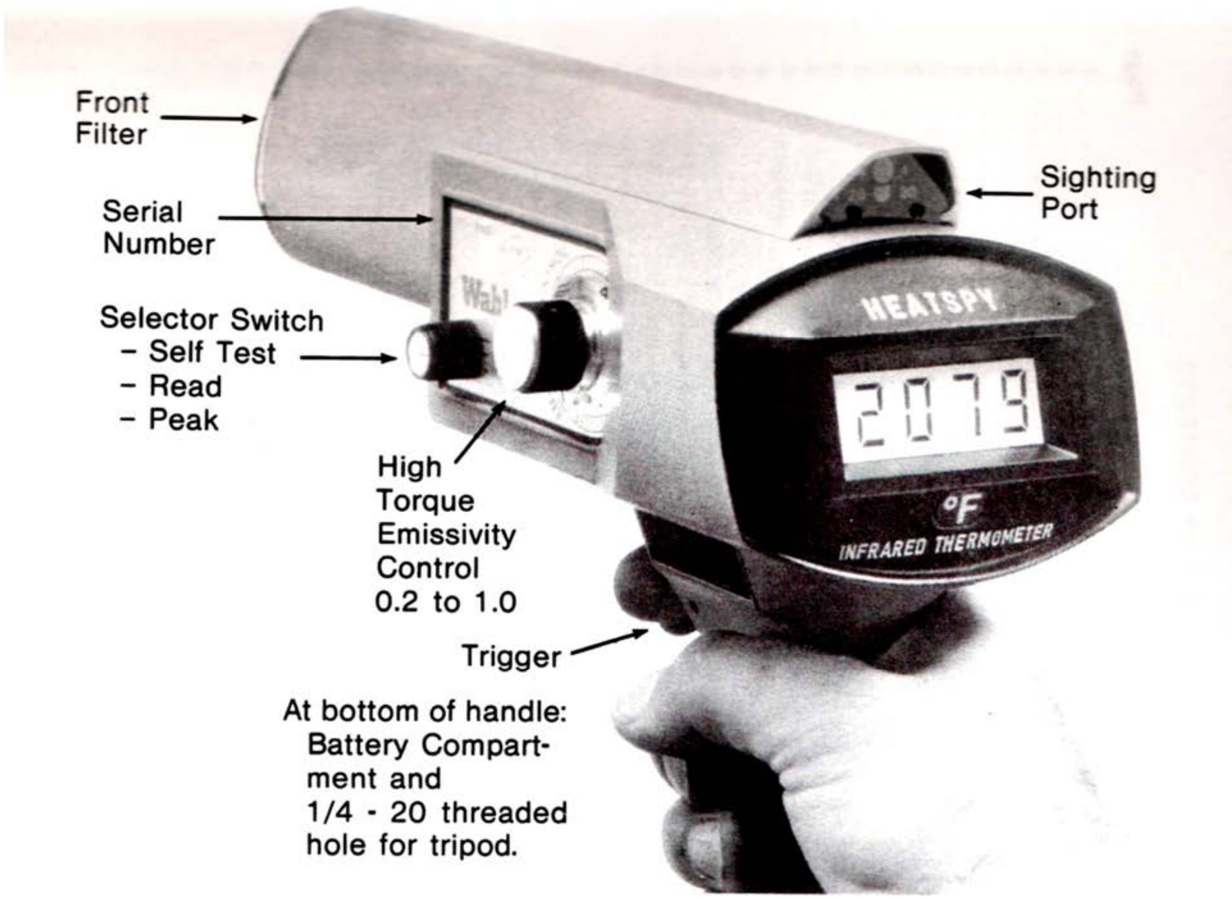
Figures and Tables


Front Filter
Serial Number
Selector Switch
- Self Test
- Read
- Peak
High Torque Emissivity Control 0.2 to 1.0
Trigger
At bottom of handle: Battery Compartment and 1/4 - 20 threaded hole for tripod.
Sighting Port
HEATSPY
2079
°F
INFRARED THERMOMETER

1.0 BASIC OPERATION

The Heat Spy is an easy instrument to operate. First put the select mode switch on the left panel to "Self Test" and pull the trigger. The instrument will indicate it is working properly by flashing on the display the internal temperature of the Heat Spy. If your battery does not have sufficient power the display will show "Low Batt" in the upper left corner.

To measure temperature set the emissivity adjustment to match the material you are measuring, put the selector switch in "Read" and pull the trigger to display the temperature. If you want to hold the peak temperature set the switch to "Peak."

2.0 HEAT SPY DESCRIPTION

This Heat Spy is designed with the newest state of the art electronic and optical components to provide the widest range of temperature ever available with the certainty of digital readout. This is the most recent design in which advanced electronics incorporate a microprocessor to translate the detector signal to temperature with conformity of less than 1°F.

2.1 How It Works

Infrared (IR) energy is emitted by all objects above absolute zero. The amount of energy is proportional to the object or target temperature. Heat Spy collects this energy by means of fixed focus optics into a sensitive detector and reads out directly in of or °e. It is fast because the IR energy is transmitted to the detector at the speed of light. Since the detector has a very low mass, it heats up very quickly supplying the Heat Spy with a signal output that represents the temperature of the object. The time constant of the detector is 0.1 second, about 10 times faster than conventional contact thermometers. Measurements are displayed in less than one second. The Heat Spy is the fastest thermometer available. The block diagram is shown in Figure 1.

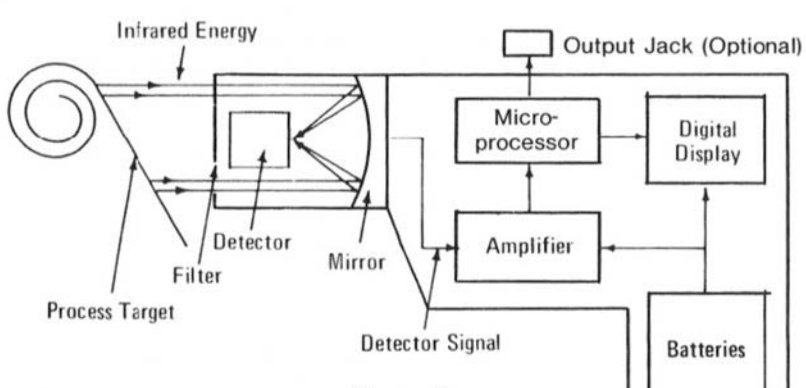


Figure 1
Block Diagram

2.2 Display

Models DHSA, DHS24, DHS26 and DHS28 use .33" high LED displays. All Models with an ″X″ suffix use .4" LCD displays.

When the display range is exceeded, above or below, the readout will show dashes (m) indicating out of range.

The meter updates at the rate of two times per second. The microprocessor computes a running weighted average of temperature. This provides steady readings, while at the same time, responding to temperature changes quickly. The detector responds to temperature change (99%) in 0.2 seconds. The digital readout will provide a new temperature in approximately 1 second.

2.3 Factory Mutual Approval

FM approved units not available as of 6/30/2012.

2.4 Trigger

The trigger is contoured to fit the index finger. This is a single position trigger, which turns the instrument on when pulled. The display will show a dash (-) for a fraction of a second before the first reading appears to allow the microprocessor to complete its initial calculation cycles.

2.5 Control Panel

On the left side of the instrument are two controls, one emissivity adjustment, and one function switch. The function switch has three positions, "Self-Test", "Read", and "Peak". "Self-Test" checks all functions of the electronics, including the microprocessor, by placing a standard signal in the place of the detector. In the "Peak" position the Heat Spy will read and display the warmest temperature and hold the reading until the trigger is released. The "Read" position provides normal indication of low or high temperatures throughout the range of the instrument.

3.0 OPERATION

The microcomputer in the instrument, along with a special display provide helpful information to the user.

3.1 "Self-Test" Position

The instrument incorporates an internal self-test circuit which verifies the gain of the electronics as set at the factory, as well as microprocessor functions. It is good practice to do self-test before use.

(a) Rotate Selector Switch to "Self-Test" position.
(b) Squeeze trigger and observe the display. The reading will show flashing readings of reference temperature (either °C or °F), which is the internal temperature of instrument. If "HLP" appears, it indicates that the self-test could not be completed successfully due to a component fault or a misadjustment in the electronics. See "Troubleshooting" section 7.

(c) The display indicates "TEST' in this position.
NOTE: The LED display version does not display "TEST'.

3.2 Emissivity Setting

Set emissivity knob on control panel to proper value. For most solid objects, this will be about 0.9; however, the exact value should be determined (see Section 13 on Emissivity) or select a value from Table 4 in section 13.
The emissivity control is an amplifier gain. It provides capability to adjust your instrument to accommodate varying surface emissivities. The emissivity control is calibrated at 1.00 and is repeatable as described in Section 13.2 at other settings. A 5% error in emissivity setting at 600°F for example, converts to only 1% error in reading. Other temperatures are shown.

Temperature Measured	5% Error in Emissivity Causes This Error in Reading
400°F	.5%
600°F	1.0%
1000°F	1.3%
1500°F	1.8%
2000°F	2.2%

3.3 Measuring Temperature

Switch to "Read" or to "Peak". "Read" will provide normal indication of high and low temperature over the range of the instrument, while "Peak" will lock the highest temperature sensed by the instrument and hold it, until the trigger is released.

Be sure to check the emissivity setting and function switch before making each reading. Hold the instrument at arms length and point barrel of the instrument at the target. Look through the internal sights to establish the target area that is to be measured. The front and aft circles in the sighting barrel are adjusted to show a target size of 2.0 inch diameter at a distance of 4 feet. Most users make their measurements at a distance of 2 to 5 feet. Pull the trigger all the way and read the temperature on the display. The display responds in 1 second; it usually takes 4 to 8 seconds to make a temperature reading. It is advisable to check your reading by making a second reading or checking against another temperature source. When in "Peak" selector position, the word "Peak" will show on the display. As long as the trigger is held on, the peak reading will be held until another higher temperature is observed. The instrument can be moved away from the target, and the temperature held for reading later. This digital peak hold locks the temperature and will not drift. For the LED version, a decimal point on the left side of the display will "blink" to indicate "peak hold" mode.

4.0 HEAT SPY FEATURES

4.1 Optical Sight

The enclosed optical sighting system used in the Digital Heat Spy allows precise aiming at the required target field of view with compensation for parallax. What you see in the sight is the center of the spot you are measuring. Two circles are utilized on the optical sighting system, one marked 4 and the other marked 20. These correspond to exact target alignment at 4 and 20 feet and correct for parallax offset.

4.2 Targeting

The instrument is focused at the factory at 2 feet. At distances greater than 2 feet, the target size grows larger consistent with an angle of 3.0 degrees. At 10 feet, for example, the target size is 6 inches. (See Figure 2a)

IMPORTANT: The target being measured must be equal to or larger than the target sizes described above in order to fill the field of view and measure the temperature of the surface accurately.

Heat Spy can be used to measure temperatures of the following targets:

(a) Any opaque surface. At long distances there is some error because the detector is not infinitely small and spherical aberration occurs.

(b) It will *not* read through glass since *glass* absorbs the infrared energy omittance. It will measure the surface temperature of the glass itself.

(c) It will measure transparent plastic materials in thick sections. (greater than .020")

(d) It will not measure thin section < 20 mil polyethylene or polypropylene which do pass infrared. The temperature of the next opaque object will be measured, modified by the attenuation of the plastic.

4.3 Output Signal (Option)]

Output signal is provided as an option and is scaled as 1Mv/degree and will represent, in millivolts, the indicated temperature on the display. Example,500°F will generate an output signal of 500:f:1 millivolts.
The output is linearized and will drive any chart recorder with input impedance of 1Ok ohms or higher. With this option, the external power connection is included.

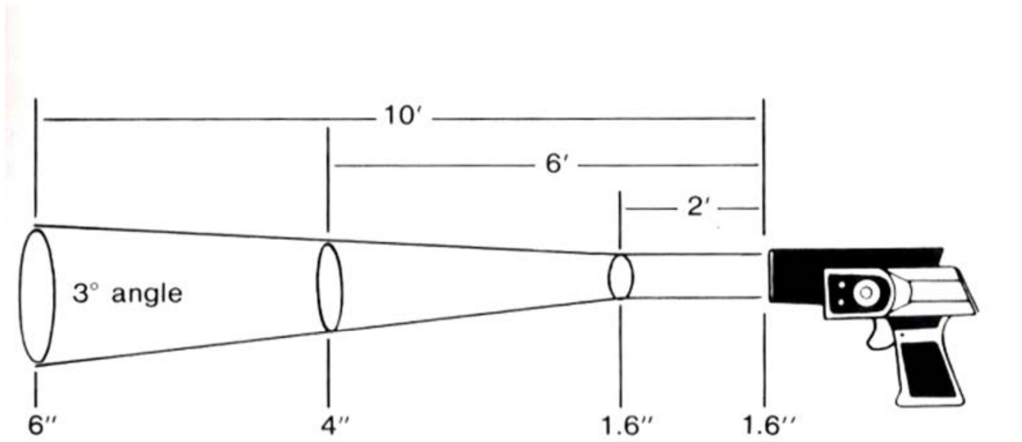


Figure 2a
Target Size for DHS-24, 26, 28

4.4 Tri-Pod Stand

A standard threaded hole is located in the base of the handle for tri-pod mounting which can be used to hold the Heat Spy in one position for recording.

4.5 Power Source

The Heat Spy operates from one 9 volt standard transistor type alkaline cell (NEDA1604A). This battery is located in the handle, and is easily replaced. Normally, the battery supplied has 500 milliampere-hours, providing about 40 hours continuous duty. A carbon-zinc battery has less power (about 350 milliampere-hours), and may also be used as replacement. The battery is connected to the system with snap on clips which are polarized. When the battery cover is removed, a spring will push the battery out for easy access. (Figure 3)

For the LED version, the batteries are two 6.0 volt Alkaline batteries with 650 milliampere-hours of energy. The LED requires more current than LCD and therefore total running time of the LED unit will be about 20 hours continuous.

4.6 P9wer Recharger (Optional)

A portable power pack (BP-6) may be ordered that provides 200 or more hours of continuous service from rechargeable batteries. In addition, this pack will also operate continuously from 115 or 230 VAC (50-60 Hz) while charging. The right side of the Heat Spy contains a power jack when this option is chosen.
Power from the external batteries is brought in by a 2-pin connector, to the right hand panel of the instrument. The battery pack has the outlet power cord and the AC adapter/recharger stored in the ziptop of the power pack case. To recharge the battery pack, plug the recharger into a 115 VAC outlet (or 230 when specified) for 10-12 hours.
Note: When this option is selected, the Factory Mutual approval for instrument safety is negated.

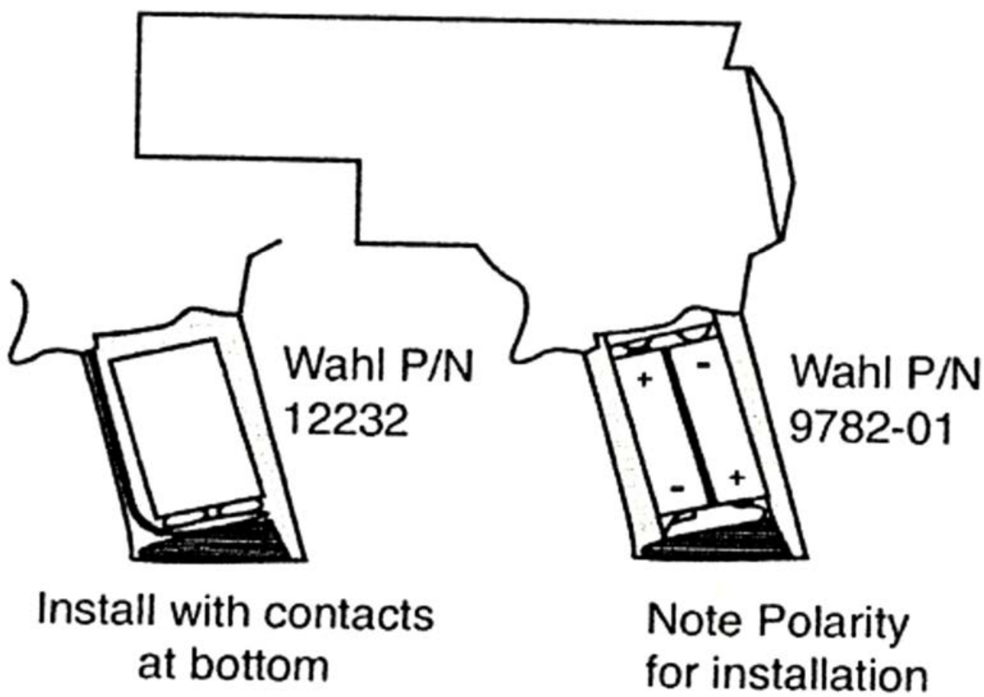


Figure 3
Heat Spy Battery Installation

4.7 Trigger Lock

At times, particularly for recording, or for calibrating, it is convenient to mechanically lock the trigger in full position. The Heat Spy is designed to permit Insertion of a pin in the housing and trigger to lock it in the "ON" position. A locking pin is supplied, but any 0.040 inch wire or pin can be used for this purpose.

4.8 Optical Filter

The front of the Heat Spy barrel contains a transparent optical plate which acts as a dust shield and as an optical filter. It provides transmission of a high percentage of energy from 8 to 14 microns. In addition, a secondary filter on the detector is used to cut off all energy below 8 microns, thus eliminating effects of sunlight - Infrared lamps, reduces reflection from shiny surfaces, and any effect from atmospheric CO2 and H20.

5.0 DESIGN PRINCIPLE

5.1 Overview

Heat Spy operates on the principle of collecting infrared energy from solid bodies and surfaces of liquid materials. This advanced Heat Spy design is protected under U.S. patent No. 4,456,390.

Infrared energy is available from any body so long as it is above absolute zero. The Heat Spy collects the infrared energy with a special mirror and focuses it on a special detector. The output from the detector is amplified and directly converted to a temperature reading.

The detector is a uniquely designed vacuum-deposited thermopile of a Wahl design. The high performance Heat Spy system features a sensitive thermopile which is sensitive to fractional degree changes in target temperature. The hot junction is exposed to the source of radiation. The cold junction is shielded and thermally coupled to the instrument body.

When heated by the collected infrared, the hot junction produces an EMF. This electrical signal is proportional to the amount of incident radiation energy on the exposed element. When the instrument and the target measured are the same temperature, there is zero output from the thermopile. A thermolinear sensor is used to measure detector body temperature and produce an equivalent EMF to register reference temperature.

The detector output signal Is amplified by a monolithic state-of-the-art computer enchanced auto zero amplifier which essentially eliminates all drift. It is thermally isolated from the ambient making it virtually immune from ambient thermal transients. Noise contribution of this subsystem is minimal, and any noise is heavily attenuated with digital filtering.

The gain of the system can be changed by means of the emissivity control. The amount of heat energy radiated by an object Is affected by Its surface. This condition Is described as emissivity. The ideal surface Is a black body and its emissivity coefficient Is equal to 1.0. The Digital Heat Spy contains an external emissivity adjustment which can be set for coefficients between 0.2 and 1.0 in precise Increments of 0.02 allowing use on virtually any type of material. In practice the correct setting Is quickly determined for each application and does not change.

Internal compensation is provided to allow the instrument to be used over a wide span of environmental temperatures. Under conditions of moderate ambient temperature variations, very little attention is required. The instrument can handle changes of 1 deg,/min. without deviation from Its stated accuracy. As a rule of thumb, allow one minute for each degree of change in room ambient for "adjustment" of reference.

The Instrument is calibrated In degrees Fahrenheit or Centigrade. The power required to drive the Instrument Is obtained from a single 9V battery for LCD display models and dual 5.4V batteries for LED display models.

5.2 Theory of Operation (Refer to Figure 4)

This is a microprocessor controlled Instrument that measures temperature by means of a thermopile detector in combination with a solid-state limited range ambient temperature detector. A wide dynamic range of temperatures are accommodated by the use of a 13-bit analog-to-digital converter which has several Internal ranges that are transparent to the user.

The microprocessor also controls the electronic function of the selector switch to put the instrument Into "PEAK", "SELF-TEST', or "READ" mode. Other features Include tests for low battery (indicates "BAIT' or "La BAIT' on display for voltage between 5.39V to 5.61V) and F or C conversion.

The measurement of temperature starts with Incident radiation falling on the thermopile detector. The electrical signal produced is amplified by a very low noise and ultra-stable amplifier U2.Aselection multiplexer U1, provides selection of either the thermopile signal or a simulated thermopile signal from R24 used to self test the Instrument operation. The microprocessor looks for values to be within certain bounds In order to indicate a usable condition. U1 Is controlled by the instrument function selector switch S2 located on the left hand side of the Instrument.

The amplified thermopile signal is presented to another multiplexer U4, which also has a voltage level at pin 15 representative of the detector body temperature along with a voltage level at pin 14 representative of the battery voltage. The microprocessor commands U4 to select and present the chosen signal to the *ND* converter for conversion to a 13-bit binary number. The binary representations are compared to resident tables in the microprocessor to detect limits or perform manipulations to arrive at a proper indicated temperature of the object being viewed by the instrument optics.

U3 functions as another multiplexer under microprocessor control to select the proper amplifier gain and values of offset voltage at pin 13 to meet the input requirements of the *ND* converter. The use of offset voltages only occurs for the measurement of amplified thermopile signals. When measuring either the detector case temperature signal (U4-15) or the battery voltage signal at U4-14, no offset voltages are applied to the *ND* converter.

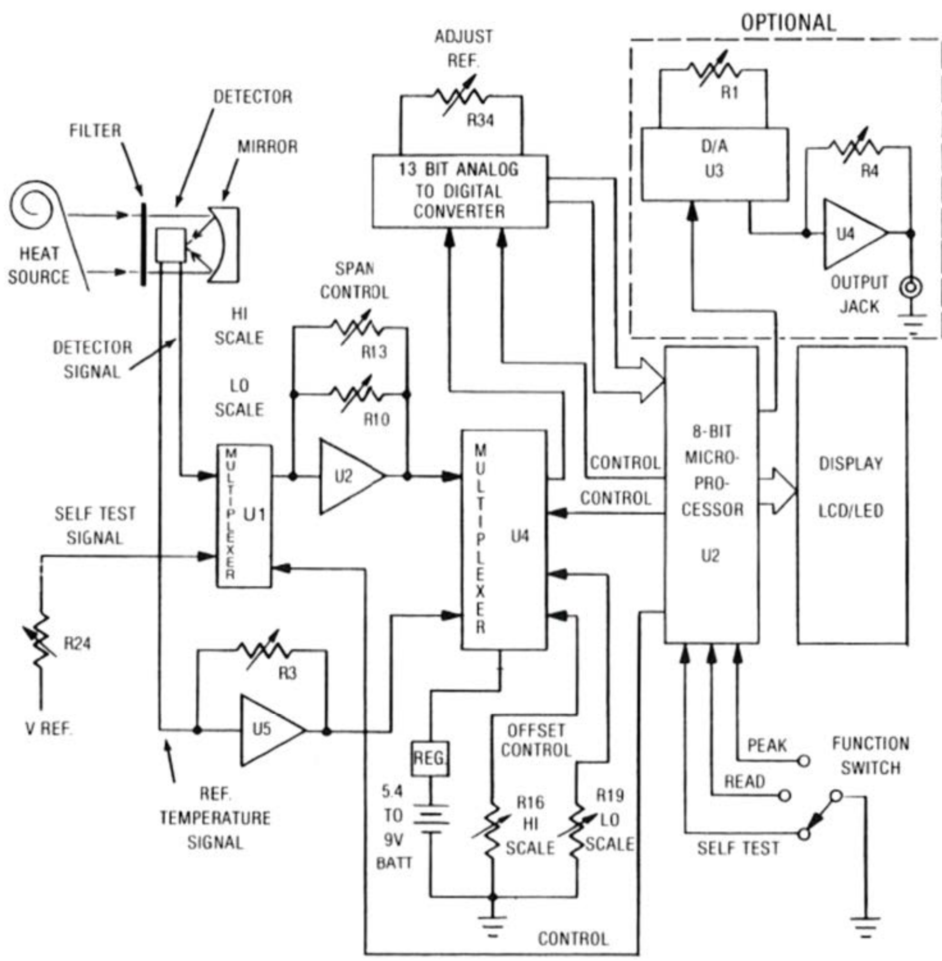


Figure 4
Simplified Schematic

5.3 Determination of Temperature

The transfer characteristic of the optical system is non-linear with changes in target temperature but defined by an equation $V_{DET} = m (T_T4 - T_A4)$, where V_{DET} is the detector output voltage, m is a proportionality constant, TT is target temperature in degrees Kelvin, TA is detector case ambient temperature in degrees Kelvin. The exponent value of four (4) is for a broadband system.
An actual system has optical filter elements to tailor the optical response for the temperature range desired and also to lessen effects of moisture absorption bands and unwanted stray radiation that could introduce errors. The effects of these filters changes the exponent to some value less than four (4) and also causes the values to change with target temperature. This complexity is solved by the microprocessor by the use of lookup tables tailor made for the optical system chosen. The temperature of the detector case is provided by the solid state temperature transducer and along with the detector voltage, the two are combined in a similar manner as shown in the above equation and target temperature determined from the tables descriptive of the optical system in use.

5.4 Self-Test

When the instrument function switch is set to "SELF-TEST', the detector signal is substituted with an electrical signal equivalent to 538°C. If this signal is processed correctly, the resultant value seen by the microprocessor will fit within predetermined limits and the word "HLP" will not be displayed as it would if the limits had been exceeded. The "SELF-TEST' feature provides a test of approximately 90% of all the electronic components for gross failure.

5.5 LSI Devices

The A/D converter (U1 of Card 2) is a 7109 type manufactured by Teledyne and Intersil. The display driver (U1 of Card 3) is a 7211AM for LCD display and 7212 for LED display, both manufactured by Intersil. See the manufacturer's specifications for function and theory of operation.
U2 of Card 2 is the microprocessor and is of the 80C49 type with 2K of factory programmed ROM or a 80C35/39 with External 2K of CMOS EPROM. See an Intel or NEC operator's manual for detailed functions of the various pins.

5.6 Power Converter Board

The instrument is designed to operate from any power source with a D.C.voltage of 5.4 volts to 9 volts with a current capability of at least 20 milliamperes. LED display models require a power source with a 120 milliampere capacity. The *ND* converter and D.C. amplifiers require a negative bias voltage for proper operation. This negative bias voltage is provided by U1 and U2 of this board. U1 and U2 operate in a synchronized "push push" mode for least ripple noise and best regulation.

Q2 is a three terminal regulator that regulates the battery voltage between 4.75 to 5.25 volts under all normal load and temperature conditions. Since the polarity converter operates post-regulator, the minus voltage is also regulated within -4.75 to -5.25 volts. The optional external power jack allows the instrument to be operated from an external power source, thereby preserving the battery life of the internal battery. The external power source can have a range of 5.4 volts to 14 volts DC.

5.7 Wiring Schematic

An internal wiring diagram is shown in Figure 5.

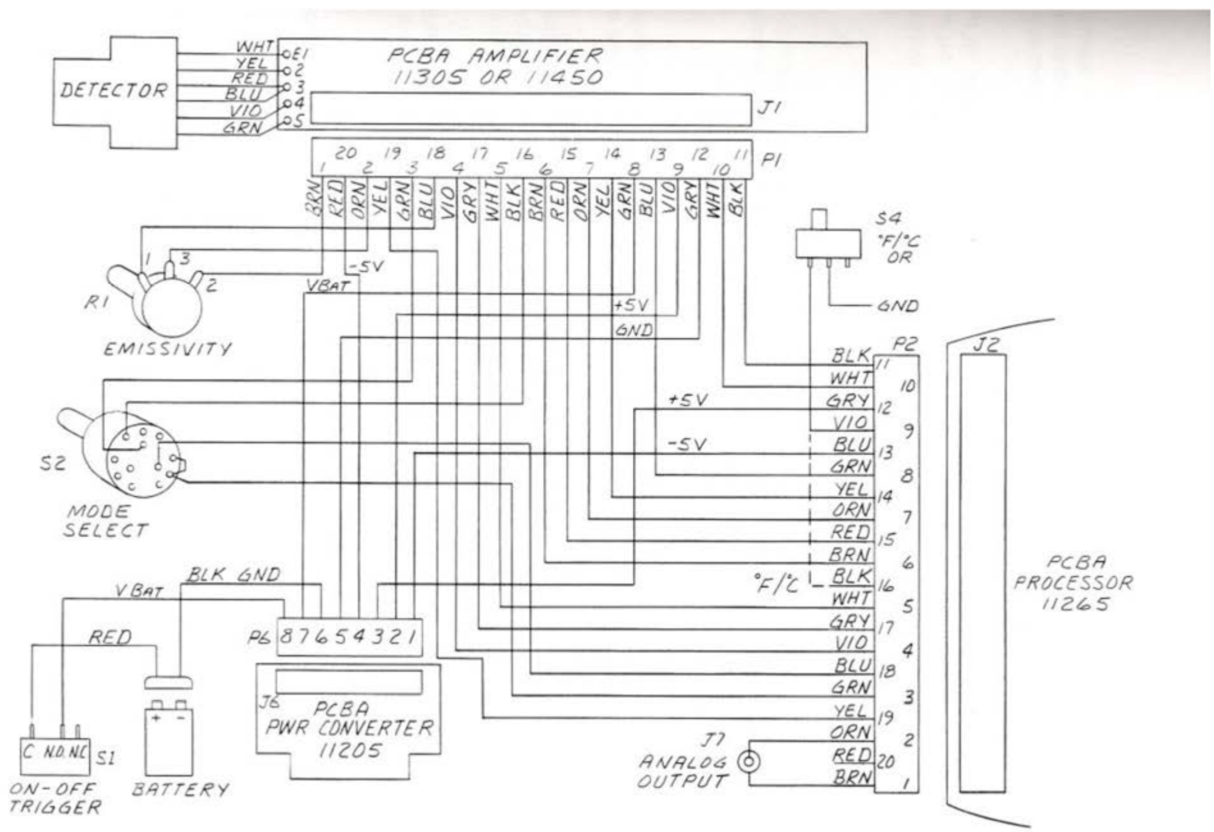


Figure 5
Internal Wiring Diagram

6.0 CALIBRATION

The Heat Spy is calibrated at a minimum of 4 temperatures at the factory against a number of black body standards. While there is no black body standard at the National Bureau of Standards, the temperature is checked with a thermocouple and potentiometer which are traceable to NBS.

The instrument calibration is checked when "self-test" is made. Should "HLP" appear on the display along with "BATT', replace the batteries. If "HLP" continues to appear, calibration may be out of specification. There are two things to do:
1. Send the instrument to the factory for re-calibration.
2. Follow the steps below for re-calibration.

The instrument information for temperature versus detector signal is stored in thu microprocessor. Therefore, only minor adjustments should be required in most cases, unless some major fault in a component has occurred.

6.1 Detailed Calibration Procedure

This calibration procedure is provided for those users with a metrology department or for those with sufficient test equipment to perform this type 01 calibration.

> Note: The user is advised to *read the entire* procedure before attempting anyone portion of it, as once the process is begun, it will be necessary to complete all the steps (with proper blackbodies) to achieve an accurate calibration.

For those users unfamiliar with infrared measuring techniques, it is advised that the quick turnaround and calibration services of Wahl Instruments be used.

A. EQUIPMENT NEEDED

1. 4-1/2 Digit Voltmeter with> 100 megohm input resistance on 2 volt range and> 10 megohm on 20 volt range. '
2. Mercury thermometer or electronic thermometer with air probe and readout resolution of 1°F.
3. A black body temperature source with readout and temperature range of 900°F to 2000°F. Blackbody target area should be at least 2" in diameter to fill the field of view of the instrument.

B. SETTING UP THE INSTRUMENT

It will be necessary to remove the rear bezel and the barrel to allow access to all components for the re-calibration operation.

First remove the single hold screw in the rear bezel and carefully pull back only 3 inches because of cable lead length. Remove the cable connection to the rear bezel board. Then remove the single hold screw in the body to the barrel, and slide the barrel from the body by pressing the rear edge of the barrel against a hard surface. Reconnect the cable to the rear bezel and proceed.

1. Normalizing Detector Diode to Electronics. This adjustment should only be attempted after the instrument barrel has been allowed to come to the surrounding room ambient temperature. Best results are obtained if at least one hour is allowed in an area where air conditioning air currents do not hit the electronics. Insert mercury thermometer into the hollow of the barrel and allow to stabilize.
The adjustment potentiometer is R3 and the DVM should be connected with plus (+) lead to TP-2 and minus (-) to TP-1 with the DVM on the 2.0 volt range.

R3 and test point locations shown in Figure 6.

2. Adjust R3 until the DVM reads the output voltage as shown in Table 1.
OP-07 Offset Adjustment.
Connect DVM plus (+) to TP3 and minus (-) to TP1. Set DVM on 2V scale.

3. Make certain that electronics is temperature stable and adjust R35 on Amplifier Board so the DVM reads 0.000 volts ± .002.
Move DVM plus (+) to TP6 and keep DVM (-) at TP1. Adjust R34 for a DVM reading of .943 ± .001 V using the 2 volt scale.
Adjustment of R19. Add a jumper between TP1 and TP2 on the Processor Board. This will force the computer to indicate counts versus degrees temperature. The count should be 591 ± 3.

Now adjust R19 for a count of 591 ± 3. The resolution is very high and the display may jump several counts above and below the 591 count. Therefore, some mental smoothing will be necessary to do this adjustment properly.

4. Check for proper room ambient display. Remove the jumper from TP1 and TP2 of the Processor Board. The display should now display the proper room ambient within ± one (1) degree F or C. If not, it is necessary to let the barrel stabilize longer and repeat step 1.

5. Assemble the instrument and move to 1000°F black body. Space the front of the instrument 18 inches from the internal target of the black body to be measured.

Use a barrier in front of the Heat Spy barrel to cut off black body radiation between measurements.

Remove barrier and adjust R10 for a correctly displayed temperature reading. Replace barrier after each R10 adjustment.

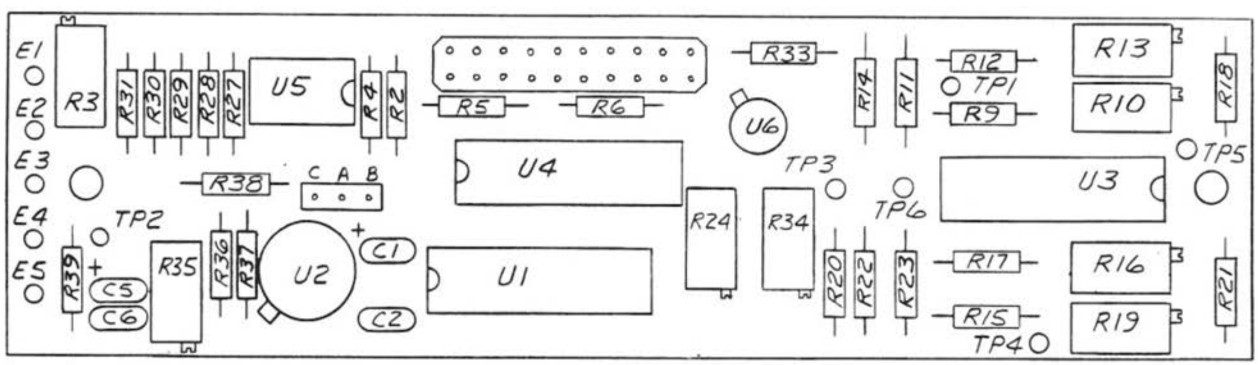


Figure 6
Component Locations, Barrel Board

6. Self Test adjustment. Switch the Read/Peak Self Test switch to Self Test. Attach a clip lead or jumper from TP1 to TP2 of the Processor Board.

Adjust R24 so the first and second numbers seen are L71 and L 13 within ± 3 counts of L13 on Models 8 and 24. Models 8 and 24 proceed to Step 11.

On the higher range models, DHS-26 and DHS-28, H19 then 89 are displayed. Adjust R13 for 89 ± 3.

Remove the jumper from TP1 to TP2 when this adjustment is complete.

7. High scale calibration (Models 26 and 28 only). Use a black body at a temperature of 1820°F for this adjustment. Use a distance of 18-19 inches. Use a barrier so that the instrument is not viewing the black body when an adjustment is not being made. Use2400°F for DHS28. Connect DVM to TP3 (+) and to TP1 (-).

Move the function switch to Read and adjust R13 for a correct high scale reading as shown in Table 1.A.

8. Check H19 and H89 in Self Test. Switch function switch to Self Test, jumper TP1 and TP2 on Processor Board, and check the H19, H89 count. If not correct, adjust R16 for correct reading.

9. Repeat steps 8 and 9 until both are reading correctly.

10. Final Self Test check. With all jumpers removed, switch the Function switch to Self Test. The display should be blinking the ambient temperature of the detector temperature within ± 2°F. This will normally be very close to room ambient.

If another temperature is flashing it means that either the detector temperature is other than room ambient or that the adjustment in step 1 was not done correctly.

If "HLP" appears, it indicates a problem with the upper scale and lower scale alignment. Go back to step 6 and repeat the procedure from there.

11. Repair. If the procedure has been followed precisely but a calibration cannot be achieved, call the factory for instructions on returning the instrument.

12. Output jack adjustment. Connect DVM plus (+) lead to output jack hot side. Connect DVM (-) to output jack low side. Set DVM on 2V scale.

Jumper TP1 and TP2 on Processor Board. Adjust R1 on Analog Output Board for 0.000 volts ± .001.

Remove jumper and view an up-scale target of at least half scale and adjust R4 until DVM and instrument displays agree.
Repeat these two adjustments until satisfactory. It should not require more than two adjustments per pot.

HEAT SPY REFERENCE SENSOR OUTPUT (TP2) vs DETECTOR TEMP.

$$Vo = -1.886 + (.025486\ V/^\circ F)\ (T_f+6)$$

Table 1

°F	Vo (Volts)
84	.408
83	.382
82	.357
81	.331
80	.306
79	.280
78	.255
77	.229
76	.204
75	.178
74	.153
73	.127
72	.102
71	.076
70	.051
69	.025
68	.000
67	−.025
66	−.051
65	−.076

Table 1A

°F	Volts
HI-SCALE DHS-26	
1800	1.435
1805	1.440
1810	1.445
1815	1.450
1820	1.456
1825	1.461
1830	1.466
1835	1.471
1840	1.476
HI-SCALE DHS-28	
2380	2.060
2385	2.065
2390	2.070
2395	2.075
2400	2.080
2405	2.086
2410	2.091
2415	2.096
2420	2.102

7.0 TROUBLE SHOOTING

The problems in order of incidence are:

1. Battery dead
2. Battery contacts bad
3. Broken wires
4. Component failure

The following procedures may be used to troubleshoot the instrument if necessary.

Table 2 TROUBLE SHOOTING GUIDE

STEP	SYMPTON	ISOLATION PROCEDURE	CORRECTIVE ACTION	
			IF NORMAL	IF ABNORMAL
1	No display.	Check battery. Battery voltage should be greater than 6.0v.	Make sure that the battery wire harness does not have a broken wire.	Replace battery.
2	No display.	Make sure that the cable connecting the amplifier to the processor board is connected so that pin 1 is the brown wire.	Go to Step 3.	Install the connector properly.
3	No display.	Make sure that no wires are broken on the switch.	Go to Step 4.	Solder wires.
4	No −5.0v. Display still does not work.	Check the voltage on Q2 power converter board. They should be as follows: J6−7 & 8 = Battery Voltage J6−2 & 3 = 5.0 ± .250	Go to Step 5.	If there is no +5v ± .250 replace Q2 (LM2431 AT-5).
5	No −5.0v. Display still does not work.	Check U1-5 and U2-5 on the power converter board. It should be −5.0v ±.25v.	Go to Step 6.	Replace U1 and U2. (ICL7660).
6	Display still does not work.	Check U1-23 with 10X probe on the processor board. It should be a clock with a frequency of 3.58 Mhz.	Go to Step 7.	Replace Y1 (3.58 Mhz crystal).
7	No display.	Check U2-2 on the processor board for a 3.58 Mhz ±10% clock.	Replace U2 (80C48).	Replace U1 (7109).
8	Displays incorrect or illegal characters.	Make sure that the battery is good, because it is possible for the battery voltage to be too low to light "LO BATT". The computer is erratic below 4.75v.	The problem is either U2 of the processor board or U1 of the display board.	Replace battery.
9	Display locks up and won't change with temperature change.	Turn unit off and on. The computer is hung in an illegal state.	Done.	Go to Step 8.
10	Displays "HLP" in self-test mode.	Re-calibrate unit per calibration procedure, or return to factory for repair.	Done.	If re-calibration did not work, then return to the factory for repair.
11	Unit displays "---".	Means "out of range." Re-calibrate unit per calibration procedure, if known target temperature is not out of range.	Done.	Return unit to factory for repair.

8.0 SPECIFICATIONS

Table 3
HEAT SPY SPECIFICATIONS

Model	DHS-24X (LCD) DHS-24 (LED)	DHS-26X (LCD) DHS-26 (LED)	DHS-28X (LCD)
Application	General Use including Glass Surfaces Best Accuracy	General Use including Glass Surfaces	High Temp including Glass Surfaces
Temperature Range	0 to 1000°F −20 to +550°C	0 to 2000°F −20 to +1000°C	32 to 2500°F 0 to 1400°C
Digital Readout LCD 0.5 in. (12mm) LED 0.33 in. (8.2mm)	LCD LED	LCD LED	LCD
Factory Mutual approved for hazardous environments	Yes	Yes	Yes
External °F/°C Switch	Optional	Optional	Optional
Spectral Range (Microns) = Meters X10-6	8-14	8-14	8-14
Accuracy at 77°F ±5°	±0.3% Full Scale	±0.3% Full Scale	±0.3% Full Scale
Ambient Operation Temperature	25 to 125°F −4 to +52°C	25 to 125°F −4 to +52°F	25 to 125°F −4 to +52°C
Temp. Coefficient	±0.1 deg/deg	±0.1 deg/deg	±0.1 deg/deg
Repeatability	±1°F	±2°F	±3°F
Resolution	1° F/C	1° F/C	1° F/C
Response Time to 95% of Reading	1 sec.	1 sec.	1 sec.
Target Size at Focal Point	1.6 in. dia. @ 2 ft.	1.6 in. dia. @ 2 ft.	1.6 in. dia. @ 2 ft.
Distance to Target Size Beyond Focal Point	20:1	20:1	20:1
Practical Working Distance	0 to 40 ft.	0 to 40 ft.	0 to 40 ft.
Sighting System	Enclosed Optical Sight	Enclosed Optical Sight	Enclosed Optical Sight
Adjustable Emissivity Range	0.2-1.0	0.2-1.0	0.2-1.0
Internal Calibration	Auto-zero	Auto-zero	Auto-zero
Internal Self-Test	Yes	Yes	Yes
Maxi-Temp Peak Hold	Yes	Yes	Yes
Output to Recorder	Option J	Option J	Option J
Battery	One 9V (LCD) Two 5.4V (LED)	One 9V (LCD) Two 5.4V (LED)	One 9V (LCD)
Continuous Operating Time	40 hrs. (LCD) 15 hrs. (LED)	40 hrs. (LCD) 15 hrs. (LED)	40 hrs.
External Power See Options	With option EP, P/N BP6 Rechargeable Battery Pack provides 200 hrs. on LCD models or 40 hrs. for LED models on one charge. Continuous line operation through recharger.		
Weight Lbs.	2.2	2.2	2.2

LASER SIGHTING

Heat Spy models DHS24XL, DHS26XL, DHS28XL and DHSA include laser beam sighting.

The laser beam defines the center of the target to be measured by projecting a spot of high intensity red light on the target surface. Note that the entire surface area to be measured is larger in diameter than the spot illuminated by the laser. If desired, look through the enclosed optical sight to determine the entire diameter of the target.

The bright laser beam will not affect temperature readings. The beam will appear brightest in indoor light and dim in outdoor light. The enclosed optical sight is more effective in other outdoor lighting conditions.
To activate laser sighting, turn on the laser power switch located on the left side of the *Heat Spy* in the area just above the handle. Squeeze the Heat Spy trigger to illuminate the laser beam. The beam ceases to illuminate when the trigger is released.

To save battery life, turn off the laser power switch after use.

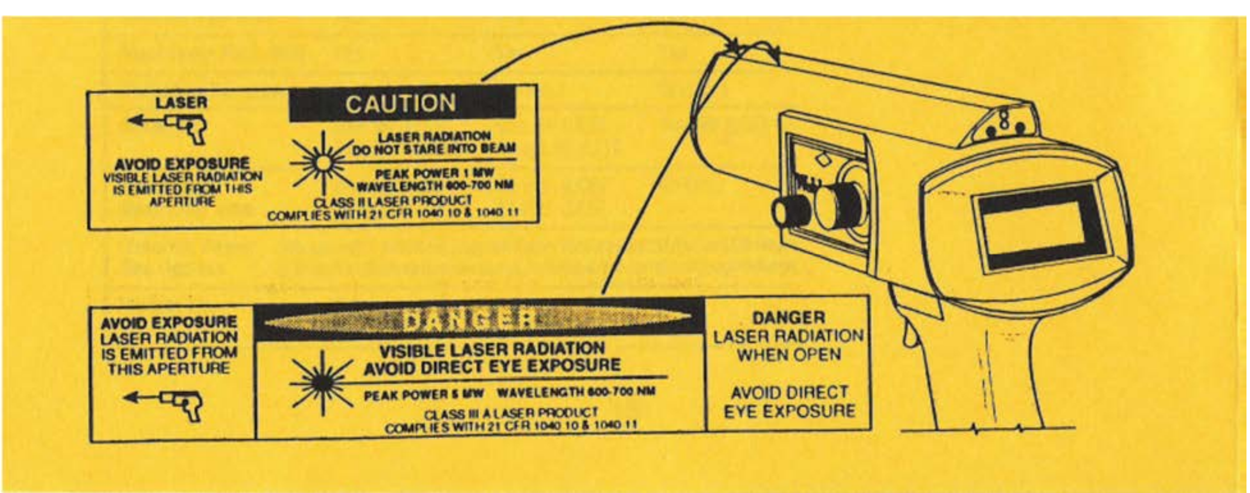
LASER SPECIFICATIONS

Power output - 4 mW maximum
Wave length -660 nm
Useful range -100 feet (indoors)

CAUTION

DO NOT AIM THE LASER SPOT AT THE EYE AS EYE DAMAGE WILL RESULT.

AVOID REFLECTIONS FROM SHINY OBJECTS SUCH AS MIRRORS, BRIGHT METAL AND GLASS. THE REFLECTED LASER LIGHT IS AS DANGEROUS AS THE DIRECT BEAM.



HAZARDS OF LASER RADIATION
(Reference: Code of Federal Regulations, CFR 1040.10)

There are essentially two laser power classifications that apply to aiming type visible lasers such as are utilized in the Wahl Infrared laser Pyrometers.

Class II

A Class II laser applies to lasers that emit energy in the 400 to 710 nm visible wavelength. The maximum power that is allowed under this classification is 1.0mW (0.001 Watts).

The energy emitted by a Class II laser is considered to be a chronic viewing hazard.

Direct viewing of the laser should be prevented at all times. Care must be taken not to allow the laser energy to be reflected from a shiny surface into the eye.

Class III-A

A Class III-A laser applies to lasers that emit energy in the 400 to 710 nm visible wavelength. The maximum power that is allowed under this classification is 5.0mW (0.005 Watts).

The energy emitted by a Class III-A laser Is considered to be either an acute intrabeam viewing hazard or a chronic viewing hazard, and an acute viewing hazard if viewed directly with optical instruments.

Direct viewing of the laser should be prevented at all times. Care must be taken not to allow the laser energy to be reflected from a shiny surface into the eye.

Laser energy reflected from a normal, non-reflective target, such as paper, wood or oxidized metals can be considered safe for viewing by the eye.

ALTERNATE LASER POWER AVAILABILITY

The laser energy emitted by the Wahl Infrared Pyrometer is adjusted at the factory and certified to be under 5.0mW conforming to the conditions specified in Class III-A of CFR 1040.10. The energy is considered dangerous if viewed directly by the eye.

Wahl Instruments can offer an alternate laser power output of 1.0mW which conforms to Class II of CRF 1040.10. Please consult the factory if this alternate laser power output is required.

Table 3 (Continued)

OPTIONS

Output Jack for 1 mv/deg linear output. Includes connection for external battery pack, BP12 below.
Specify Option "J"

Modification to use External Battery, BP12 below.
Specify Option "EP"

External Battery Pack with recharger for 11OV.
Specify BP12-110

External Battery Pack with recharger for 220V.
Specify BP-12-220

Optional of to °C Computer Calculated, switch selection on handle.
Specify Option "S"

Wahl Heat Spy Thermometers are specified and tested in accordance with ASTM specifications.

9.0 FACTORY REPAIR PROCEDURE

Pack the instrument in the original shipping container to prevent additional damage. We specify this requirement because the package is designed to protect against damage.
Ship Parcel Post/Prepaid to:

Wahl Instruments, Inc.
234 Old Weaverville Road
Asheville, NC 28804-1260

Your instrument will receive immediate attention.

10.0 OTHER HEAT SPY MODELS

Standard Heat Spy portable infrared thermometers are available covering target temperatures from below zero to 3200°F (DHS 17X, 19X).

Request up-to-date brochure covering Heat Spy Automatic Infrared' Thermometers (HSA Series) from Wahl Instruments, Inc. for complete detailed specifications.

A complete line of continuous temperature monitoring systems is available from Wahl designated "Heat Spy Monitors" (HSM series). These systems are designed for continuous process monitoring and control and cover temperature ranges from -50°F to +4000°F. A selection of special spectral ranges for glass and plastic and a variety of set point and proportional controllers are available. Request up-to-date brochure covering "Heat Spy Monitors" for detailed specifications.

11.0 HEAT SPY ACCESSORIES AND SPARE PARTS

Strip Chart Recorder, Model RHS-a, or RHS-14
Chart Paper CP30, 69176
Tripod, PIN T1 0
Safety Strap, PIN WS14
Carrying Case, PIN 9990
Holster, PIN H-7
Battery, MN 1604
Replacement Front Filter, PIN 11349-1

12.0 INFRARED TEMPERATURE MEASUREMENT

Any object at a temperature above absolute zero emits infrared energy. A fixed relationship exists between the temperature of an object and the amount of energy it radiates. It is therefore possible to obtain accurate target temperature by measuring this amount of radiation.

Infrared is one form of electromagnetic energy; other forms are visible light, ultraviolet, gamma rays and microwaves. The standard unit for measurement of wavelength is a micron, a micron being one millionth of a meter. (In referring to wavelengths of visible light, the angstrom is commonly used as a unit of measure. 10,000 angstroms equal 1 micron). 1 Angstrom equals 10-^{10} meter.

Referring to Figure 7, the spectrum on the bottom of the diagram indicates the relative relationship between visible and infrared energy. The visible spectrum, is from approximately 0.3 to 0.7 microns, the infrared is in the longer wavelength region, to approximately 1,000 microns. For our purposes, we are concerned with the infrared region only at 1 micron to 20 microns. This graph shows relative amplitude of radiation as a function of the wavelength.

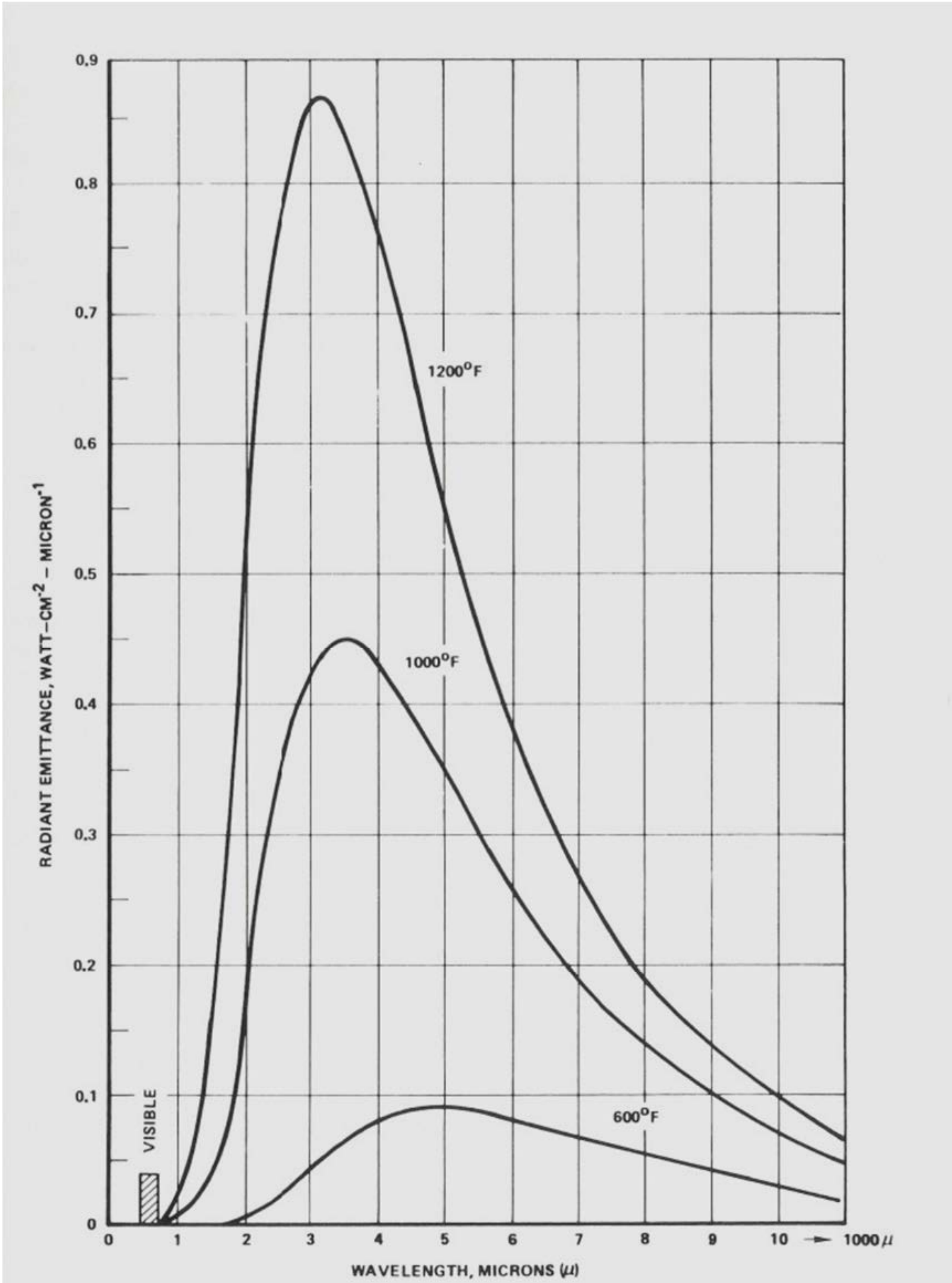


Figure 7
Wavelength vs. Energy

The lower curve in the graph shows the approximate distribution of infrared radiation from a material at a relatively low temperature (about 600°F). The peak radiation is at 5 microns with approximately half that amount of radiation at 3.5 and 7.0 microns. The total amount of radiation being emitted from the surface is indicated by the area under the curve.

As the temperature of this material is increased, two significant things happen. First, the total amount of energy being radiated, the area under the curve, increased quite rapidly, in fact, by the fourth power of the temperature. The upper curve shows the radiation at a higher temperature (about 1200°F). Note how the area under the curve (the total radiation) has increased compared to the lower temperature curve. When we measure the temperature of a surface without contact, we are measuring the difference (change) between the total amounts of radiation at various temperatures.

The second significant change with temperature is that the peak energy in the upper curve is located at a shorter wavelength as compared to that for the lower curve. Not only does the total amount of energy being radiated from a material increase as its temperature is increased, but also this energy becomes concentrated more and more towards the shorter wavelengths (the visible spectrum). This can easily be demonstrated by observing a piece of steel being heated. Below 1000°F there is not appreciable change in color of the material. At 1000°F the material begins to glow with a "cherry red" color. This is because there is enough energy being radiated in the longer wavelength region (red portion) of the visible spectrum for the eye to detect. As we further heat the piece of steel it now becomes "white hot"; the energy being radiated by this material is spread more evenly throughout the entire visible spectrum and the eye receives the sum of all colors, or white.

Two important things happen as the material heats up. First, the amount of energy being radiated from the surface increases quite rapidly and second, the concentration of energy is more in the shorter wavelengths. Knowledge of this latter effect allows us to establish certain application rules. For example, an infrared instrument which is sensitive only in the shorter wavelengths is used for measurement of higher temperature surfaces. For lower temperature measurements, however, the instrument must be sensitive in the longer wavelengths since most of the radiated energy is concentrated in this region.
The purpose of the optical system is to collect and focus incoming infrared radiation on the detector with a minimum transmission loss.

Infrared radiation, after passing through the optical system, is focused on the sensitive area of the detector.

The detector converts the radiated energy to an electrical signal which requires amplification and conditioning for final temperature readout.

13.0 EMISSIVITY

The characteristics of materials, particularly with respect to the ability of materials to absorb, transmit or reflect infrared energy leads to a discussion of emissivity. See Table 4 for measured data on common materials of industry.

13.1 Theoretical Aspects of Emissivity

In Figure 8, assume the block on the left-hand side is a hot source which is radiating infrared energy. One the right is the target material. Since the block on the left is hotter than the material on the right, the net transfer of radiation will be from left to right. One of three things will happen to the energy as it reaches the material on the right.

(a) Some energy will be absorbed and converted into heat.

(b) Some energy will be reflected from the surface of the material.

(c) Some energy will be transmitted completely through the material.

As one or more of these three things must happen to the energy, the amount of energy absorbed, reflected and transmitted must add up to 100%. Therefore, the coefficients of absorption, reflection and transmission (A, Rand T) must equal 1. If we reverse the situation and make the material on the right hotter than the block on the left, the net transfer will not be from right to left. It can be demonstrated that the emissivity - or the relative ability of this material to radiate energy, is exactly equal to its coefficient of absorption (its ability to absorb energy).

Therefore, we can substitute E (emissivity) for A (absorption) resulting in the formula in Figure 8. This formula states the emissivity plus the reflectivity plus the transmittance of a material must equal 1.

The ideal material in non-contact temperature measurement and in fact the source against which instruments are calibrated is the black body. *This is defined* as a *surface which emits the maximum amount of radiation at* a *given temperature*. The name "black body" is misleading because it implies color - the color of the material is not as important as the surface finish. Materials which are good radiators (absorbers) and approximate black body conditions are carbon, asbestos and rubber. Highly polished metals are poor black bodies and therefore good reflectors.

By definition, the black body material (see Figure 8) will have an absorption and therefore an emission of 1, surface reflectance of 0 and transmittance of O. Therefore, looking at the net transfer of radiation from left to right, all of the energy being radiated from a source to a black body will be absorbed; in turn, when the black body radiates back to the source, or any other object, the maximum possible amount of energy will be radiated.

Compare a material which is more often found in actual situations and which we define as a "grey body" (see Figure 9). Here with the source on the left and the material on the right, we have an absorption coefficient (and therefore an emissivity) of 0.7, reflectance of 0.3 and transmission of O. This means 70% of the energy is absorbed by the material and 30% is reflected off the surface. This also means the emissivity is 0.7 and the ability of the material to emit, as compared to a black body at the same temperature, is only 70%. If we heat both the black body and the grey body to exactly the same temperature, the grey body will emit only 70% of the energy being emitted by the black body. (See Figure 10).

The upper curve in Figure 10 shows the distribution of radiation of a black body material at a given temperature. The lower curve (E =0.7) gives the distribution of energy for a grey body material of emissivity of 0.7 at that same temperature. Note the curves have a common shape except that the latter is reduced by 30% at all points.

The result is that the area under the latter curves is only 70% of the area under the black body curves.

Obviously, in developing a practical instrument for non-contact temperature measurement, this situation poses a problem. The problem being: how can we accurately measure temperature without contact when we are really measuring radiation from a surface knowing that the amount of radiation can vary due to the emissivity of the material?

The problem is solved in the design of Heat Spy by correcting for the emissivity. In the example shown in Figure 10, with a material emissivity of 0.7, we will set in 0.7 on the emissivity compensation knob on the instrument.

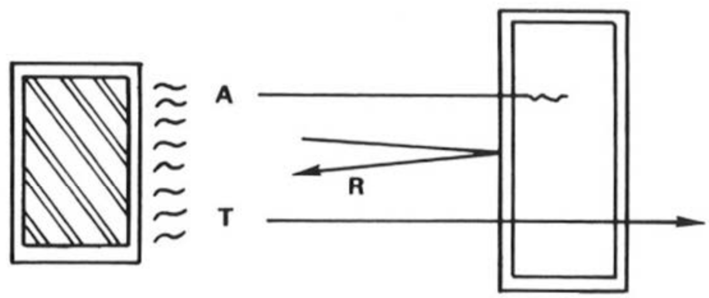
This supplies an electrical gain in the instrument of a magnitude of 1~ Note that now 70% of the measured energy (as compared to a black body against which the instrument was calibrated) times .1f equals 100% of the energy or the proper reading on the dial. Therefore, as long as the emissivity knob on the instrument is properly set with respect to the material being measured, all measurements with the Heat Spy Infrared Thermometer will be precise.

13.2 Practical Determination of Material Emissivity

Many materials have an emissivity of essentially 1.0 (black body) condition. These are most organic materials and non-metallic materials, those surfaces which appear to be rough and highly absorbent. Materials such as cloth, leather, rubber, paint, asbestos and wood are, for practical measurement purposes, black body surfaces. For measurement of these materials the emissivity setting can be left at 1.0.

When the emissivity of the material is obviously less then 1.0, the user must know where to set the compensation knob.
If an exact determination of emissivity is required, then it is best to determine this figure experimentally. One method is to determine the actual temperature of the material independently either by using a thermocouple or other contact device or by bringing the material up to a known temperature, and the emissivity control adjusted until the temperature reading is the same as obtained by the

independent temperature measurement instrument. This emissivity figure is then always used when measuring the temperature of this material.



$$A + R + T = 1$$

$$E = A$$

$$E + R + T = 1$$

Figure 8
Blackbody Emissivity

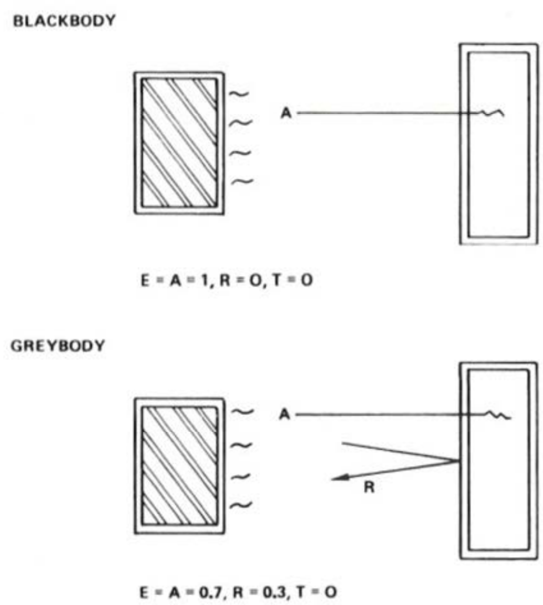


Figure 9
Greybody Emissivity

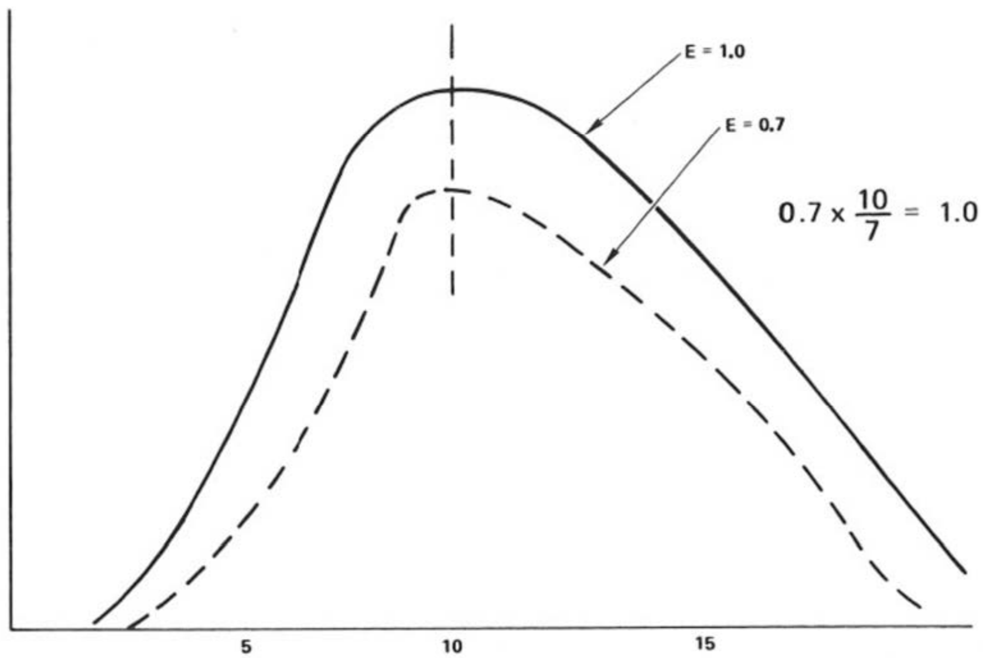


Figure 10

Emissivity Correction

When it is not practical to take a sample of the material, emissivity may be determined as follows:

Paint a small area of the material with a dull black paint. Note that this area must be larger than the field of view (target size). This coated portion of the surface now has an emissivity of 1.0 (black body) and can be measured with the Heat Spy emissivity control at 1.0. Reading should then be taken of the unpainted portion of the surface (as close to the painted area as possible without overlapping) and the emissivity control should be adjusted until the reading is the same as that obtained from the painted area. Again, the emissivity setting should be noted and used when the same material is being measured.

13.3 Emissivity Tables

Tables for typical emissivity of various surfaces are shown on the following pages.

Materials with emissivities greater than 0.5 can be handled with emissivity adjustment on the Heat Spy.
Below emissivities of 0.5, there is a surface variation factor (i.e. small changes in the surface can create great changes in actual energy radiated). A good example is molten steel. Clean/running molten steel has an emissivity of 0.3 and good measurements can be made with Heat Spy in continuous casting. But, in ladle steel, where oxidation layers can form, or even slag floats to the surface, large emissivity variations occur. Measuring across such a surface can show "wild" readings.

Measurement of freshly machined steel is also not recommended. While ordinary cold-rolled steel has an emissivity of 0.8, machined steel emissivity is 0.2 or lower, and small surface variations can cause great variation in the instrument readings.

13.4 Wavelength Effect on Temperature

The Heat Spy Instrument described herein all measure in the 9 to 14 micron range. This was selected for several reasons:

(1) To measure room temperature, the long wave energy must be measured.
(2) This range is not affected by atmospheric water vapor, CO2 or other radiating gases.
(3) This micron range is not subject to sunlight or sunlight reflections.

However, there is more sensitivity in the longer wave lengths to emissivity error if not set exactly which will cause larger temperature errors. An error of 5% in emissivity setting (say 0.95 instead of 1.0) would cause the temperature errors in actual readings at the narrow wave lengths as shown below. Shorter wave lengths are better, especially above 1500°F. But other drawbacks come into play, mainly that sunlight and sunlight reflections can affect instrument readings with spectral sensitivity of 4 microns and less, and of course susceptible to errors in the presence of Infrared Heaters.

Spectral Range of Instrument, Microns	With 5% Error in Emissivity Error % Error in Temperature Measurement at 1200°F	at 2000°F	Comments
9-15	1.5%	2.2%	Not affected by sunlight or IR Lamps.
2-2.5 & .4 to 4.4	0.7%	.9%	Can be affected by sunlight reflectance and IR Lamps.
0.7 - 1.1	0.3%	.5%	Can be affected by sunlight reflectance and IR Lamps.

13.5 Wahl Emissivity Laboratory

Wahl can make emissivity determination for the user in a manner similar to that described in 13.3. Contact our service department.

Table 4

NORMAL TOTAL EMISSIVITY OF VARIOUS SURFACES
METALS AND THEIR OXIDES

MATERIAL	TEMPERATURE °F	EMISSIVITY
ALUMINUM		
Polished	212	0.095
Commercial sheet	212	0.090
nodized sheet, chromic acid proc	212	0.55
eavily oxidized	200 — 940	0.200—0.310
luminum Oxide	930 — 1520	0.420—0.260
ighly polished	212	0.03
xidized		0.61
IUM		
olished	100 — 2000	0.080—0.360
olished	212	0.075
R		
Polished	212	0.052
Plate, heated long time, covered with thick oxide layer	77	0.780
Plate heated at 1110°F	390 — 1110	0.570
Cuprous oxide	1470 — 2010	0.660—0.540
Molten copper	1970 — 2330	0.160—0.130
DOW METAL	450 — 750	0.240—0.200

MATERIAL	TEMPERATURE °F	EMISSIVITY
GOLD		
Pure, highly polished	212	0.02
INCONEL		
Type X,	450 — 1620	0.550—0.780
Type B,	450 — 1620	0.350—0.550
600 as rolled, - oxidized	900 — 2000	0.860—0.980
IRON AND STEEL (not including stainless)		
Cast Iron, polished	392	0.210
Cast Iron, newly turned	72	0.440
Cast Iron, turned and heated	1620 — 1810	0.600—0.700
Wrought Iron, highly polished	100 — 480	0.280
Polished steel casting	1420 — 1900	0.520—0.560
Ground sheet steel	1720 — 2010	0.550—0.610
Oxidized Surfaces		
Iron plate, pickled, then rusted red	68	0.610
Iron plate, completely rusted	67	0.690
Rolled sheet steel	70	0.660
Oxidized iron	212	0.740
Cast iron, oxidized at 1100°F	390 — 1110	0.640—0.780
Steel, oxidized at 1100°F	390 — 1110	0.790
Smooth oxidized electrolytic iron	260 — 980	0.780—0.820
Iron oxide	930 — 2190	0.850—0.890
Rough-ingot iron	1700 — 2040	0.870—0.950
Sheet steel		
Strong, rough oxide layer	75	0.800
Dense, shiny oxide layer	75	0.820

EMISSIVITY OF VARIOUS SURFACES (Cont)

MATERIAL	TEMPERATURE °F	EMISSIVITY
IRON AND STEEL (cont)		
Oxidized Surfaces		
Cast plate, smooth	73	0.800
Cast plate, rough	73	0.820
Cast iron, rough, strongly oxidized	100 — 480	0.950
Wrought iron, dull oxidized	70 — 680	0.940
Steel plate, rough	100 — 700	0.940—0.970
Molten Surfaces		
Cast iron	2370 — 2550	0.290
Mild steel	2910 — 3270	0.280
Steel, various with 0.25—1.2%C (slightly oxidized surfaces	2840 — 3110	0.270—0.390
Steel	2730 — 3000	0.420—0.530
Steel	2770 — 3000	0.430—0.400
Pure iron	2760 — 3220	0.420—0.450
Armco iron	2770 — 3070	0.400—0.410
LEAD		
Pure (99.96%) unoxidized	260 — 440	0.057—0.075
Gray, oxidized	75	0.280
Oxidized at 300°F	390	0.630
MAGNESIUM		
Magnesium oxide	530 — 1520	0.550—0.200
Magnesium oxide	1650 — 3100	0.200

EMISSIVITY OF VARIOUS SURFACES (Cont)

MATERIAL	TEMPERATURE °F	EMISSIVITY
MERCURY		
	32 — 212	0.090—0.120
MOLYBDENUM		
Filament	1340 — 4700	0.096—0.202
MONEL METAL		
Oxidized at 1110°F	390 — 1110	0.410—0.460
NICKEL		
Electroplated polished	74	0.045
Electroplated, not polished	68	0.110
Wire	368 — 1844	0.096—0.186
Plate, oxidized by heating at 1110°F	390 — 1110	0.370—0480
Nickel Oxide	1200 — 2290	0.590—0.860
NICKEL ALLOYS		
Chromnickel	125 — 1894	0.640—0.760
Nichrome wire, bright	120— 1830	0.650—0.790
Nichrome wire, oxidized	120 — 930	0.950—0.980
Nickel-silver polished	212	0.135
PLATINUM		
Filament	80 — 2240	0.036—0.192
Wire	440 — 2510	0.073—0.182
SILVER		
Polished	212	0.052

MATERIAL	TEMPERATURE °F	EMISSIVITY
STAINLESS STEELS		
Type 18-8, buffed	68	0.160
Type 304 (8 Cr; 18 Ni)		
Light silvery, rough brown, after heating	420 — 914	0.440—0.360
After 42 hrs heating at 980°F	420 — 980	0.620—0.730
Type 310 (25 Cr, 20 Ni)		
Brown, splotched, oxidized from furnace service	420 — 980	0.900—0.970
Allegheny metal No. 4, polished	212	0.130
Allegheny metal No. 66, polished	212	0.110
TANTALUM FILAMENT	2420 — 5430	0.190—0.310
THORIUM OXIDE	530 — 930	0.580—0.360
THORIUM OXIDE	930 — 1520	0.360—0.210
TIN		
Commercial tin-plated sheet iron	212	0.070, 0.080
TUNGSTEN		
Filament, aged	80 — 6000	0.032—0.350
Filament	6000	0.390
ZINC		
Oxidized by heating at 750°F	750	0.110
Galvanized sheet iron, fairly bright	82	0.230
Galvanized sheet iron, gray oxidized	75	0.280
Zinc, galvanized sheet	212	0.210

NORMAL TOTAL EMISSIVITY OF VARIOUS SURFACES

REFRACTORIES, BUILDING MATERIALS, PAINTS AND MISCELLANEOUS

MATERIAL	TEMPERATURE °F	EMISSIVITY
ASBESTOS		
Board	74	0.960
Paper	100	0.930—0.940
BRICK		
Red, rough, no gross irregularities	70	0.930
Grog brick, glazed	2012	0.750
Building	1832	0.450
Fireclay	1832	0.750
CARBON		
T-carbon (Gebruder Siemens) 0.9% ash. Started with emissivity at 260°F of 0.720, but on heating changed to values given	260 — 1160	0.810—0.790
Filament	1900 — 2560	0.526
Rough plate	212 — 608	0.770
Rough plate	608 — 932	0.770—0.720
Graphitized	212 — 608	0.760—0.750
Graphitized	608 — 932	0.750—0.710
Candle Soot	206 — 520	0.952
Lampblack-waterglass coating	209 — 440	0.960—0.950
Thin layer of same on iron plate	69	0.927
Thin coat of same	68	0.967

MATERIAL	TEMPERATURE °F	EMISSIVITY
CARBON (cont)		
Lampblack, 0.003-in or thicker	100 — 700	0.945
Lampblack, rough deposit	212 — 932	0.840—0.780
Lampblack, other blacks	122 — 1832	0.960
Graphite, pressed, filed surface	480 — 950	0.980
CARBORUNDUM		
87 SiC; density 2.3	1850 — 2550	0.920—0.820
CONCRETE TILES	1832	0.630
ENAMEL		
White, fused on iron	66	0.900
GLASS		
Smooth	72	0.940
Pryex, lead and soda	500 — 1000	0.950—0.850
GYPSUM		
0.02-in thick on smooth or blackened plate	70	0.903
MAGNESITE		
Refractory brick	1832	0.380
MARBLE		
Light gray, polished	72	0.930
OAK		
Planed	70	0.900

EMISSIVITY OF VARIOUS SURFACES (Cont)

MATERIAL	TEMPERATURE °F	EMISSIVITY
OIL LAYERS ON ALUMINUM FOIL (Linseed Oil)		
Aluminum foil	212	0.087
+1, 2 coats oil	212	0.561, 0.574
PAINTS, LACQUERS, VARNISHES		
Snow white enamel varnish on rough iron plate	73	0.906
Black shiny lacquer, sprayed on iron	76	0.875
Black shiny shellac on tinned iron sheet	70	0.821
Black matte shellac	170 — 295	0.910
Black or white lacquer	100 — 200	0.800—0.950
Flat black lacquer	100 — 200	0.960—0.980
Oil paints, 16 different (all colors)	212	0.920—0.960
Aluminum paints and lacquers: 10% A1, 22% lacquer body, on rough or smooth surface	212	0.520
Other A1 paints, varying age and A1 content	212	0.270—0.670
A1 lacquer, varnish binder, on rough plate	70	0.390
A1 point after heating to 620°F	300 — 600	0.350
Radiator paint; white, cream, bleach	212	0.790, 0.770, 0.840
Radiator paint; bronze	212	0.510
Lacquer coatings, 0.001-0.015-in thick on aluminum alloys	100 — 300	0.870—0.970

MATERIAL	TEMPERATURE °F	EMISSIVITY
PAINTS, LACQUERS, VARNISHES (cont)		
Clear silicone vehicle coatings, 0.001—0.150-in. thick:		
On mild steel	500	0.660
On stainless steels, 316, 301, 347	500	0.680, 0.750, 0.750
On Dow metal	500	0.740
On A1 alloys 24 ST, 75 ST	500	0.770, 0.820
Aluminum paint with silicone vehicle, two coats on Inconel	500	0.290
PAPER		
Thin, pasted on tinned or blackened plate	66	0.920—0.940
PLASTER		
Rough lime	50 — 190	0.910
PLASTICS		
Opaque, any color	77	0.950
PORCELAIN		
Glazed	72	0.920
QUARTZ		
Rough, fused	70	0.930
Glass, 1.98mm thick	540 — 1540	0.900—0.410
Glass, 6.88mm thick	540 — 1540	0.930—0.470
Opaque	570 — 1540	0.920—0.680

EMISSIVITY OF VARIOUS SURFACES (Cont)

MATERIAL	TEMPERATURE °F	EMISSIVITY
ROOFING PAPER	69	0.910
RUBBER		
Hard, glossy plate	74	0.940
Soft, gray, rough (reclaimed)	76	0.860
SERPENTINE, polished	74	0.900
SILICA		
(98 SiO_2, Fe-free) effect of grain size, microns (μ)		
10 μ	1850 — 2850	0.420—0.330
70—600 μ	1850 — 2850	0.620—0.460
WATER	32 — 212	0.950—0.963
ZIRCONIUM SILICATE	460 — 930	0.920—0.800
ZIRCONIUM SILICATE	930 — 1530	0.800—0.520

OTHER		
Turbojet engine, operating	350 — 600°C	0.900
Liquid propellant rocket engine	600 — 4500°C	0.900
Human Skin	98 — 99°F	0.985

NOTE: When temperature and emissivities appear in pairs separated by dashes, they correspond and linear interpolation is permissible.

HEAT SPY INFRARED THERMOMETERS

ADDENDUM TO INSTRUCTION MANUAL FOR MODELS DHS-24/26/28 TO ADD MODEL DHS29XT

REFERENCE PARAGRAPH	DHS29XT
2.1 How It Works	Refer to the block diagram for the DHS29XT. This diagram replaces Fig. 1 on Page 1. The principles of operation remain the same.
3.3 Measuring	Models designated "XT" have a telescopic sight mounted above the barrel.
4.8 Optical Filter	The optical filter on the above model is located in the detector assembly. The spectral range is: DHS29XT 2.1 to 2.5 microns
5.2 Theory of Operation	Fig. 4 - Block Diagram is to be modified to reflect changes in optics of the unit for DHS29XT.
5.4 Self Test	When the Instrument switch is set to "Self Test", the detector signal is substituted with an electrical equivalent to 1780 degees F. If this signal is processed correctly, the resultant value seen by the microprocessor will fit within the predetermined limits and the word "HLP" will not be displayed as it would if the limits had been exceeded. The "SELF TEST" feature provides a test of approximately 90% of all the electronic components for gross failure.

6.1 Detailed Calibration

A.3 Black Body Calibration Source should be capable of 900 to 3200 degrees F.

B.1 Connect DVM (+) to TP2 and (-) to TP1. Adjust R3 on the unit until the DVM reads the output voltage as shown in table 1B.

B.2 Optics should be looking at a room temperature source. Connect the DVM (+) to TP3 and (-) to TP1. Adjust R35 on the Amplifier Board for a reading of 0.00V ±0.002V. Move the DVM (+) to TP6. Adjust R34 for a reading of 0.714V, using the 2V scale.

B.3 Connect the DVM (+) to TP4 and the (-) to TP1. Adjust R19 for a reading of 1.348V. Connect the DVM (+) to TP5 and adjust R16 for a reading of 1.417V.

B.4 Assemble the unit and set the Black Body Calibration Source to 1800 degrees F. Adjust R10 for a reading of 1800 on the display. (982 for a Centigrade reading unit) Set the Black Body Calibration Source to 1000 degrees F. Adjust R19 for a reading of 1000. (538 for Centigrade reading unit) Repeat B.3 and B.4 until both 1800 and 1000 are achieved. Use a distance of 10' from target to instrument.

B.5 Connect TP-1 and TP-2, of processor board, with a jumper. Set the Mode switch to Self Test and view the display for a sequence of four number pairs. The numbers are displayed two at a time and are preceded by "L" for low range and "H" for High Range.

REFERENCE PARAGRAPH DHS29XT

6.1 Detailed Calibration (Continued)	Adjust R24 so that the first two number pairs read: L55 L28.

Remove the jumper from TP-1 to TP-2 and set the Mode switch to READ.

B.6 Set the Black Body Calibration Source to 2300 degrees F. Connect the DVM (+) to TP-3 and the DVM (-) to TP-1.

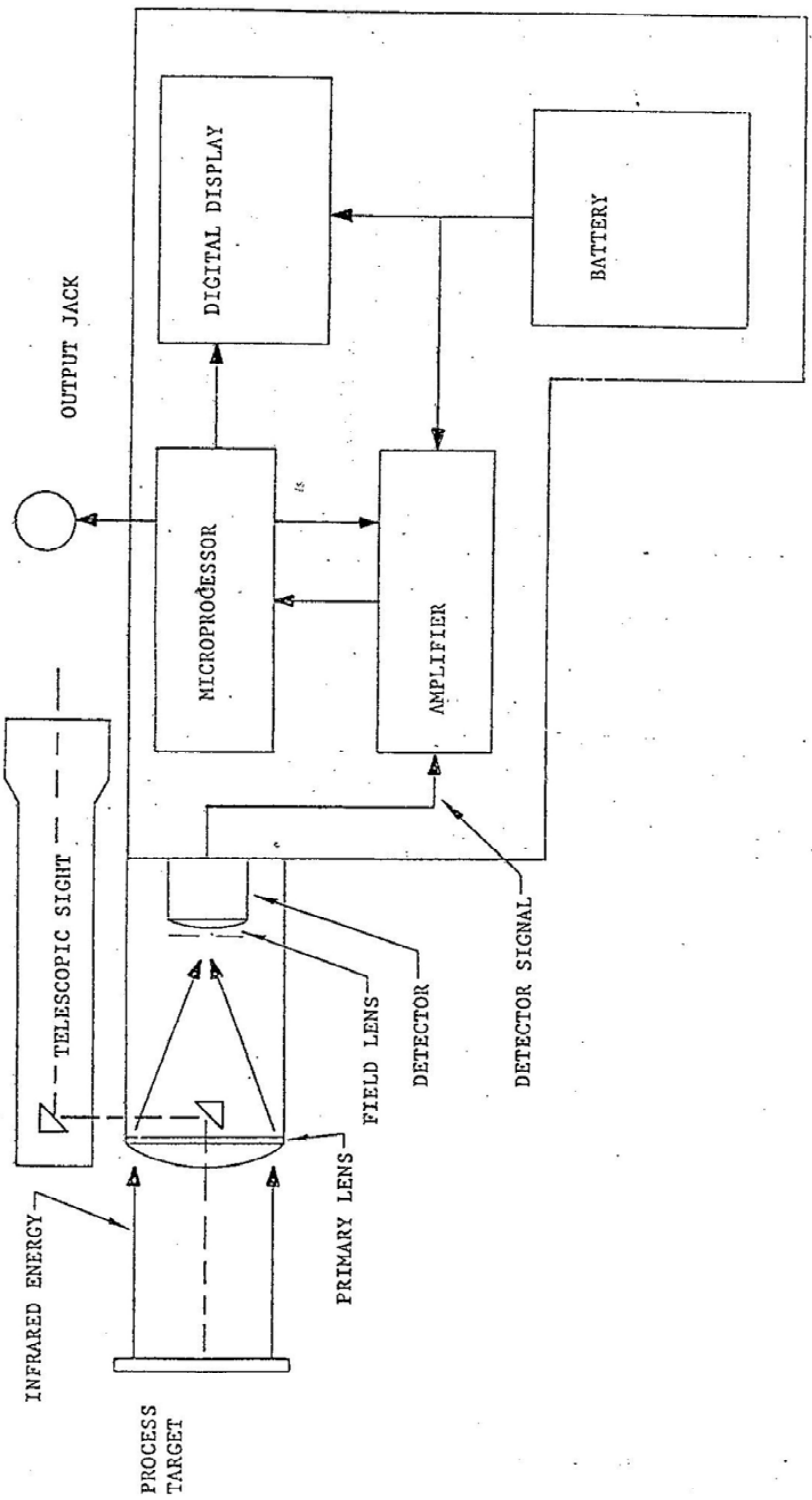
B.7 Set the Function switch to READ and adjust R13 for the correct voltage reading shown in table 1A

B.8 Set the Function switch to SELF TEST. Jumper TP-1 and TP-2 on the Processor board. Adjust R16 to obtain H7 H67 on the display. Remove the jumper from TP-1 to TP-2. Re-check the calibration at 2300 degrees F without the DVM at TP-3 but use the DHS29XT display and touch up R13 as necessary.

Adjust R13 if necessary. Jumper TP-1 and TP-2 and re-check the display for an indication of H7 H67. Adjust R16 if necessary.

B.9 Repeat the last two steps until acceptable calibration is achieved. Remove the TP-1 to TP-2 jumper.

B.10 Set the FUNCTION switch to SELF TEST. The display should be blinking the ambient temperature within 2 degrees F. If a different temperature is flashing it means that either the detector temperature is



BLOCK DIAGRAM

6.1 Detailed Calibration (Continued)

other than room temperature or that the adjustment in step one was not performed correctly.

If "HLP" appears, it indicates a problem with the upper scale and lower scale alignment. Go back to step B.5 and repeat the procedure from there.

TABLE 1B
HEAT SPY REFERENCE SENSOR OUTPUT
(TP2) vs DETECTOR TEMP.

DEGREES F	Vo (VOLTS)
84	0.308
83	0.289
82	0.270
81	0.250
80	0.231
79	0.212
78	0.192
77	0.173
76	0.154
75	0.135
74	0.115
73	0.096
72	0.077
71	0.057
70	0.038
69	0.019
68	-0.001
67	-0.020
66	-0.039
65	-0.058

TABLE 1A
HI-SCALE DHS29

DEGREES F	VOLTS
2208	0.687
2309	0.804
2412	0.930

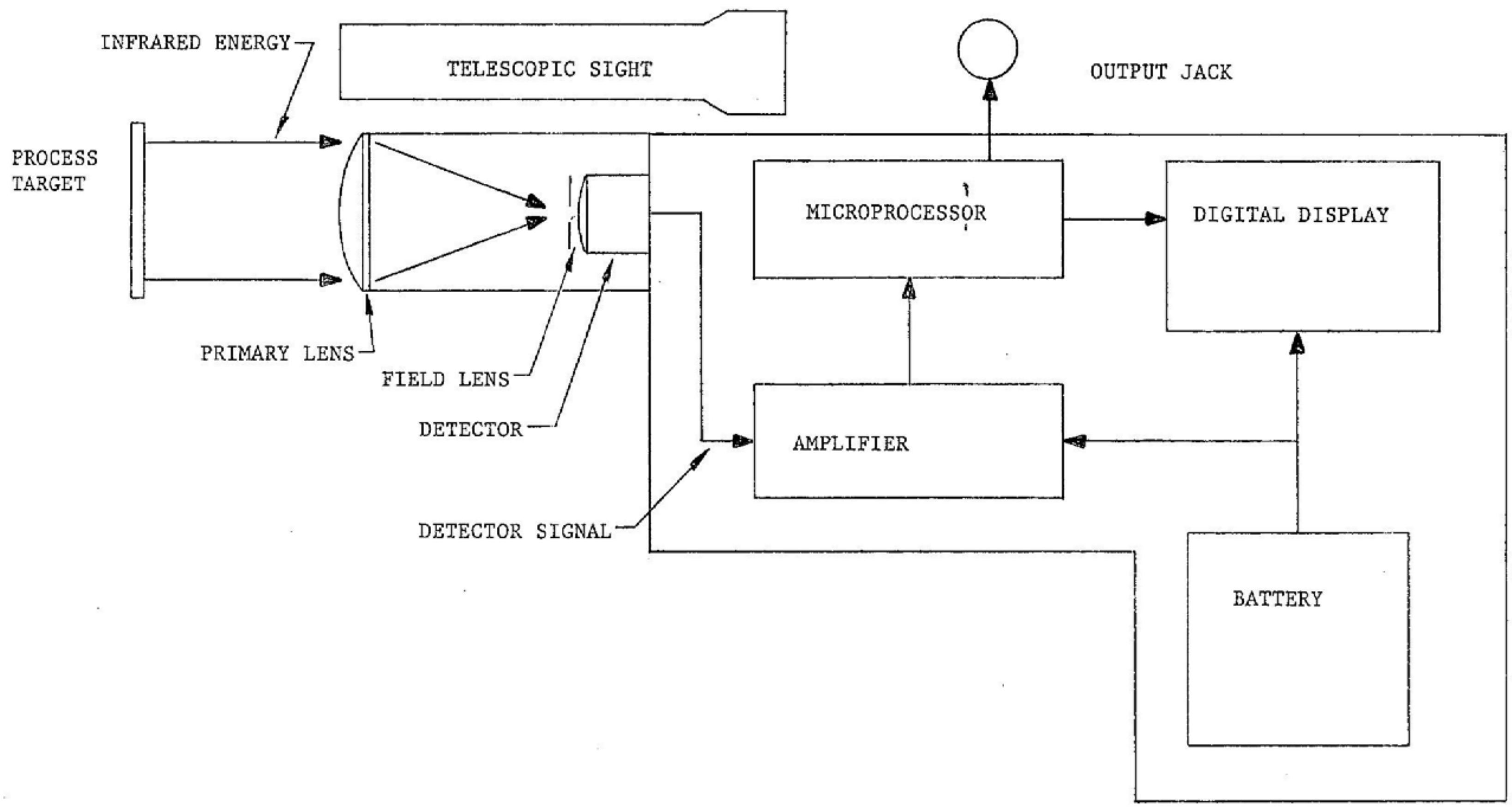
REFERENCE PARAGRAPH DHS29XT

8.0 SPECIFICATIONS	Table 3
Application	Measures through glass ports and furnace gasses. Measures internal temperatures of glass gobs and surface temp. of molten metals.
Temperature	900 to 3200 deg. F. 482 to 1760 deg. C.
Spectral Range	2.1 to 2.5 microns
Distance to Target Size	120:1
Practical Working Distance Range	3 to 40 feet

HEAT SPY INFRARED THERMOMETERS

ADDENDUM TO INSTRUCTION MANUAL FOR MODELS DHS-24/26/28
TO ADD MODEL DHS35XT

REFERENCE PARAGRAPH	DHS35XT
2.1 How It Works	Refer to the Block Diagram for DHS-35XT. This Diagram replaces Fig. 1 on Page 1. The Principles of Operation remain the same.
3.3 Measuring Temperature	Models designated "XT" have a telescopic sight mounted above the barrel.
4.8 Optical Filter	The optical filter on the above model is located in the detector assembly. The spectral range is: DHS 35XT 3.5 to 4.1 microns
5.2 Theory of Operation	Fig. 4 - Block Diagram is to be modified to reflect changes in Optics of the unit shown for DHS-35XT.
5.4 Self Test	The electrical equivalent for self test is: 5.733 mV.
6.1 Calibration Procedure	Follow Procedure 6.1 in the main manual but substitute the parameters shown here to correctly calibrate the DHS 35XT. Paragraph A, Step 3. Black body temperature source should be capable of 800 to 3200°F. Paragraph B, Step 1. Connect DVM (+) to TP2 and (-) to TP1. Adjust R3 on the unit until the DVM reads the output voltage as shown in table 1B. Paragraph B, Step 2. Connect DVM (+) to TP3 and (-) to TP1. Adjust R35 on amplifier board to 0.000 ±.002V. Move DVM (+) to TP6 and adjust R34 for a DVM reading of .714 ±0.001V. Paragraph B, Step 3. Adjust R19 for a count of : 60 ±3. Paragraph B, Step 5. Point the instrument to a blackbody @2000°F or higher and adjust R10 for correct temperature display. Use 10' as distance to target. Paragraph B, Step 6. Adjust R24 so the first and second numbers seen are: L68 and L19. Paragraph B, Step 7. At this point the high range is automatically set to H68, H19. There is no need to calibrate the high range independently.



DHS-35XT BLOCK DIAGRAM

Wahl

TABLE 1B
HEAT SPY REFERENCE SENSOR OUTPUT
(TP2) vs DETECTOR TEMP.

Degrees F	Vo (Volts)
84	0.308
83	0.289
82	0.270
81	0.250
80	0.231
79	0.212
78	0.192
77	0.173
76	0.154
75	0.135
74	0.115
73	0.096
72	0.077
71	0.057
70	0.038
69	0.019
68	-0.001
67	-0.020
66	-0.039
65	-0.058

8.0 SPECIFICATIONS - TABLE 3

MODE	DHS-35XT
Application	Furnace Tubes
Temperature Range	800 to 3200°F 426 to 1760°C
Spectral Range (microns)	3.5 to 4.1
Distance to Target Size Beyond Focal Point	100:1
Practical Working Distance	3 to 150 Feet

WAHL INSTRUMENTS, INC. • 234 OLD WEAVERVILLE ROAD
ASHEVILLE • NORTH CAROLINA • 28804-1260
TEL: (828) 658-3131 • TOLL FREE: (800) 421-2853 • FAX: (828) 658-0728
EMAIL: info@palmerwahl.com • www.palmerwahl.com