THERMOGRAPHIC TERMINOLOGY

SUPPLEMENT 2
TO
ACTA THERMOGRAPHICA

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THERMOGRAPHIC TERMINOLOGY

presented by
Terminology Commission
of
European Thermographic Association

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TO «ACTA THERMOGRAPHICA»

CONTENTS

PREFACE

Before the Tower of Babel, language problems did not exist. Since that event, however, diversification of language has been tremendous. Different tongues have developed over the centuries, which with individual use, have contributed to international misunderstanding. Up to the seventeenth century, the scientific language was Latin. Any scientist could communicate freely throughout the world by this means. After the influence of the Roman Catholic Church had declined, national languages became more fashionable and communication difficulties increased.

Within a short period of time thermography has become subject to the Babylonian Confusion. For this reason the European Thermographic Association has brought together a Commission to agree upon a common terminology. Translation is still needed today, but with the help of this report, an exact understanding should be achieved.

N.J.M. Aarts

Introduction

Language is the basis of communication. Within geographical Europe, widely differing languages occur within relatively short distances. Since the development of infrared technology, the use of thermographic and thermal measuring techniques have been steadily increasing. It is inevitable that differing shades of meaning have arisen for certain words and terms employed. Scientific literature is now increasing at an exponential rate. Translation also brings certain hazards. It is important that the correct terminology for reporting thermographic publications should be sought. Equivalent meanings in other European languages must be established.

To meet this need the European Thermographic Association set up a Terminology Commission in 1973. Scientific workers from most European countries, with experience in various aspects of this technology were brought together. The commission has now, after 4 years, prepared the following work as a guide, primarily for the medical user of thermographic techniques. It does not claim to be an exhaustive collection of scientific terms. The aim has been to acquaint the clinician with technical terms likely to be used in scientific publications. Most of the words listed have already been defined by some specialised authority. In the normal way such terms are unlikely to be familiar to all clinically trained personnel. Certain new words have been included which have originated from this still young technology. In other cases words have been included, in the hope that the misuse of words and tradenames will be corrected.

"Thermographic Terminology" is presented in English as a basic reference. For translation purposes and local use, the European Thermographic Association proposes to publish other versions e.g. French and German, which will be available through the Secretary General.

It is anticipated that regular reviews and further work will be undertaken by the Commission. All constructive comments or proposals for amendment will be welcomed, and will receive careful consideration. While this short Glossary marks but the first stage of the Commission's work, it is hoped that it will improve both national and international communication in this field. The achievement of this goal will be adequate reward for the many hours and travelling undertaken by the members of this Commission.

E. F. J. Ring
(Secretary to the Terminology Commission)

Historical note

At the Annual General Meeting of the European Thermographic Association held in Madrid (Spain) on October 17th, 1973, Doctor N.J.M. Aarts and Doctor M. Gautherie proposed the inauguration of two special commissions, one for Terminology and the other for Teaching.

The three prime objectives for the Terminology Commission were as follows:

- To establish a detailed nomenclature of terms, symbols and units employed in thermography.
- To circulate this nomenclature among all persons using, or concerned with thermography (including commercial organisation, etc).
- To promote the accurate use of this nomenclature in all documents, publications and communications on the subject of thermography.

The Terminology Commission was set up some months later at the same time as the Teaching Commission, and has met regularly - Strasbourg (21-22 November 1974) (17-19 April 1975), Lille (28-29 November 1975), Bath (8-9 April 1976), Paris (12-13 November 1976), Gent (19th November 1977).

The present publication is the result of much work, additional to these plenary meetings, and achieving the first two objectives. The improvement and application of thermographic terminology will only be effected by the cooperation of its users.

M. Gautherie

Terminology Commission: 1973-1977

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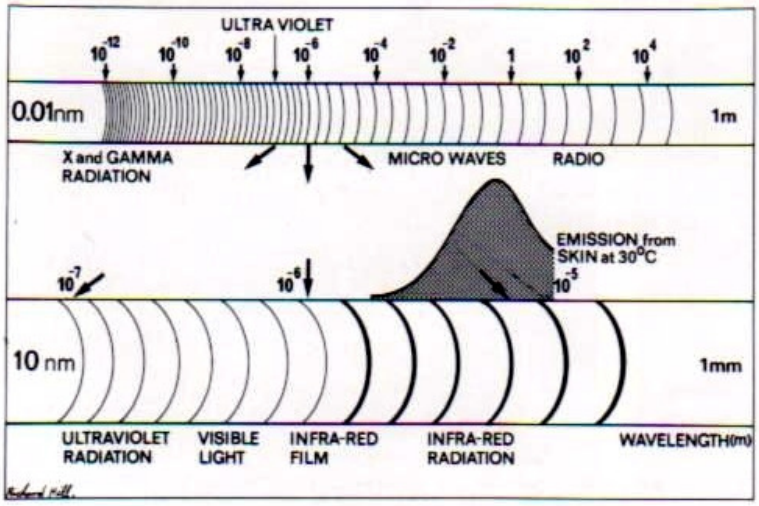
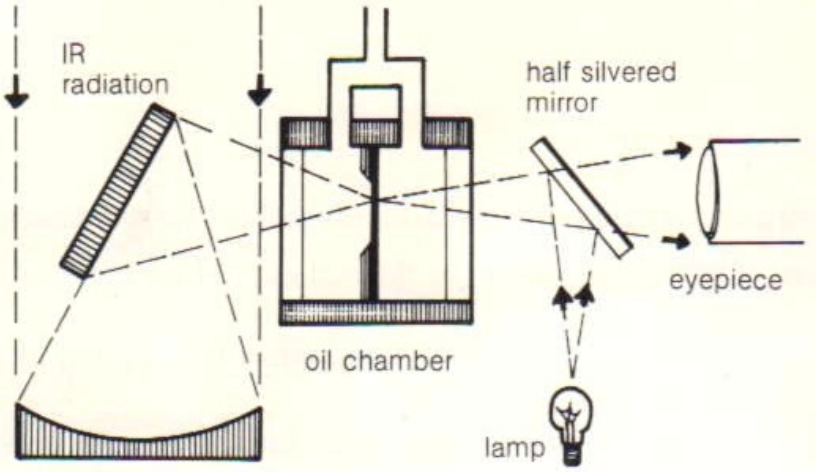
A. Technique

1. **Thermology.** This is a general term for the study of the nature and effects of thermal energy.
2. **Thermometry.** The measure of one parameter of the thermal state of a body, which is temperature.
3. **Thermography.** The recording of the temperature of temperature distribution of a body (whether obtained by conduction, convection or radiation).
   N.B. The term thermography is often used in a narrower sense for a method of forming an image (the thermogram) of temperature distribution on the surface of a body.
4. **Thermoscopy.** Visual representation of the temperature or temperature distribution of a body (this term does not imply a recording as in thermography).
5. **Contact Thermography.** The recording of the temperature (distribution) of a body when the thermal sensor is in contact with that body (e.g. liquid crystal thermography).
6. **Contact Thermoscopy.** Visual presentation of the temperature (distribution) of a body when the thermal sensor is in contact with that body.
7. **Non-contact Thermography.** The recording of the temperature (distribution) of a body when the thermal sensor is not in contact with that body.
8. **Infrared Thermography.** The recording of the temperature (distribution) of a body using infrared radiation emitted by the surface of that body at wavelengths between 0,8 μm and 1.0 mm.
   N.B. infrared thermography should not be confused with infrared photography using the infrared radiation from an *external* source which is *reflected* by the body.
9. **Microwave Thermography.** The recording of the temperature (distribution) of a body using the microwave energy emitted by that body at wavelengths between 1 mm and 1 m.



The Electromagnetic Spectrum.

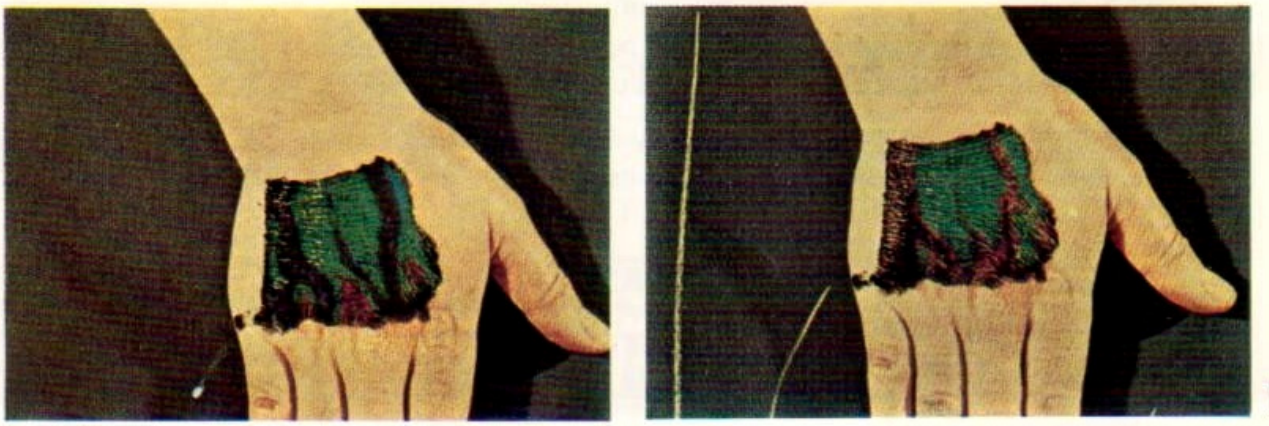
10. **Evaporography.** The recording of the temperature distribution depending on the volatilization of a thin layer of material which is warmed by exposure to infrared radiation.



The Evaporograph.

11. **Liquid Crystal.** A liquid that has optical anisotropy and other properties similar to those of a crystal. Such a substance is said to be in a mesomorphic state. Certain substances which behave in this way are altered by temperature, mechanical stress, electromagnetic radiation or chemical change. They may be used as indicators of this change, if the optical properties can be utilised, I.E. colour change of mesomorphic cholesterol crystals.

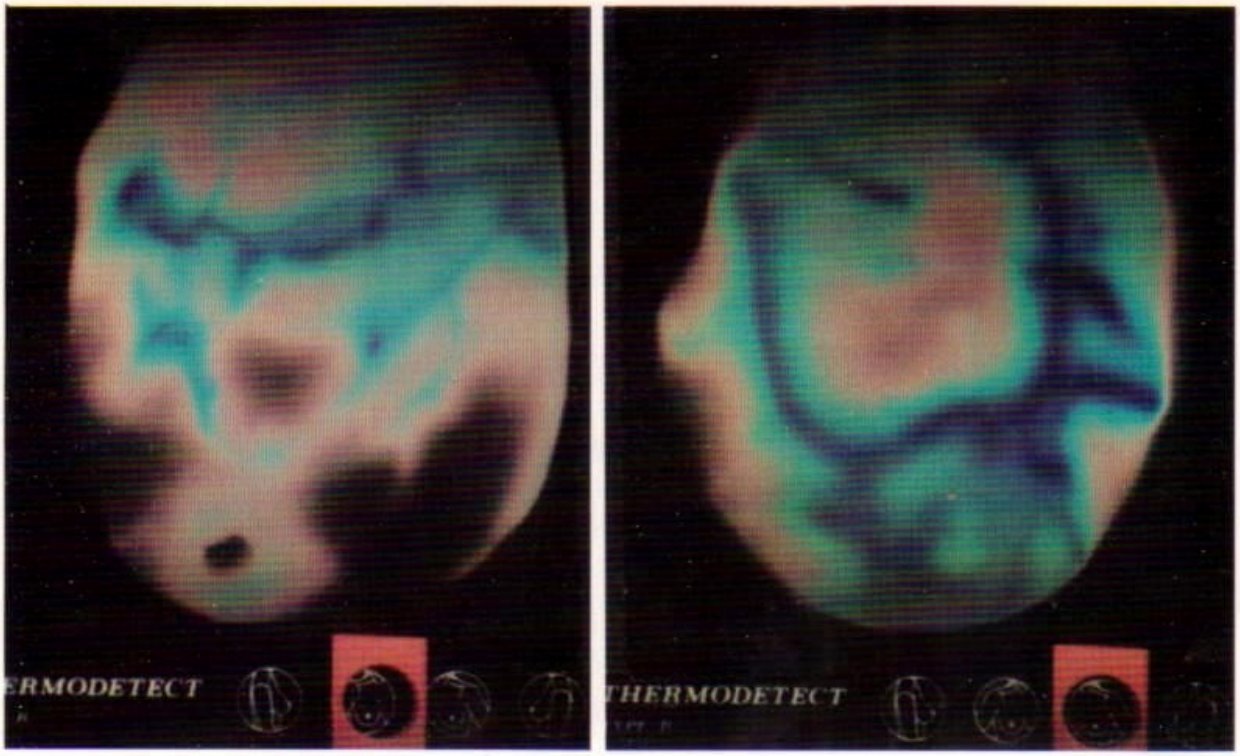
12. **Liquid Crystal Thermography.** The recording of the temperature distribution of a body by covering the body surface with liquid crystals and observing the colour (changes) of the liquid crystals.



A B

Liquid crystals painted on the dorsal surface of the hand, with blue representing the hottest areas and red the coldest. A) Fingers in hot water; veins warm = blue. B) Fingers in cold water; veins cold = red-brown. (From: Lloyd Williams, K.: Mesomorphic cholesterol crystals in surface temperature measurement. *Jour. Radiol. Electrol.*, **48**, 68, 1967).

The liquid crystals are often in the form of micro capsules disposed between two polyester films. In this form they can be used several times.



C D

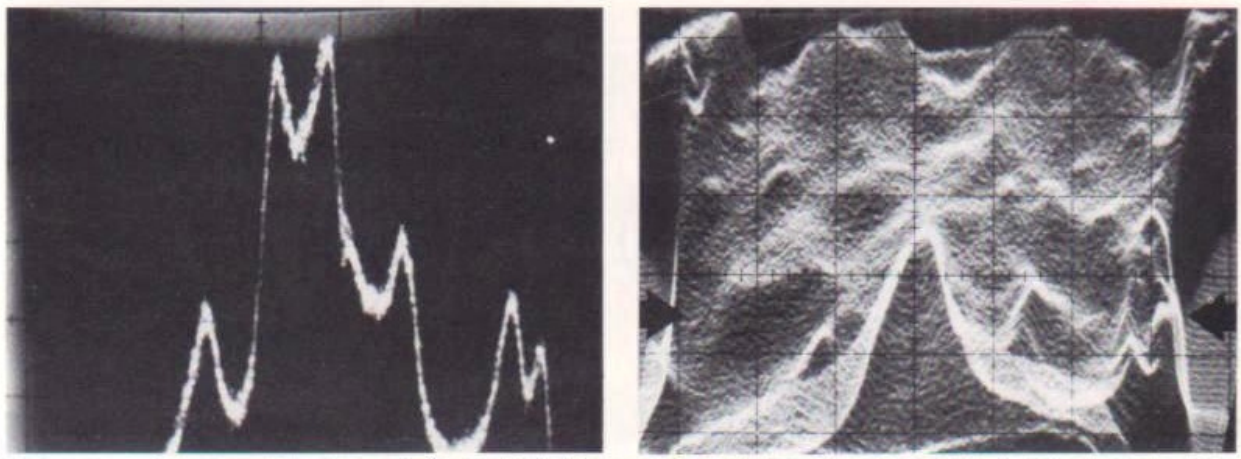
Contact thermography (liquid crystals). C-D) Liquid crystal sheets held in contact with the breast, recorded by colour photography. Blue is the hottest colour, showing the venous pattern.

13. **Thermographer.** The person who practices the technique and interpretation of thermography.

14. **Blackbody.** An ideal body which absorbs all electromagnetic radiation falling on its surface or, when acting as a radiator: an ideal body of which the surface radiation can be described with Planck's law:

$$L(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$$

15. **Linescan (A-Scan) or Thermoprofile.** Distribution of temperature along the intersection of any plane with the surface of the body.



A B

A) Linescan: from breast thermogram. B) Multiple Linescan Z mode (breast thermogram). Arrows show the location of the single linescan.

THE ENVIRONMENT

16. **Ambient Temperature.** The temperature of the surroundings.
N.B. (1) This can only be accurately measured when all surrounding bodies are in thermal equilibrium. (2) All major radiating sources i.e. sunlight, heating and lighting, and air currents will affect thermal equilibrium.

17. **Thermal Equilibrium.** A condition where the net rate of heat exchange between adjacent objects or substances is nil.

18. **Humidity.** The degree of wetness in the atmosphere.

19. **Absolute Humidity.** The mass of water vapour in unit volume of air. This is usually measured as kilograms water per cubic metre of air, ignoring the effect of temperature.

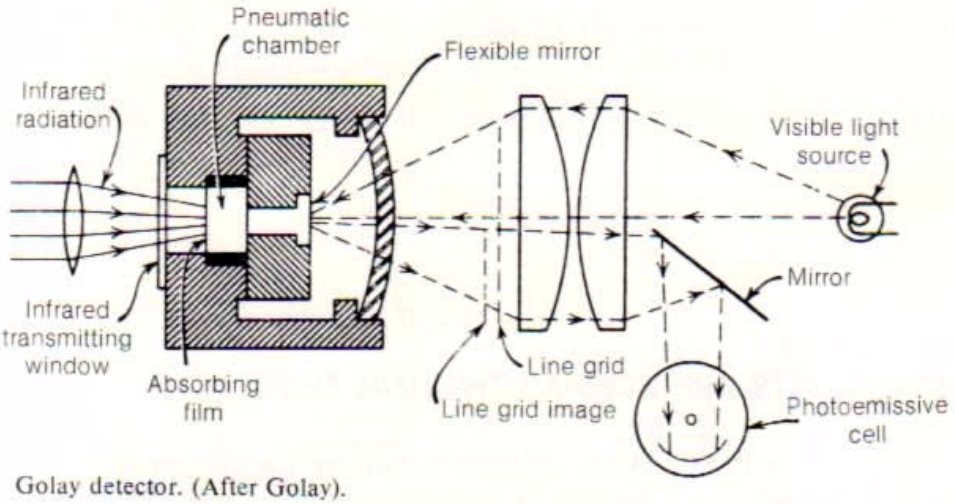
20. **Relative Humidity.** The ratio of the mass of water vapour actually present in unit volume to the mass of vapour required to saturate that volume at the same temperature.

B. Systems; Apparatus and Properties

1. **Detector (for radiation).** A device for monitoring the presence of electromagnetic radiation.
2. **Photo Detector.** A detector based on the freeing of bound electrons by the absorption of single quanta of radiation.
   Note: the essential difference between a photo detector and a thermal detector is that the former in principle counts the number of effective quanta of radiation absorbed whereas the response of the latter depends on the total energy absorbed.

PHOTO DETECTORS CAN BE CLASSIFIED AS:

3. **Photo-Emissive Detectors.** In which electromagnetic charge is emitted from the surface when exposed to radiation (photocell and photo-multiplier).
4. **Photo-Conductive Detectors.** Whereby the resistance of a poor conductor of electricity is decreased by electromagnetic radiation.
5. **Photo-Voltaic Detectors.** In which a voltage is generated across the interface of two semiconductors caused by absorption of radiation.
6. **Golay Cell.** A pneumatic thermal detector based on the high thermal expansivity of gas. The infrared radiation is absorbed in a small gasfilled chamber, resulting in an increase in the pressure and displacement of the flexible mirror. This displacement causes a shift in the reflected image on the line grid, causing a change in the amount of light falling upon the photocell.

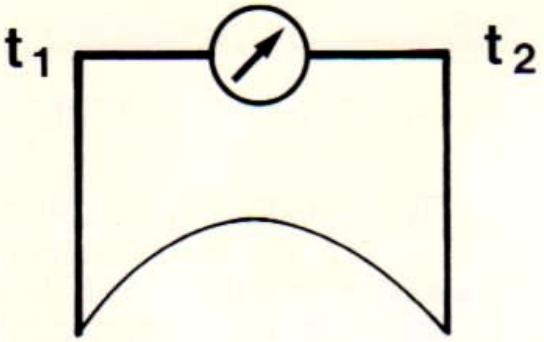


Golay detector. (After Golay).

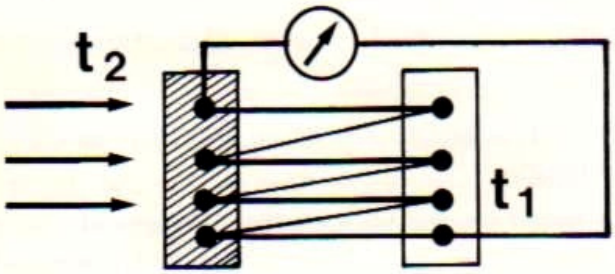
7. **Pyro-Electric Detector.** A cell consisting of certain assymetric crystals (i.e. tourmaline lithium sulphate) which develop opposite electric charges at the ends of their polar axes, under changing temperature conditions.

8. **Thermal Detector.** A detector using the heating effect of radiation.

9. **Thermocouple.** A junction of two wires or rods of dissimilar metals or semiconductors in which an E.M.F. is produced when two junctions are at different temperatures.



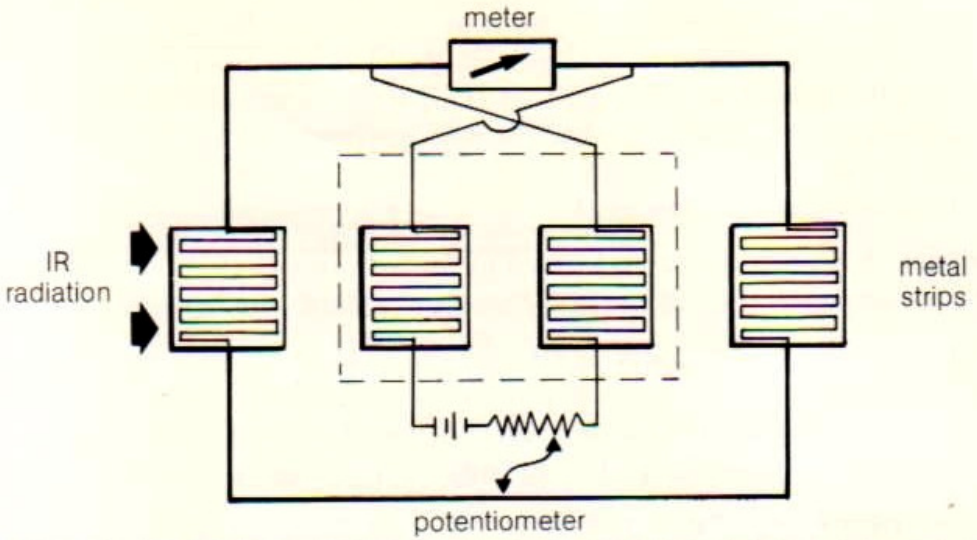
10. **Thermopile.** A series of thermocouple junctions alternately arranged on a flat surface and on surfaces parallel to it, the whole protected by insulating material. When one end surface is exposed to radiant heat, the temperature difference between the two surfaces gives rise to a thermo-electric current which can be measured. The thermopile gives greater output than a single thermocouple.



11. **Thermistor.** Electrical resistance element made of a semiconducting material; its resistance varies with temperature.

THE FOLLOWING INSTRUMENTS ARE USED AS THERMAL DETECTORS:

12. **Bolometer.** An instrument for the detection of radiant heat by the change in resistance of material (e.g. platinum strips) when heated. A *bolometer* is often used for measuring total radiation and consists of very thin blackened strips arranged in series on an insulating former. Two similar strips are used in adjacent arms of a wheatstone bridge, one being exposed to the radiation and the other shielded. The change in resistance of the exposed strip can be estimated by deflection of a galvanometer in the bridge circuit. A temperature change of 10^{-7}k can be observed.



Schematic diagram of a bolometer circuit. Two groups of metal strips are exposed to infrared radiation and two are shielded. The Wheatstone bridge principle is used to indicate the difference in the two halves of the circuit.

13. **Semiconductor Bolometer.** A bolometer in which the sensitive element (platinum strips) are replaced by semi-conductor strips.

14. **Thermometer.** Device for measuring temperature by using any temperature-dependent property of matter, such as volume, resistence, etc.

15. **Radiometer.** An instrument for detection and measurement of electromagnetic radiation e.g. bolometer, thermopile, thermoscope.

16. **Pyrometer.** An instrument for measuring high temperatures, usually by the effects of emitted radiation, or optically by comparing the glow with an incandescent standard of known temperature.

17. **Thermograph.** (A) All systems used to record the temperature of a body. (a general term implying all instruments used to record temperature). (B) (In a narrower sense:) an infrared thermograph is a system to form an image of the temperature distribution of a body using the infrared radiation emitted by the surface of that body at wavelengths between 0.8 μm an 1.0 mm. (In practice mostly between 1 and 4 μm).

18. **Infrared camera.** The optical system and the detector with a preamplifier usually form one unit: *the infrared camera.*

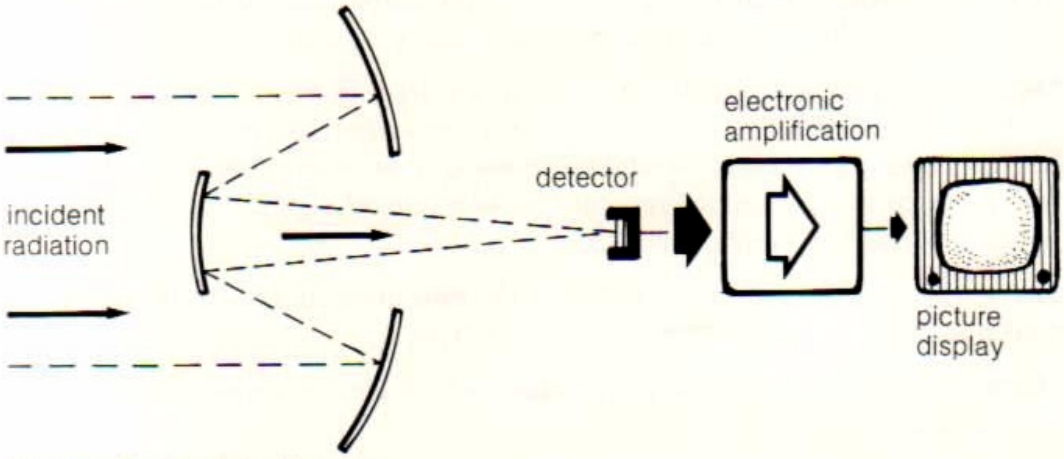


Diagram of a thermographic system.

19. **Point Detector (Discrete).** When the detector is very small the picture of the body is obtained by scanning optical system, which collects the radiation from the object point after point and line after line. The detectorsignal is amplified and used to modulate the intensity of the electron beam of a picture tube. The electron beam sweeps across the screen of the picture tube in synchronism with the camera scanning system, producing on the display screen a thermal image of the object.

20. **Array of detectors.** A thermal sensor is formed by an array of detector elements in line. An array may have certain advantages i.e. faster scanning speeds can be used.

21. **Pyro-Electric Vidicon.** Thermal sensors formed by a thin wafer of pyro-electric material on which the image is projected giving rise to a surface distribution of charges on this material. These charges are compensated for by a scanning beam of electrons, which give rise to a video signal, similar to the working of a vidicon in a TV-camera.

22. **Temperature reference source** any medium of known temperature suitable for calibration. In infrared thermography, a temperature reference may be any radiator of known temperature whose emissivity is known and constant within a given range of wavelength, and is suitable for temperature calibration. (This term does not necessarily imply that the radiator or source is a blackbody).

23. **Raster.** A predetermined pattern of scanning lines which provides substantially uniform coverage of an area. (I.R.E., 1948).

24. **Line Frequency.** The number of times per second that a fixed vertical line in the picture is crossed in one direction by the scanning spot. Scanning during vertical return intervals is counted. (I.R.E., 1948).

25. **Picture Element.** Any segment of a scanning line, the dimension of which along the line is exactly equal to the nominal line width. (I.R.E., 1948).

26. **Depth of Field.** The distance in the object space along the optical axis of the system within which the system gives a sharply defined picture of the object.

27. **Object Angle.** The angle subtended by two points or lines of an object as seen from the forward principle plane of an optical system.

28. **f-Number of an Optical System.** The f-number of an optical system is defined as the ratio of the focal length to the diameter of the entrance pupil.

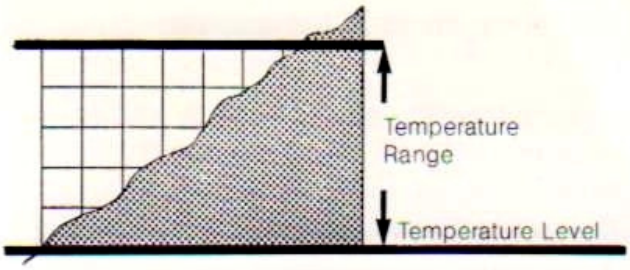
29. **Entrance Pupil.** Image of the limiting aperture stop (iris) in the object space.

30. **Temperature (Thermal) Resolution.** The minimum temperature difference between two black bodies which can be distinguished by an imagining system.

31. **Spatial Resolution.** The measure of the ability of a system to identify two adjacent points separately. It can be expressed as a *number of lines per millimetre* (measured in the image field) which can be separated on a test object (*linear spectral resolution*) or as the minimum object angle in which two points or lines can be seen separately, expressed as a *number of lines per radian (angular spectral resolution).*

32. **Temperature Range.** The difference between the minimum and maximum temperature *which can be measured in a given adjustment of a system.*

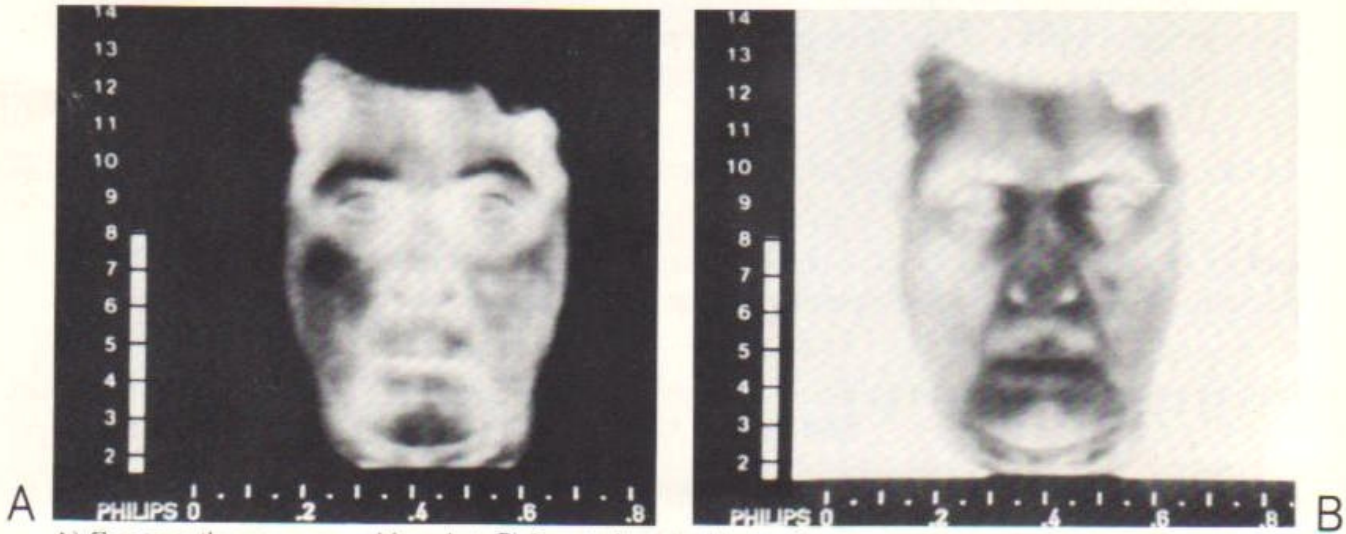
33. **Temperature Level.** The minimum temperature which can be measured in a given adjustment of a system.



34. **Temperature Sensitivity.** The difference in output of the system divided by the temperature difference, generating this output.

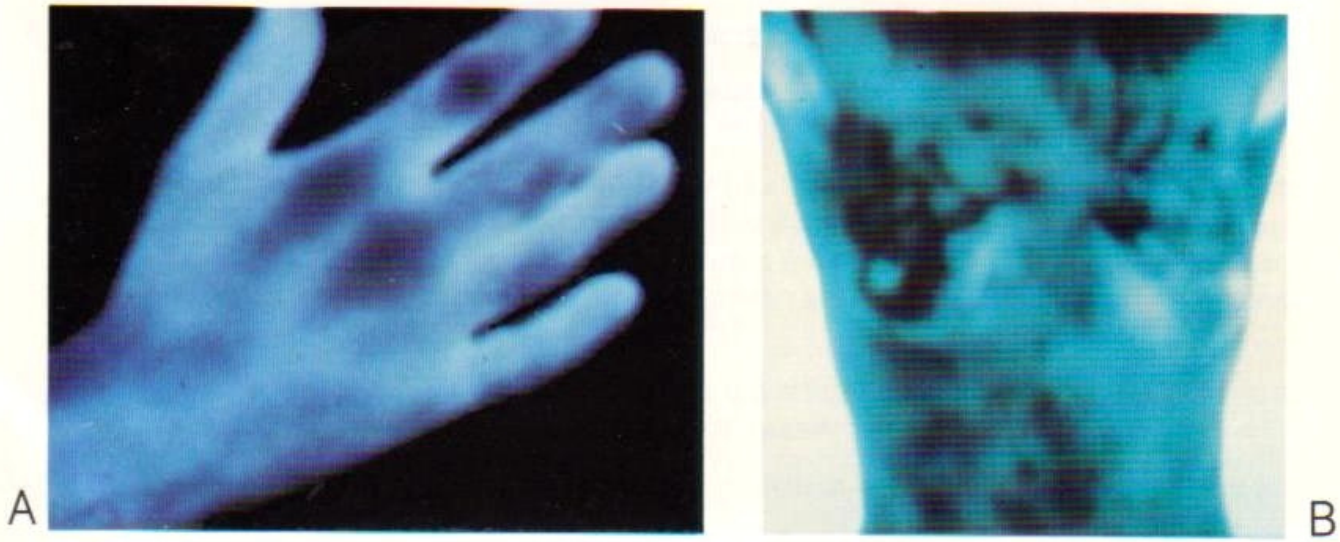
C. The Image

1. **Thermal Image.** A visible product of thermography or thermoscopy.
2. **Thermogram.** A graphic recording of the thermal image obtained by thermography. This term does not describe a magnetic recording or any other storage system which is not graphic and seen by the eye. Prefixes infrared-, microwave- etc. also apply to this term.
3. **Greytone Thermogram.** A thermogram in which temperature differences are represented by density differences (cold ≡ black hot ≡ white). (a) The term black and white thermogram is not recommended because an isothermogram is also a black and white thermogram. (b) When cold ≡ white and hot ≡ black the thermogram is often called *inverted.*



A) Greytone thermograms: white = hot. B) Inverted mode: black = hot.

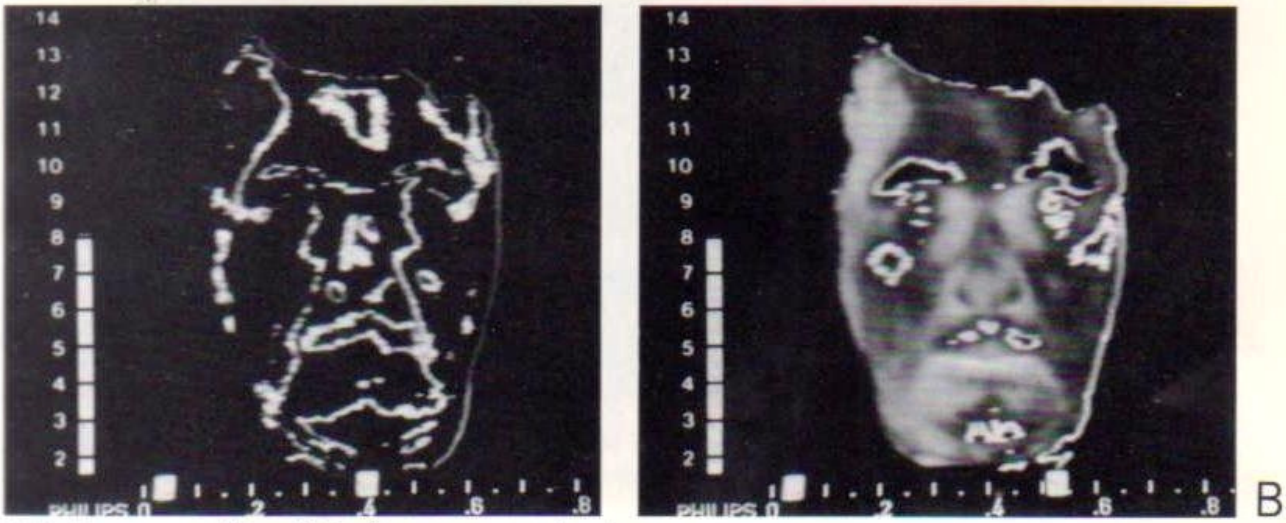
4. **Monochrome Thermogram.** As greytone thermogram, but with density differences in one colour e.g. a record made on colour film.



A) Monochrome thermograms. B) Inverted mode.

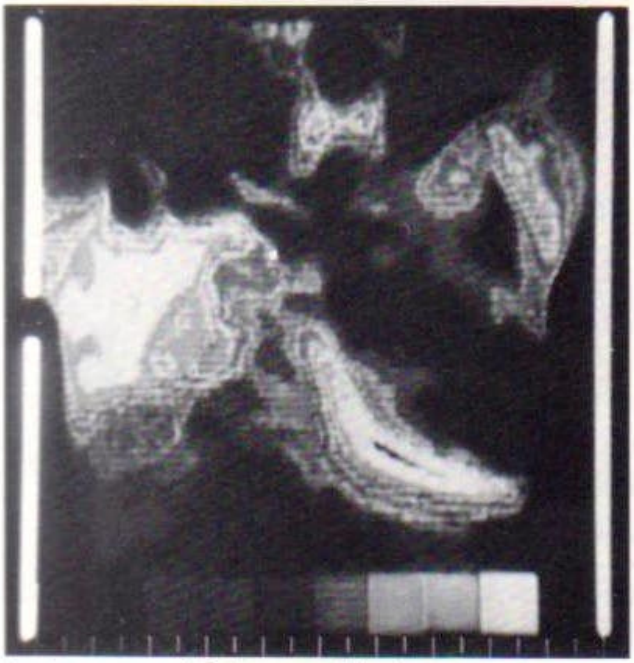
5. **Colour Thermogram.** *A thermogram in which the different temperatures are represented* by different colours.

6. **Isotherm.** A set of points within the same range of temperature.
N.B. (1) Thermal contour – an alternative term to isotherm, should not be used. (2) Usually the temperature range in the isotherm mode of a system is very small and is called the *width* of the isotherm (e.g. width, $\Delta T = 0.5°C$).



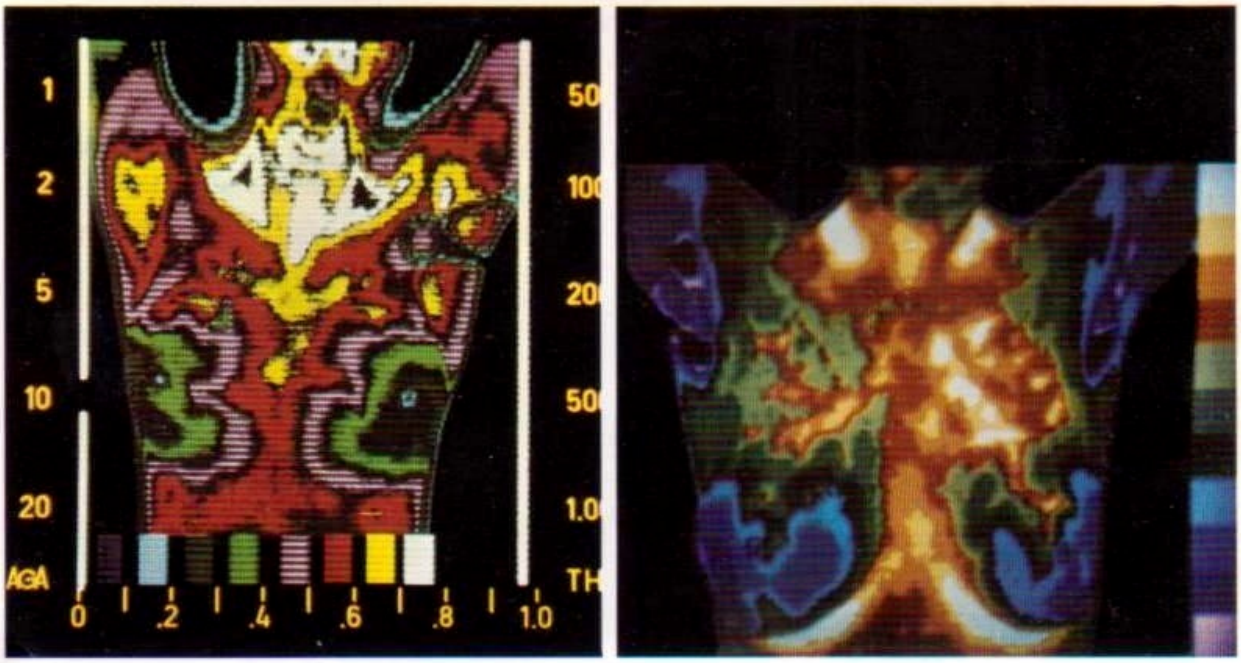
A) Isothermogram of face. B) Isotherms on a greytone image.

7. **Isothermogram.** A graphic recording of one or more isotherms of the thermal image.



Isothermogram showing several isotherms.

8. **Colour Isothermogram.** An isothermogram in which each isotherm is represented by a different colour.



Colour isothermograms.

9. **Spatial Temperature Difference.** The difference in temperature between two points at the same time.

   Unit: Kelvin (K)

10. **Temporal Temperature Difference.** The difference in temperature of the same point at different times.

    Unit: Kelvin (K)

    Rate of change of temperature may therefore be expressed as:

    (a) Temperature gradiant $\frac{\Delta T}{\Delta x}$ in which ΔT is the (spatial) temperature difference between two adjacent points of the surface of a body and Δx is the shortest distance between them.

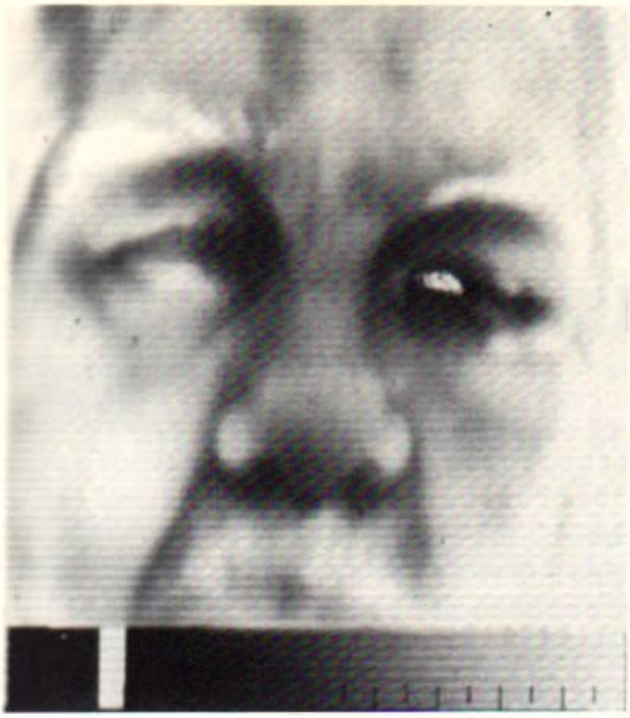
    Unit: Kelvin per metre: Km^{-1}

    (b) Difference quotient $\frac{\Delta T}{\Delta t}$ (or time derivative $\frac{Lim}{\Delta t - 0} \frac{\Delta T}{\Delta t}$) in which ΔT is the (temporal) temperature difference of the same point at different times and Δt is the time difference.

    Unit: Kelvin per second: $K.s^{-1}$

    N.B. (1) The definition temporal thermal gradient is incorrect since it is not a time gradient. (2) Temperature gradient should not be confused with temperature difference as is often seen in literature.

11. **Hyperthermal Focus (Hot Spot).** A small area on a thermogram with high radial decreasing temperature gradients.



Hyperthermal focus marked by an isotherm on the eyelid against an inverted thermogram. (Naevocarcinoma).

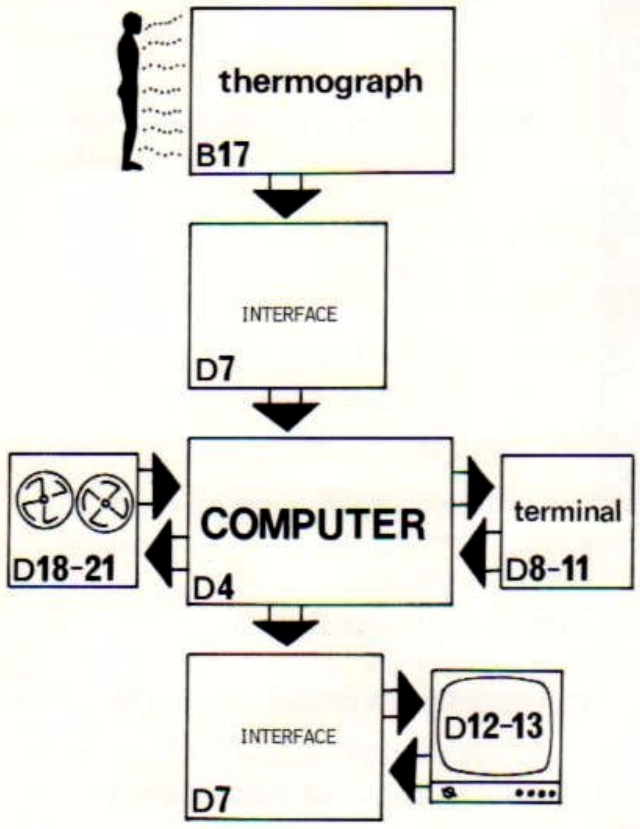
12. **Hypothermal Focus (Cold Spot).** A small area on a thermogram with high radial increasing temperature gradients.

Hypothermal focus. Area cooled by cryo-probe showing concentric isotherms.

13. **Pattern (Thermographic).** A characteristic distribution of temperature according to classified criteria.
14. **Contrast.** The ratio between the maximum and minimum radiance values in a picture.

D. The Processed Image

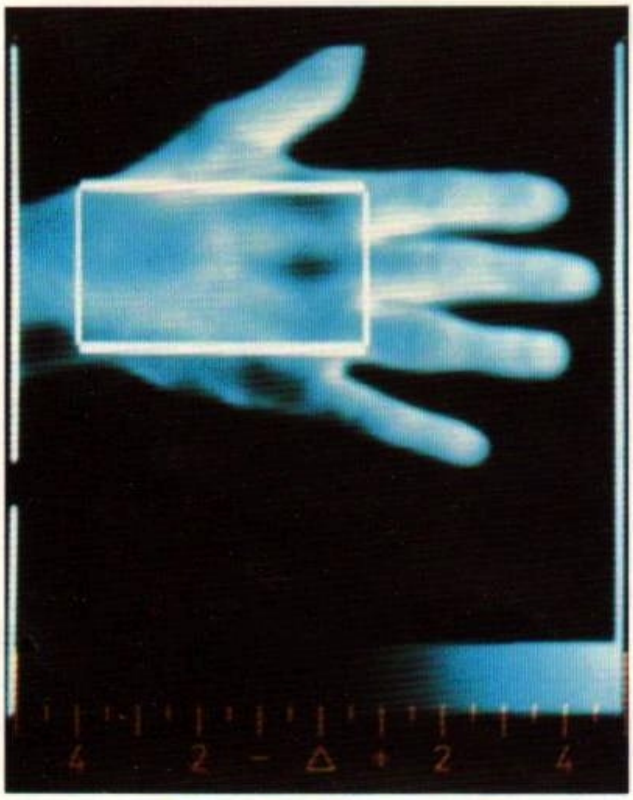
1. **Hardware.** Electronic, electrical or mechanical devices making up a computer system.
2. **Computer.** Any machine, capable of accepting and processing data in a prescribed form. The results may be supplied as information, or a signal to control some other system or machine. There are three main categories of computers. Viz - analog, digital and hybrid.
3. **Analogue Computer.** A machine designed to perform arithmetical operations on numbers, where the numbers are represented by some physical quantity. The operations can be assembled in a configuration agreeing with the differential equations of a linear or non linear dynamic system, and thus used to simulate it. The output of the devices (usually voltages) vary continuously with time, unlike digital devices which change in discrete steps. The computing units are able to respond immediately to the changes they detect in input, analogue computers can perform very complex functions at high speed while a process in operation. They do not have the capacity to store data in large quantities. Temperature control mechanisms, heat flows in tissue and dynamics of chemical processes are some examples of their application to biological studies.
4. **Digital Computer.** A programmable computing system that performs arithmetic or logical sequences on discrete data. The system usually consists of a central processing unit, and storage, with peripherals at input and output stages. The data is arranged in a coded form to represent numbers. The operations to be performed are specified by means of a stored programme. Instructions are stored within the memory as data, which can be modified by the programme itself to perform calculations.



5. **Minicomputer.** A small digital computer system.
6. **Microcomputer (Microprocessor).** A miniaturised digital computer usually designed for specific application.
7. **Interface.** A device, usually electronic circuits, connecting the central processor to peripheral units.
8. **Terminal.** Any device for the transfer of data to and from the computer.
9. **Teleprinter.** A keyboard operated peripheral for input and output of data. A keyboard and printer are used as two separate devices. Incoming signals may be printed out, and messages or data can be typed and transmitted. A teleprinter may be directly linked to a central processor. Paper tape facilities may also be used, with or without the keyboard. (Teletype is a commercial term).
10. **Visual Display Unit (V.D.U.).** A display unit comprising a cathode ray tube and a keyboard. It can function like a teleprinter but uses the screen to display characters or graphs of data recalled from the central processor of the computer.
11. **Paper Tape Reader/Punch.** A system of devices for punching and reading coded data on continuous strips of paper. Each character is recorded as a single row of holes across the width of the tape. It is often used as an input and output system, i.e. reading in programs for the digital computer.
12. **Video Display Monitor.** A cathode ray screen used only to display processed images. Monochrome and colour monitors are used.

Computer processed thermogram of the hand recorded from a video display monitor. (Isotherms: 0.5°C; reference: 34°C).

13. **Region of Interest.** A selected point or portion of the displayed image.



Region of interest: area selected for measurement on a thermogram of the hand.

14. **Integrator.** Device with one input (e.g. the thermal image) and one output. The output is proportional to the integral of the input with respect to the region of interest. In thermography this will correspond to the mean temperature of the selected surface area.
15. **Light Pen.** A sensitive photo-electric device, used as a manual pointer for delineating regions of interest in a displayed image. The signal from the pen can be used to activate the programme.
16. **Tracker- Ball.** A marker system, used for selecting a region of interest by the manual operation of a lever or ball.
17. **Data Storage.** An assembly of large numbers of magnetic rings or semiconductors, which can store binary data according to their sense of magnetisation. It is used to store blocks of data in fast and direct link with the central processor of a computer system.
18. **Auxillary Storage (Backing Store, Bulk Store).** Storage devices for data, which are separate from the central processor of a computing system. They have larger capacity, but slower access time than the main memory of the system.
19. **Magnetic Disk.** Data may be stored by the use of one or more of the following: A flat circular magnetic plate designed for high speed rotation and rapid collection and retrieval of data.
20. **Floppy Disk.** A smaller, inexpensive flexible version of the magnetic disk.
21. **Magnetic Tape.** Multiple track magnetic tape designed for recording and retrieving data for the computer.

22. **Paper Tape.** A standard gauge tape, made of paper, specially preparated for use in mechanical punching and reading devices. See paper tape punch/reader.

23. **Software.** All programs and routines associated with the computer.

24. **Language.** A system for the communication of instructions and information to the computer, e.g. BASIC FORTRAN, ALGOL.

25. **Binary.** A number system with a base two. Only the digits 0 and 1 are used.

26. **Binary Code.** A code of characters using groups of binary digits.

27. **Binary Numbers.** A system of numbers in binary form used by most digital computers, where only two physical stores can be represented, e.g. on or off, perforated and non perforated, clockwise or anticlockwise magnetisation (of a ring).

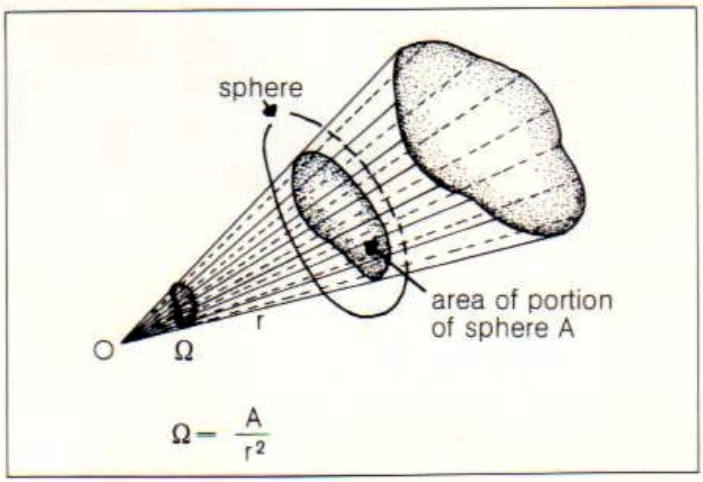
28. **Octal Numbers.** A simplified binary application of numbers using digits 0-7 in an array of threes, e.g. 001 = 1, 010 = 2, 011 = 3, 110 = 6 etc.

29. **Hexadecimal System.** A binary numbering system using digits 0-15 in an array of fours. Numbers over nine, are represented by letters A to F.

30. **Firmware.** A fixed programme designed for a specific task as in a microprocessor controlled system.

E. Radiometric Quantities, Symbols and Units

1. *Quantity:* **Solid angle**
   Symbol: Ω, ω
   Definition: The solid angle of a cone is defined as the ratio of the area cut out on a spherical surface (with its centre at the apex of that cone) to the square of the radius of that sphere.
   Name of unit: steradian (a dimensionless unit)
   Symbol for unit: sr



2. *Quantity:* **Temperature**
   Symbol: *T* (absolute); t, ∅, ϑ (customary)
   Definition: The property of a system that determines whether it is in thermal equilibrium with other systems.
   Name of unit: Kelvin; degree Celsius
   Symbol for unit: K; °C

$$t = T - T_o \text{ in which } T_o = 273{,}15$$

3. *Quantity:* **Power**
   Symbol: *P*
   Definition: Energy trasferred in a certain time interval, divided by the duration of that interval.
   Name of unit: Watt
   Symbol for unit: W

4. *Quantity:* **Heat**
   Symbol: Q
   Name of unit: Joule
   Symbol for unit: J

5. *Quantity:* **Heat flow rate**
Symbol: Φ
Definition: Heat crossing a surface, divided by time.
Name of unit: Watt
Symbol for unit: W

6. *Quantity:* **Density of heat flow rate**
Symbol: q
Definition: Heat flow rate, divided by area.
Name of unit: Watt per square metre
Symbol for unit: W/m^2

7. *Quantity:* **Thermal conductivity**
Symbol: $\lambda(k)$
Definition: Density of heat flow rate, divided by temperature gradient.
Name of unit: Watt per metre degree
Symbol for unit: W/m.deg.

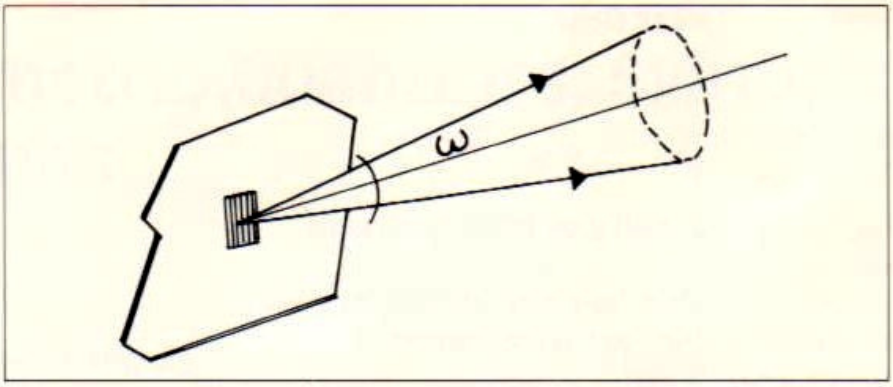
$$q = \frac{dT}{dx}, \text{ thermal resistance is sometimes used as } \frac{1}{\lambda}$$

8. *Quantity:* **Thermal diffusivity**
Symbol: a
Definition: $a = \frac{\lambda}{pc_p}$ λ = thermal conductivity
p = density
c_p = specific heat capacity at constant pressure
Name of unit: Square metre per second
Symbol for unit: m^2/s

9. *Quantity:* **Radiant energy**
Symbol: Q, W
Definition: Energy emitted, transferred or received as radiation.
Name of unit: Joule
Symbol for unit: J

10. *Quantity:* **Radiant flux; radiant power**
Symbol: *P*, Φ
Definition: Power emitted, transferred or received as radiation
Name of unit: Watt
Symbol for unit: W

11. *Quantity:* **Radiant intensity**
Symbol: I
Definition: The radiant intensity for a source in a given direction is the radiant power leaving the source, or an element of solid angle containing the given direction, divided by that element of solid angle.
Name of unit: Watt per steradian
Symbol for unit: W/sr



12. *Quantity:* **Radiance**
Symbol: L
Definition: At a point of a surface and in given direction, the radiant intensity of an element of the surface, divided by the area of the orthogonal projection of this element on a plane perpendicular to the given direction.
Name of unit: Watt per steradian and per square metre
Symbol for unit: $W/sr.m^2$

13. *Quantity:* **Spectral radiance**
Symbol: $L(\lambda)$
Definition: The radiance in an infinitesimal wavelenght interval divided by the range of this interval.
Name of unit: Watt per steradian and per cubic metre
Symbol for unit: $W/sr.m^3$

14. *Quantity:* **Radiant excitance**
Symbol: M
Definition: At a point of a surface, the radiant power leaving an element of the surface, divided by the area of that element.
Name of unit: Watt per square metre
Symbol for unit: W/m^2

15. *Quantity:* **Emissivity**
Symbol: ε
Definition: Ratio of the radiant exitance M of a thermal radiator to that of a blackbody* (full) radiator at the same temperature.

$$\varepsilon = \frac{M}{M_b}$$

16. *Quantity:* **Spectral emissivity**
Symbol: $\varepsilon(\lambda)$
Definition: Ratio of the spectral radiant exitance $M(\lambda)$ of a thermal radiator to that of a blackbody* (full) radiator at the same temperature.

$$\varepsilon(\lambda) = \frac{M(\lambda)}{M_b(\lambda)}$$

* Defined in A14.

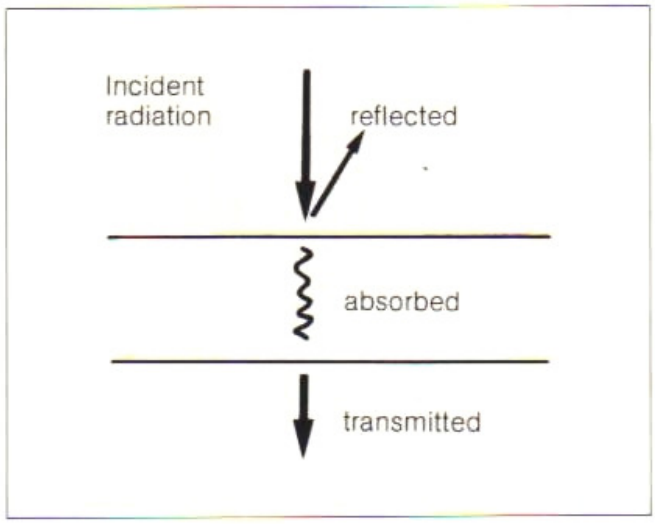
17. *Quantity:* **Directional spectral emissivity**
Symbol: $\varepsilon(\lambda,\Phi,\emptyset)$
Definition: Ratio of the spectral radiance $L(\lambda)$ in a given direction Φ, $\emptyset$ of a thermal radiator to that of a blackbody* (full) radiator at the same temperature.

$$\varepsilon(\lambda,\Phi,\emptyset)=\frac{L(\lambda)}{L_b(\lambda)}$$

18. *Quantity:* **Spectral absorptance****
Symbol: $\omega(\lambda)$
Definition: Ratio of the spectral radiant flux absorbed to that of the incident radiation.

19. *Quantity:* **Spectral reflectance**
Symbol: $\rho(\lambda)$
Definition: Ratio of the spectral radiant flux reflected to that of the incident radiation.

20. *Quantity:* **Spectral transmittance**
Symbol: $\tau(\lambda)$
Definition: Ratio of the spectral radiant flux transmitted to that of the incident radiation.



* Defined in A14.
** Absorptance should not be confused with absorption coefficient, which is often reprented by the same symbol ω however the symbol a for absorption coefficient is preferred.

Index

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