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MEASUREMENT AND MODELLING OF CLOTHING CONDITIONS

This invention relates to apparatus and methods for the measurement and modelling of clothing conditions.

In the field of clothing design it is highly desirable to be able to predict the effect of factors such as fabric type and thickness, garment fit, and the effect of combining several layers of garments. Such a prediction should be able to provide information on both heat loss and moisture loss through the layers of clothing, since those factors will affect the temperature and humidity experienced on the skin of the wearer, which in turn determines how comfortable the particular combination of garments feel to the wearer. By performing such a modelling procedure, it would be possible to optimise the design of individual garments and, additionally, to design a clothing “system”, comprising a number of garment layers adapted to perform within certain specifications under pre-defined conditions.

Although much work has been performed on the passage of air, heat and moisture through clothing, effort has largely been concentrated in two areas:-

i) laboratory measurements of isolated properties such as resistance to vapour transpiration, usually in conditions which are not representative of actual clothing, or

ii) in vivo investigations in which the garments are treated as an ensemble, with little or no effort made to separate the effects of different components.

The detailed relationship between wearer, clothing and surroundings is extremely complicated in part because physiological factors are incompletely understood - often there is no full mathematical description of them and other relevant factors are difficult or impossible to measure. General equations defining “comfortable surroundings” exist, but they treat physiological responses empirically,
and consider the clothing system as a single unit represented by a composite insulation value.

Thus, there is a need for a method of simulating the effect of clothing which is sufficiently complex to approach reality, but which is sufficiently simple to be tractable, and to allow testing and optimisation with real data. There is also a need to model the effect of several layers of clothing by treating the effect of each layer, and the air gaps between said layers, separately. Furthermore, there is a need to provide real, experimental data of quantities such as temperature and humidity, the measurements being made at selected locations on the body of a wearer or in the gaps between layers of clothing.

The present invention provides methods and apparatus which satisfy the above-mentioned needs and considerations.

According to a first aspect of the invention there is provided a method for steady state modelling of temperature and humidity levels in a clothing ensemble worn by a wearer comprising the steps of:

- defining a steady state heat output of the wearer;
- defining the heat transfer resistances and water vapour transfer resistances of the layers of clothing in said clothing ensemble;
- defining air gap functions between the clothing layers and between the wearer and a first layer of clothing;
- calculating the dry heat flow and water vapour flow through the layers of clothing and the air gaps in accordance with the transfer resistances and air gap functions, and thereby calculating the total clothing ensemble heat output;
- comparing the total clothing ensemble heat output with the steady state heat output of the wearer; and
using the comparison to prescribe a clothing ensemble such that the heat outputs correspond in a desired manner.

The iteration of the steady state heat output may be performed until the steady state heat output substantially matches the total clothing ensemble heat output.

Alternatively, iteration of the clothing ensemble may be performed until the steady state heat output substantially matches the total clothing ensemble heat output.

The iteration may comprise adjustment of skin temperature and/or sweating rates.

The calculation of total clothing ensemble heat output may comprise calculation of convective and radiative heat losses to the atmosphere.

At least four layers of clothing may be modelled. The layers may comprise vest, shirt, fleece and coat layers. The heat and water vapour resistance of the fleece layer may vary as a function of wind pressure.

The outermost layer of clothing may be airtight but water vapour permeable.

The layers of clothing may be radiation impervious.

The ambient atmospheric conditions may be inputted into the model.

The calculation of water vapour flow may include the effects of condensation.
The effects of internal air convection may be included in the calculations of dry heat flow and water vapour flow.

Data from temperature and/or humidity sensors may be included in the model.

According to a second aspect of the invention there is provided a computer adapted to perform the method of the first aspect of the invention.

According to a third aspect of the invention there is provided an experimental apparatus adapted for testing a model of temperature and humidity levels in a clothing ensemble worn by a wearer comprising:

- sensor means having an electrical output;
- a sensor body containing sensor output transduction means yielding data and data storage means therefor; and
- cable connecting said sensor means and said sensor body, permitting said sensor means to be deployed at desired locations with the ensemble and the sensor body to be carried on or by the wearer.

Measurements may be of a clothed person, and may be made on the body of the wearer or between layers of clothing.

The sensor means may comprise a temperature and/or a humidity sensor.

A temperature sensor may be a thermistor or a platinum sensor.

The sensor body may comprise digital data storage means, and the data may be transferable, via interfacing means, to a computer. The computer may be used to
input apparatus operation characteristics, and one of these characteristics may be the length of time between successive measurements.

The sensor body may comprise a modified Tinytalk™ datalogger of the type produced by the Orion Group.

The apparatus may take both temperature and humidity measurements.

According to a fourth aspect of the invention there is provided a method for making measurements within a clothing ensemble worn by a wearer comprising the steps of:-

providing an apparatus according to the third aspect of the invention;
deploying the sensor means at a desired location within the ensemble;
disposing the sensor body on the wearer or within the ensemble; and using the apparatus to make said measurements.

Measurements may be made on the body of the wearer, or between layers of clothing.

Temperature and/or humidity measurements may be made.

Embodiments of methods and apparatus in accordance with the invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 shows a first example of a screen output;

Figure 2 shows a second example of a screen output;

Figure 3 shows an apparatus according to the invention; and
Figure 4 shows stages in the development of a modelling system.

The invention, comprises in one aspect, a method for steady state modelling of temperature and humidity levels in a clothing ensemble worn by a wearer comprising the steps of:

- defining a steady state heat output of the wearer;
- defining the heat transfer resistance and water vapour transfer resistance of the layers of clothing in said clothing ensemble;
- defining air gap functions between the clothing layers and between the wearer and a first layer of clothing;
- calculating the dry heat flow and water vapour flow through the layers of clothing and the air gaps in accordance with the transfer resistances and air gap functions, and thereby calculating the total clothing ensemble heat output;
- comparing the total clothing ensemble heat output with the steady state heat output of the wearer; and
- using the comparison to prescribe a clothing ensemble such that the heat outputs correspond in a desired manner.

The method avoids complex modelling of physiology and instead uses a “steady state” approach where the body of the wearer is treated as a source of heat and, as will be described in more detail below, moisture. Heat flow and water vapour flow are calculated from the skin of the wearer and outwards, through successive air gaps and layers of clothing, with allowance being made for variation of thermal conductivity and vapour diffusion with temperature and humidity. In this way, a total heat output from the clothing ensemble to the atmosphere can be calculated. If the total clothing ensemble heat output differs from the steady state heat output by more than a predetermined amount, an iterative procedure is employed in which the steady state heat output is varied and the calculation performed again. The iterative process is repeated until the mismatch is reduced to a defined, acceptable level. Any “danger” conditions.
such as excessive heat loss or gain, or condensation, are signalled. Such danger conditions would indicate significant levels of discomfort for the wearer.

The calculation of total clothing ensemble heat output comprises the calculation of convective and radiative heat losses to the atmosphere, for which purposes standard physical equations may be employed.

**Generalised Operation of the Model**

1. **Dry heat flow**

An initial guess is made of the steady state heat output from the skin of the wearer. The temperature intervals across successive gaps and layers of clothing are calculated. This calculation is performed by considering the ‘dry’ heat flow through the ensemble, taking account of: the thermal resistances of the fabrics, convective and radiative heat losses between layers, heats of condensation arising from vapour condensation at interfaces, and the effects of movement on heat conductance between layers. Further details can be found in the Annex, which contains a computer program listing, between pages 27 and 28 thereof. By summing the temperature intervals, a temperature for the outer layer of clothing is calculated. Given this temperature, the convective heat loss to the atmosphere can be calculated by fluid dynamics. Clearly, this heat loss is a function of wind speed. Additionally, radiative heat losses are calculated: in some cases this can represent a significant fraction of the total heat loss. The convective and radiative heat losses are calculated as follows:

\[
Q_l = \frac{L}{d} \cdot \Delta T \cdot N
\]  

(1)
where \( Q_1 \) is the convective heat loss to the atmosphere, \( L \) is the heat conductance, \( d \) is the body diameter of the wearer, \( \Delta T \) is the temperature difference between the outer layer of clothing and ambient temperature and \( N \) is the Nusselt number.

\[
Q^2 = e \cdot \sigma \cdot 303 \left[ (0.0033 \cdot T^4_{\text{out}}) - (0.0033 \cdot T^4) \right] \tag{2}
\]

where \( Q^2 \) is the radiative heat loss to the atmosphere, \( e \) is the emissivity of the outer layer, \( \sigma \) is Stefan’s constant \((x \cdot 303^3)\) and \( T_{\text{out}} \) and \( T \) are, respectively, the temperature of the outer layer in K and the radiant temperature in K.

If the total clothing ensemble heat output does not match the initial steady state heat output, the difference is used to alter the initial guess, and the calculation is performed again. The iterative process is repeated until the difference falls within an acceptable range (typically 0.01 Wm\(^{-2}\)).

If the total heat loss is significantly higher than the assumed steady state heat output, the assumed skin temperature of the wearer is allowed to cool (following an empirical relationship) to a minimum temperature of 30°C. If the total heat loss is less than the steady state heat output, the skin temperature is increased slightly.

\[\text{2. Vapour flow}\]

In the case where total clothing ensemble heat flow is less than the steady state heat output, the difference is accounted for by the evaporation of sweat. This difference defines the vapour flow at the skin (the contact of proportionality being the latent heat of water). Vapour flow is driven by vapour pressure, and thus from an initial value of the vapour pressure at the skin, successive pressure drops across the gaps and
the layers may be determined. (It is noted that many previous investigations into
moisture travel in clothing mistakenly attribute the occurrence of vapour flow solely to
the present of concentration gradients, and overlook the role of temperature). Local
temperature and humidity are involved in the calculation, the eventual loss to the
atmosphere being determined by the fluid dynamics equations:

\[ V_{L_{\text{out}}} = \text{Tran} \cdot \Delta P \]  \hspace{1cm} (3)

where \( V_{L_{\text{out}}} \) is the vapour loss from the outer layer, \( \text{Tran} \) is the vapour flow compliance
at the outer layer and \( \Delta P \) is the pressure interval from outer layer to ambient.

Further details can be found in the Annex, which contains a computer
program listing, between pages 18 and 19 thereof. The calculations take into account the
effects of condensation and internal convection, as described below. Adjustments to skin
humidity are made to achieve an acceptable balance between initial vapour loss from the
skin and final vapour loss.

3. Condensation

When water vapour is added to the heat loss mechanism pursuant to section
2, above, local humidities in excess of 100% can result. In practice, when this limit is
reached moisture is removed from the air as dew. In order to allow for this occurrence,
an extra variable - the condensation rate - is associated with each surface in the clothing
ensemble. When a state of supersaturation is predicted, the model reduces local humidity
to 100% and increases the condensation rate accordingly. This process involves the
release of latent heat of vaporisation, which heat is added to the dry heat flow. This step
effects the surface temperature and thus the dry heat calculation is performed again,
which in turn impacts upon the humidity distribution. Thus the process is iterated until
a steady state is achieved. In extreme conditions, where condensation is copious a
"danger condition" is flagged, indicating significant levels of discomfort for the wearer. If skin humidity reaches 100%, the heat balance equations cannot be satisfied and the calculations are abandoned.

4. **Internal Convection**

In general, air contained between layers of clothing is not still. The movement of the wearer can force air around the gaps present in the clothing ensemble and out of apertures such as cuffs and hoods etc. This is the so-called "bellows effect". At least two mechanisms should be considered: local mixing of the air and venting for the atmosphere. The former has the effect of increasing the diffusion rates of heat and vapour in a similar way. A "movement" variable is incorporated into the model, the distribution rates being adjusted according to the value of this parameter.

Air exchange with the atmosphere is difficult to quantify. The model employs a venting coefficient for each air gap in the clothing ensemble, defined as the mean exchange rate per second (expressed as a percentage of the total volume of air contained in the gap). The heat and vapour contained in this "exchange volume" can be calculated and compared with the amounts in the ambient air: the difference represents the local loss which is incorporated into the flow calculations.

The above described internal convection mechanisms are extremely difficult to quantify, and cannot be predicted from static measurements of garments and fit. For example, venting to the atmosphere will be moderated or eliminated by closing up the apertures in the outer layer of clothing. However, increased levels of sophistication in the modelling of internal convection are within the scope of the invention.
5. **Input/Output**

The ambient atmospheric conditions may be inputted into the models. Such conditions include air temperature, sky temperature, wind speed and relative humidity. Alternatively, it is possible to pre-select the weather conditions of a given type i.e. “Mediterranean summer” or “Scottish winter”. The work rate of the wearer, or a level of exercise, such as “brisk walk”, which can be equated with a pre-defined work rate, is also inputted into the model. The resistances of the layers of clothing to heat (in Togs) and water vapour are input to the model, as are the gaps between the layers. The above-mentioned venting conditions and movement parameters are also inputs.

In the present embodiments, four layers of clothing can be modelled comprising vest, shirt, fleece and coat layers. Clearly different numbers of layers, or different types of layers, are within the scope of the invention. The number of layers is easily reduced by setting a resistance to zero.

Figures 1 and 2 show the output of a computer program which performs modelling according to the invention. This version of the invention runs on an EXE file within Windows (RTM). The upper portion of the screen displays the input variables whilst the lower portion displays the results.

In Figure 2, the box in the lower portion of the screen displays the calculated temperature across the layers of clothing and the gaps. The portions labelled 10, 12, 14, 16, 18 represent the skin, vest, shirt, fleece and coat layers respectively. The portions labelled 20, 22, 24 represent the gaps between layers (the model assumes that there is no gap between the skin and the vest layer, although a gap could be included if this were desired). Identical labels apply in Figure 2, where the relative humidity is shown as a function of distance from the skin. The humidity output is shown as a broken line where there is a danger of condensation.
Certain assumptions and simplifications are made in the model: these are detailed below. It will be apparent that these assumptions and simplifications are not intended to be limiting: rather, they provide physical realism without resulting in an intractable or over-complicated solution.

(a) Assumptions about the Atmosphere

1. Total pressure is constant at 101.5 kPa (i.e. the wearer is near sea level).

2. Density, specific heat, viscosity coefficient, diffusion coefficient and thermal conductivity are known functions of temperature and humidity.

2.2 Saturated vapour pressure and concentration are known functions of temperature: the relation of actual vapour pressure/concentration to these defines humidity.

3. Condensation occurs at any surface if the humidity exceeds 100%.

4. In still air, heat conduction and moisture vapour flow are linear functions of the gradients of temperature and vapour pressure respectively.

5. Changes in the latent heat evaporation, and the specific heat, heat of expansion and thermal diffusion of vapour are ignored.

6. Radiation is governed by Stefan’s law, with a constant external radiation temperature.

7. Heat loss by conduction and convection from the outer surface follows the behaviour of heating pipes in a transverse air flow. Convective losses are calculated with respect to a cylinder of 104 cm circumference.
8. Vapour loss from the outer garment is described by minor adjustments to the heat convection equations, using the Lewis relation.

9. Internal convection requires empirical treatment (discussed above).

(b) Assumptions about the body

1. Skin temperature is normally 35°C

2. Skin temperature can fall to ca. 30°C at tolerable heat flow deficit.

3. Skin temperature can rise to 36°C at a heat excess of 80 W/m².

4. Effective body area (duBois area) = 1.8 m² allowing heat flows in w/m² to be calculated.

5. Metabolic heat depends on activity, according to a "standard man".

6. Sweating occurs if metabolic heat production exceeds dry heat flow.

7. The latent heat of evaporation is lost at the skin.

8. "Insensible perspiration" is ignored.

9. A skin humidity of 70% or more causes discomfort.

(c) Assumptions about the clothing

1. The clothing is represented by up to four fabric and air layers.
2. The "vest" layer is in contact with the skin.

3. These layers are of constant thickness (for set conditions).

4. Thickness does not vary as a result of wind pressure with the exception of the fleece layer.

5. The fabrics are not porous.

6. The fabrics are opaque.

7. All surface emissivities are the same and constant at 0.94.

8. Each layer has a fixed resistance to the conduction of heat and vapour.

9. Resistances can be estimated from laboratory tests.

10. Resistances are independent of temperature.

11. Air movement within gaps affects heat transfer by (i) a "stirring up" effect (ii) exchange with the surrounding atmosphere: both result from the wearer's movements. Flow in the gaps parallel to the surface is ignored.

12. The length scale required in (a) 7. is set at 33 cm.

13. Each air gap is defined by a single parameter.

The model is linear, in that the interfaces are considered to be a series of plane surfaces. All component fabrics are assumed to be impenetrable to radiation: in
fact, radiometer experiments have demonstrated the validity of this assumption. The outer layer is assumed to be airtight, i.e. windproof. Heat flow and vapour flow are treated independently, an assumption which appears to be valid, certainly under most practical conditions. Fabric thickness depends significantly on wind pressure only in the case of the fleece. The wind pressure $p$ is related to the air density $\rho$ and wind speed $v$ by $p = \frac{\rho \cdot v^2}{\sqrt{2}}$. Air gaps also change with air pressure: gaps facing the wind will tend to collapse, whilst a receding wind can cause an increase in the gap - sometimes pronounced “ballooning” is observed. The present embodiment accounts empirically for such conditions only in the gap between the coat and the fleece. More sophisticated methods are within the scope of the invention. It is known that there is a consistent and well defined relationship between the Nusselt number $N$ (describing heat transfer) and the Reynolds number $Re$ (describing air speed) which accurately predicts heat loss from cylinders of diameters in the range 1 to 500 mm:

$$N = \exp \left[ -0.15 + 0.325 \ln Re + 0.015 \left( \ln Re \right)^2 \right]$$  \hspace{1cm} (4)

The relationship holds for the case of steady air flow and circular cylinders, and is used in the model. Heat loss from a roughly elliptical cylinder, which would describe better the human torso, is also accurately described by the relationship when air flow is parallel to the long axis of the cylinder, but flow in the perpendicular direction can result in some inaccuracies.

There are numerous variations to the above described model which are within the scope of the invention. For example, a three dimensional model more closely resembling the human body might be modelled. Such a model might include the possibility of different zones experiencing different levels of temperature and humidity. Furthermore, different zones might be clothed in different ways. The interconnection of zones, possibly including the effects of lateral heat flow, diffusion and wicking would have to be considered. Additionally, three dimensional shielding effects on radiative and convective heat loss might be considered. The influence of rain on heat and moisture
loss is another variation within the scope of the invention. Furthermore, more sophisticated descriptions of the “fit” of a garment might be incorporated into the model. Thus, more complicated air gap functions might be employed, which take into account non-uniformity in the gaps between layers over an entire garment. The present embodiment assumes a constant air gap.

Figure 4 shows stages in the construction of a “full” model, taking into account the developments discussed above. Stages 40 and 42 involve, respectively, dry heat and vapour flow calculations on a flat system. Stage 44 involves a comparison of such calculations with laboratory tests of dry heat flow and controlled movement of air within layers. Stages 46 and 48 are, respectively, dry heat and vapour calculations taking account of “bellows” effects, i.e. fabric movement on walking, forced internal convention and exchange with the atmosphere. Stages 50 and 52 involve the extension of dry heat and vapour calculations to a model having different zones, which involves the use of different temperatures and clothing for different zones, different local moisture sources and a consideration of wicking between zones. Stages 54 and 56 represent a full three dimensional calculation of, respectively, dry heat and vapour flow. Stages 58 involves comparison and optimisation of the model with data obtained from in situ measurements of a clothed person under “real” conditions. The computer program listed in the Annex provides stages 40, 42, 46, 48, whilst the apparatus and method described below is directed towards the provision of stage 58.

The invention also encompasses the design of clothing and clothing ensembles using the modelling method described above. Such design might comprise providing the modelling with a variety of clothing specifications under certain operating conditions in order to ascertain optimum combinations, fabric thickness, types etc. Alternatively, the iteration of the clothing ensemble might be preferred until the steady state heat output substantially matches the total clothing ensemble heat output. Such iteration of the clothing ensemble might comprise adjustment of the number of layers.
the nature of the layers and/or the thickness thereof, or of the gaps between layers. It should be noted that iteration in this manner is more complicated than the iteration of steady heat output described above, since unique solutions will not exist. However, the provision of a number of solutions which lie within pre-determined boundaries is within the scope of the invention.

Although the model described above is primarily a steady state one, it may be extended to model transient phenomena. This might be achieved by perturbing the steady state balance.

An important aspect of the invention is the use of experimental data in the model. Such data comprises measurements of temperature and humidity made at different locations on a wearer and between different layers of clothing. The model might be compared to such data, or the model might be adapted to fit to such data. However, at present such data is very difficult to obtain. The present invention also provides a portable sensor apparatus capable of making such measurements.

Figure 3 shows an experimental apparatus adapted for testing a model of temperature and humidity levels in a clothing ensemble worn by a wearer comprising sensor means 30 having an electrical output, a sensor body 32 containing sensor output transduction means yielding data and data storage means therefor and a cable 34 connecting said sensor means 30 with said sensor body 32, permitting said sensor means 30 to be deployed at desired locations within the ensemble and the sensor body to be carried on or by the wearer.

In a preferred, but non-limiting embodiment, the sensor body 32 is a modified Tinytalk™ datalogger of the type produced by the Orion Group. The sensor means 30 comprises a thermistor temperature sensor. The unmodified thermistor datalogger is unsuitable for personal temperature and humidity measurement because the
thermistor is located within the sensor body. Although the sensor body is compact - it is essentially a cylinder of height ca. 4 cm and diameter ca. 2.5 cm - it would be at the least inconvenient to have the sensor positioned directly against the skin for temperature measurement. Indeed, for measurements of foot temperature - which is within the scope of the invention - such an approach would be highly impractical. By positioning the thermistor 30 outside of the sensor body 32 and using a thin cable 34 for connection purposes, this problem is overcome. The thermistor 30 may now be positioned easily and conveniently on the body, either directly onto the skin or between layers of clothing. The sensor body 32 is conveniently stored on or in the clothing, for example, in pockets.

The cable 34 should be sufficiently flexible and of sufficiently narrow diameter to be virtually unnoticeable whilst the person upon which the sensor is positioned performs any body movement associated with any activity, such as walking, climbing or running, for which the test garment is intended. Advantageously, the cable 34 is capable of repeated flexure, and the entire sensor arrangement produces minimal disruption during dressing and undressing.

The small physical dimensions of the thermistor 30 are in keeping with the dimensions of the cable 34 in two senses. Firstly, the cross-sectional diameter of the thermistor 30 is such that it is readily retained in the tip of the cable 34. Secondly, the thermistor 30 is of short length; as a result the portion of the cable tip, which contains the thermistor 30 (and, therefore, is inflexible) is minimised. There is no need, for instance, for an inflexible “probe” upon which the sensor might be positioned.

The stored data comprises measurements made at predefined intervals over a predefined period of time. A maximum of 1800 measurements may be stored in the datalogger, and these data may be transferred via a serial port (not shown) to a personal computer. Furthermore, operational characteristics, such as the length of time between successive measurements, may be input via the computer. Thus selection of a 1.6 minute
gap between measurements would permit coverage of a two day garment testing period, after which data from the testing could be downloaded for subsequent analysis. Longer testing periods are possible, but increasing the time between measurements and/or performing one or more downloading operations. It should be noted that the datalogger is powered by batteries which can provide up to 4 years continuous use.

Other forms of temperature sensor, such as a platinum sensor, are within the scope of the invention, as are relative humidity sensors. A combined temperature and humidity sensing device is also within the scope of the invention. It is, of course, possible, and generally advisable, to utilise a plurality of sensor arrangements to provide temperature and humidity measurements at a number of locations on the body. The use of other forms of sensor for other purposes, such as for measurement of heartbeat, is also within the scope of the invention.
ANNEX

' Declarations

Dim hRatio, wRatio
Dim t(8), th(8), r(8), press(8), Cm(8), qWet(8), q(8), qLoss(8), jLoss(6), Jv(8), Tog(7), Gap(7),
Vnt(6)
Dim U(30), Lim(30), X(21)
Dim Thick(4), extnt(8), Thick3, DripLim(1)
Dim x1, x2, y1, y2, ex, ey
Dim Ta, Tr, td, Tn, Cma, po, Transmittance
Dim Ag, Rf
Dim Qtot, q0, Q1, Q2, Jv0, Jv1, Nu, Mt
Dim d, e, L, sigma, v, rh, mu, ff, j%, n%, s%, ssat, kp, nt
Dim scl
Dim sizeflag As Integer, dotflag As Integer, dripflag(1) As Integer, Wetsum As Integer
Dim flashflag As Integer, whiteflag As Integer, greyflag As Integer, initflag As Integer
Dim ct As Integer, bc As Integer, cb(2) As Integer, inx As Integer
Dim bb As Long
Dim num1, neg%
Dim crstc As String, mant As String
Dim jump, finger, fall(1), TopLim(1)
Dim actfilnam$(2)
Dim news As Integer

Sub AlignLabels () ' picture legend

    lbpT(0).Top = 44.84
    For j% = 1 To 4
        lbpT(j%).Top = 19.9 * j% - 46.8
    Next

    lbpH(0).Top = 35.38
    For j% = 1 To 3
        lbpH(j%).Top = 40.2 * j% - 77.2
    Next

    lbpP(0).Top = 40.54
    For j% = 1 To 6
        lbpP(j%).Top = 18.13 * j% - 60.28
    Next

    image2(0).Top = -17.91
    image2(1).Top = -17.91
    image3(0).Top = -18.5
    image3(1).Top = -18.5

End Sub
Sub Check1_Click () ' "Wet / Dry" toggle: (not implemented)

If Check1.Value = 1 Then
    wLbl(3).Caption = "Rain"
    wLbl(5).Visible = -1
    wLbl(6).Visible = -1
    tx(2).Visible = -1
End If

If Check1.Value = 0 Then
    wLbl(3).Caption = "Sky"
    wLbl(5).Visible = 0
    wLbl(6).Visible = 0
    tx(2).Visible = 0

    If Val(tx(2).Text) > 0 Then
        command5(0).Caption = ""
        combo1(0).Text = ""
    End If

    tx(2).Text = "0"
End If

End Sub

Sub Combo1_Change (ik As Integer) ' Flags new data to file
    news = 1
End Sub

Sub Combo1_Click (ik As Integer) ' Opens box & file for input
    command5(ik).Visible = -1
    nm$ = combo1(ik).Text
    match$ = 0

    If InStr(nm$, "+") = 0 Then
        Open actfilnam$(ik) For Input As # (ik + 4)
        While match$ = 0
            Line Input #(ik + 4), nm$
            If nm$ = nm$ Then match$ = 1: command5(ik).Caption = ""
        Wend

    Select Case ik
        Case 0
            Input #(ik + 4), Tac, Trc, Rain, v, X(11)
tx(0).Text = Str$(Tac)
tx(1).Text = Str$(Trc)
tx(2).Text = Str$(Rain)
tx(3).Text = Str$(v)
tx(4).Text = Str$(Int(100 * X(11)))
Check1.Value = -(Rain > 0)
Case 1
Input #(ik + 4), Qtot, Mvt, v
tx(5).Text = Str$(Qtot)
tx(6).Text = Str$(0.01 * Int(Val(tx(5).Text) / 1.05 + .5))
tx(7).Text = Str$(Mvt)
If Val(tx(3).Text) < v Then
  tx(3).Text = Str$(v)
If Abs(v) < .5 Then tx(3).Text = "0.5"
End If
Case 2
Input #(ik + 4), X(8), Gap(4), Gap(2), Vnt(6), Vnt(4), Vnt(2)
tx(19).Text = Str$(X(8))
tx(20).Text = Str$(Gap(4))
tx(21).Text = Str$(Gap(2))
tx(22).Text = Str$(Vnt(6) * 100)
tx(23).Text = Str$(Vnt(4) * 100)
tx(24).Text = Str$(Vnt(2) * 100)
End Select
Close #(ik + 4)
End If
End Sub

Sub Combo1_KeyDown (ik As Integer, KC As Integer, Shift As Integer)"
' Traps "Delete" button

If KC = &H2E And combo1(ik).ListIndex > 0 Then
  combo1(ik).RemoveItem combo1(ik).ListIndex
End If
End Sub

Sub Combo1_LostFocus (ik As Integer) ' Marks button with reference letters

If InStr(combo1(ik).Text, "+") = 0 Then
  command5(ik).Caption = Left$(combo1(ik).Text, 2)
End if
End Sub
Sub Command1_Click () ' "Exit"

Unload Form1
Close #0
End

End Sub

Sub Command2_Click () ' "Print" (Not working)
    If sizeflag > 1 Then
        For j% = 8 To 15
            tx(j%).Visible = 0
        Next
    End If

    PrintForm
        If sizeflag > 1 Then
            For j% = 8 To 15
                tx(j%).Visible = -1
            Next
        End If

End Sub

Sub Command3_Click () ' "Save" - to be developed
    printer.Print "Clothing Heat Flow Model (W1)"
        For j% = 0 To 12
            printer.Print tx(j%).Text; " ",
        Next
        printer.Print
        For j% = 13 To 25
            printer.Print tx(j%).Text; " ",
        Next

        For j% = 0 To 8
            printer.Print Tab(3 + 8 * j%); lblt(j%);
        Next
        For j% = 0 To 8
            printer.Print Tab(3 + 8 * j%); lblh(j%);
        Next
        For j% = 0 To 8
            printer.Print Tab(3 + 8 * j%); lbllp(j%);
        Next
        printer.Print
        printer.Print Tab(12); Dry.Caption; Tab(27); vap.Caption; Tab(42); rad.Caption

End Sub
Sub Command4_Click ()  ' "Run"

    label1.Visible = 0
    label48.Visible = 0
    command4.Visible = 0
    greyflag = 0: nt = 0
    Sunwit
    Tot_n.Caption = "T " + nt
    command2.Enabled = -1
    command3.Enabled = -1
    If OptN.Value = -1 Then OptN_click
    If OptP.Value = -1 Then OptP_click
    If OptR.Value = -1 Then OptR_click
    If OptT.Value = -1 Then OptT_click
    If OptS.Value = -1 Then OptS_click
    If initflag > 0 Then alignlabels
        initflag = 0
    command1.Enabled = -1

End Sub

Sub Command5_Click (ik As Integer)  ' Open / Shut combo box

    If InStr(combo1(ik).Text, "+") = 0 Then
        If combo1(ik).Visible = -1 Then
            combo1(ik).Visible = 0
        Else
            command5(ik).Visible = 0
            combo1(ik).Visible = -1
        End If
    If news > 0 Then NewEntry (ik)
End If

End Sub

Sub Command6_Click ()  ' "Recall" particular data set - to be developed
End Sub

Sub Drawl ()  ' Draw line segment of graph

    eex = ex
    eey = ey / (.3 + .7 * sizeflag)
    If dotflag < 2 Then
        picture1.Line (x1, y1)-(x2, y2)
        x1 = x2: y1 = y2
Else While x1 < x2 - eex
    x1 = x1 + 2 * eex: y1 = y1 + 2 * eey
    picture1.PSet (x1, y1)
    Wend
End If

End Sub

Sub Drip () ' Show drop falling into test tube

    xDrip = extnt(j%) * scl - 2.5 - 3 * (j% / 2 > Int(j% / 2))
    If dripflag(0) < 0 Then
        dripflag(1) = -1
        DripLim(1) = 1 - .05 * qWet(j%)
        If DripLim(1) < 0 Then DripLim(1) = 0
        fall(1) = -58 - 425 * DripLim(1)
        TopLim(1) = 32.4 - 22.4 * sizeflag - (40.1 - 11.5 * sizeflag) * DripLim(1)
        image1(1).Left = xDrip - 1.67
        image2(1).Left = xDrip - 2.87
        image3(1).Left = xDrip - 1.401
        image1(1).Visible = -1
        image2(1).Visible = -1
        image3(1).Visible = -1
    End If
    If dripflag(0) = 0 Then
        dripflag(0) = -1
        DripLim(0) = 1 - .05 * qWet(j%)
        If DripLim(0) < 0 Then DripLim(0) = 0
        fall(0) = -40 - 340 * DripLim(0)
        TopLim(0) = 32.4 - 22.4 * sizeflag - (40.1 - 11.5 * sizeflag) * DripLim(0)
        image1(0).Left = xDrip - 1.67
        image2(0).Left = xDrip - 2.87
        image3(0).Left = xDrip - 1.41
        image1(0).Visible = -1
        image2(0).Visible = -1
        image3(0).Visible = -1
    End If
    Randomize Timer

End Sub

Sub Form_click () 'to be developed
End Sub
Sub Form_Load () ' Startup

    Left = (screen.Width - Width) / 2
    Top = (screen.Height - Height) / 2
    hRatio = 1: wRatio = 1
    If (screen.Width > Width) Or (screen.Height > Height) Then grow

    Thick(1) = 1
    Thick(2) = .39
    Thick(3) = 6.13
    Thick(4) = .45

    For j% = 0 To 8
        extnt(j%) = 2 * j%
        t(j%) = 35 - 5 * j%
        r(j%) = .12 + .113 * j%
        press(j%) = 2142 * r(j%) * Exp(18.927 - 5300 / (273 + t(j%))}
    Next

    Tn = 310

    sizeflag = 1
    greyflag = 1
    flashflag = 1
    whiteflag = 0
    initflag = 1
    bc = 1: cb(0) = 4: cb(1) = 3: cb(2) = 2: ex = 1
    bb = &H40FFFF
    inx = 16 'dead text box

    actfilnam$(1) = "c:\workshop\vbmodel\typact.dat"
    actfilnam$(2) = "c:\workshop\vbmodel\typfit.dat"
    actfilnam$(0) = "c:\workshop\vbmodel\typclim.dat"

    For i% = 0 To 2
        If Dir(actfilnam$(i%)) <> "" Then
            Open actfilnam$(i%) For Input As #(i% + 4)
            Do Until EOF(i% + 4)
                Line Input #(i% + 4), nm$nn
                combo1(i%).AddItem nm$
                Line Input #(i% + 4), dummy$
            Loop
        Else
            Open actfilnam$(i%) For Output As #(i% + 4)
            Print #(i% + 4), " + + + "
            combo1(i%).AddItem " + + + "
            z$ = Chr$(9)
            z$ = Chr$(9)
    Loop

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Select Case i%
    Case 0
        'weather
    Case 1
        Print #5, "Heat" & z$ & ", " & z$ & "Motion" & z$ & ", " & z$ & "Wind" & z$ & "Qtot, Mvt, V
        'work
    Case 2
        Print #6, "Gap6" & z$ & "Gap4" & z$ & "Gap2" & z$ & "Vent6" & z$ & "Vent4" & z$ & "Vent2" & z$ & "fit
End Select
End If
Close #(i% + 4)
Next

jump = 12
finger = 1.3

For j%= 0 To 1
    clipboard.SetData LoadPicture("c:\workshop\vmodel\drop5.bmp")
    image1(j%).Picture = clipboard.GetData()
    image2(j%).Top = 3.6
    image3(j%).Top = 3.65
    clipboard.SetData LoadPicture("c:\workshop\vmodel\ttube3.bmp")
    image2(j%).Picture = clipboard.GetData()
    clipboard.SetData LoadPicture("c:\workshop\vmodel\plunger.bmp")
    image3(j%).Picture = clipboard.GetData()
Next

'input limits
Ul(0) = 40: Ul(1) = 50: Ul(2) = 20: Ul(3) = 10: Ul(4) = 100: Ul(5) = 73:
    Ul(6) = 2.6
Ll(0) = -39: Ll(1) = -39: Ll(2) = 0: Ll(3) = -10: Ll(4) = 0: Ll(5) = 21: Ll(6) = .2

Ul(7) = 10: Ul(8) = 5: Ul(9) = 5: Ul(10) = 5: Ul(11) = 5: Ul(12) = 40:
    Ul(13) = 40
Ll(7) = 0: Ll(8) = 0: Ll(9) = 0: Ll(10) = 0: Ll(11) = 0: Ll(12) = 0: Ll(13) = 0

Ul(14) = 40: Ul(15) = 40: Ul(16) = 20: Ul(17) = 20: Ul(18) = 15: Ul(19) = 50:
    Ul(20) = 30
Ll(14) = 0: Ll(15) = 0: Ll(16) = 0: Ll(17) = 0: Ll(18) = 0: Ll(19) = 1: Ll(20) = 1

Ul(21) = 20: Ul(22) = 250: Ul(23) = 150: Ul(24) = 100: Ul(21) = 1: Ul(22) = 0:
    Ul(23) = 0: Ul(24) = 0

End Sub
Sub Greyout () ' Alters background on numerical output if initial conditions change

    For j% = 0 To 8
        If lb1t(j%).BackColor = &H80FFFF Then lb1t(j%).BackColor = &HC0C0C0
        If lb1h(j%).BackColor = &H80FFFF Then lb1h(j%).BackColor = &HC0C0C0
        If lb1p(j%).BackColor = &H80FFFF Then lb1p(j%).BackColor = &HC0C0C0
    Next

End Sub

Sub Grow () ' Expands form & contents to fill screen

'Resize Form
    wRatio = screen.Width / Width
    Width = Width * wRatio
    hRatio = screen.Height / Height
    Height = Height * hRatio

    Left = 0: Top = 0

    If hRatio > 1.13 And wRatio > 1.1 Then
        For j% = 0 To 24
            tx(j%).FontSize = 9.8
        Next
        For j% = 0 To 8
            lb1t(j%).FontSize = 12
            lb1h(j%).FontSize = 12
            lb1p(j%).FontSize = 12
        Next
        Dry.FontSize = 12
        vap.FontSize = 12
        rad.FontSize = 12
    End If

' list boxes
    For j% = 0 To 4
        lst(j%).Top = lst(j%).Top * hRatio
        lst(j%).Left = lst(j%).Left * wRatio
        lst(j%).Height = lst(j%).Height * hRatio
        lst(j%).Width = lst(j%).Width * wRatio
    Next

'text boxes
    For j% = 0 To 25
        tx(j%).Top = tx(j%).Top * hRatio
        tx(j%).Left = tx(j%).Left * wRatio
        tx(j%).Width = tx(j%).Width * wRatio
    Next
'buttons
command1.Top = command1.Top * hRatio
command1.Left = command1.Left * wRatio
command1.Height = command1.Height * hRatio
command1.Width = command1.Width * wRatio

command2.Top = command2.Top * hRatio
command2.Left = command2.Left * wRatio
command2.Height = command2.Height * hRatio
command2.Width = command2.Width * wRatio

command3.Top = command3.Top * hRatio
command3.Left = command3.Left * wRatio
command3.Height = command3.Height * hRatio
command3.Width = command3.Width * wRatio

command4.Top = command4.Top * hRatio
command4.Left = command4.Left * wRatio
command4.Height = command4.Height * hRatio
command4.Width = command4.Width * wRatio

command6.Top = command6.Top * hRatio
command6.Height = command6.Height * hRatio
command6.Width = command6.Width * wRatio

For j% = 0 To 2
command5(j%).Top = command5(j%).Top * hRatio
command5(j%).Left = command5(j%).Left * wRatio
command5(j%).Width = command5(j%).Width * wRatio
Next

'check box
Check1.Top = Check1.Top * hRatio
Check1.Left = Check1.Left * wRatio
Check1.Height = Check1.Height * hRatio
Check1.Width = Check1.Width * wRatio

'combo boxes
For j% = 0 To 2
combo1(j%).Top = combo1(j%).Top * hRatio
combo1(j%).Left = combo1(j%).Left * wRatio
combo1(j%).Width = combo1(j%).Width * wRatio
Next

'frame
frame1.Top = frame1.Top * hRatio
frame1.Left = frame1.Left * wRatio
frame1.Height = frame1.Height * hRatio
frame1.Width = frame1.Width * wRatio

`images`
For j% = 0 To 1
image1(j%).Top = image1(j%).Top * hRatio
image1(j%).Left = image1(j%).Left * wRatio
image1(j%).Height = image1(j%).Height * hRatio
image1(j%).Width = image1(j%).Width * wRatio

image2(j%).Top = image2(j%).Top * hRatio
image2(j%).Left = image2(j%).Left * wRatio
image2(j%).Height = image2(j%).Height * hRatio
image2(j%).Width = image2(j%).Width * wRatio

image3(j%).Top = image3(j%).Top * hRatio
image3(j%).Left = image3(j%).Left * wRatio
image3(j%).Height = image3(j%).Height * hRatio
image3(j%).Width = image3(j%).Width * wRatio
Next

`options`
OptN.Top = OptN.Top * hRatio
OptN.Left = OptN.Left * wRatio
OptN.Height = OptN.Height * hRatio
OptN.Width = OptN.Width * wRatio

OptP.Top = OptP.Top * hRatio
OptP.Left = OptP.Left * wRatio
OptP.Height = OptP.Height * hRatio
OptP.Width = OptP.Width * wRatio

OptR.Top = OptR.Top * hRatio
OptR.Left = OptR.Left * wRatio
OptR.Height = OptR.Height * hRatio
OptR.Width = OptR.Width * wRatio

OptS.Top = OptS.Top * hRatio
OptS.Left = OptS.Left * wRatio
OptS.Height = OptS.Height * hRatio
OptS.Width = OptS.Width * wRatio
OptT.Top = OptT.Top * hRatio
OptT.Left = OptT.Left * wRatio
OptT.Height = OptT.Height * hRatio
OptT.Width = OptT.Width * wRatio

`shapes`
For j% = 0 To 10
shap(j%).Top = shap(j%).Top * hRatio

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shap(j%).Left = shap(j%).Left * wRatio
shap(j%).Height = shap(j%).Height * hRatio
shap(j%).Width = shap(j%).Width * wRatio
  Next
Skin.Width = Skin.Width * wRatio

'picture box'
picture1.Top = picture1.Top * hRatio
picture1.Left = picture1.Left * wRatio
picture1.Height = picture1.Height * hRatio
picture1.Width = picture1.Width * wRatio

'group titles'
  For j% = 0 To 3
    Ttl(j%).Top = Ttl(j%).Top * hRatio
    Ttl(j%).Left = Ttl(j%).Left * wRatio
    Ttl(j%).Height = Ttl(j%).Height * hRatio
    Ttl(j%).Width = Ttl(j%).Width * wRatio
    lHed(j%).Top = lHed(j%).Top * hRatio
    lHed(j%).Left = lHed(j%).Left * wRatio
    lHed(j%).Height = lHed(j%).Height * hRatio
    lHed(j%).Width = lHed(j%).Width * wRatio
  Next

'weather labels'
  For j% = 0 To 10
    wLbl(j%).Top = wLbl(j%).Top * hRatio
    wLbl(j%).Left = wLbl(j%).Left * wRatio
    wLbl(j%).Height = wLbl(j%).Height * hRatio
    wLbl(j%).Width = wLbl(j%).Width * wRatio
  Next

'work / fabric labels'
  For j% = 0 To 4
    aLbl(j%).Top = aLbl(j%).Top * hRatio
    aLbl(j%).Left = aLbl(j%).Left * wRatio
    aLbl(j%).Height = aLbl(j%).Height * hRatio
    aLbl(j%).Width = aLbl(j%).Width * wRatio
    fILbl(j%).Top = fILbl(j%).Top * hRatio
    fILbl(j%).Left = fILbl(j%).Left * wRatio
    fILbl(j%).Height = fILbl(j%).Height * hRatio
    fILbl(j%).Width = fILbl(j%).Width * wRatio
  Next

'Fit labels'
  For j% = 0 To 1
    fLbl(j%).Top = fLbl(j%).Top * hRatio
    fLbl(j%).Left = fLbl(j%).Left * wRatio
fLbl(j%).Height = fLbl(j%).Height * hRatio
fLbl(j%).Width = fLbl(j%).Width * wRatio

' Options
For j% = 0 To 3
OPTLbl(j%).Top = OPTLbl(j%).Top * hRatio
OPTLbl(j%).Left = OPTLbl(j%).Left * wRatio
OPTLbl(j%).Height = OPTLbl(j%).Height * hRatio
OPTLbl(j%).Width = OPTLbl(j%).Width * wRatio
Next

' Results
For j% = 0 To 8
lbtt(j%).Top = lbtt(j%).Top * hRatio
lbtt(j%).Left = lbtt(j%).Left * wRatio
lbtt(j%).Height = lbtt(j%).Height * hRatio
lbtt(j%).Width = lbtt(j%).Width * wRatio

lbth(j%).Top = lbth(j%).Top * hRatio
lbth(j%).Left = lbth(j%).Left * wRatio
lbth(j%).Height = lbth(j%).Height * hRatio
lbth(j%).Width = lbth(j%).Width * wRatio

lbtp(j%).Top = lbtp(j%).Top * hRatio
lbtp(j%).Left = lbtp(j%).Left * wRatio
lbtp(j%).Height = lbtp(j%).Height * hRatio
lbtp(j%).Width = lbtp(j%).Width * wRatio
Next

'Table
For j% = 0 To 3
Hed(j%).Top = Hed(j%).Top * hRatio
Hed(j%).Left = Hed(j%).Left * wRatio
Hed(j%).Height = Hed(j%).Height * hRatio
Hed(j%).Width = Hed(j%).Width * wRatio
Next

For j% = 0 To 5
Leg(j%).Top = Leg(j%).Top * hRatio
Leg(j%).Left = Leg(j%).Left * wRatio
Leg(j%).Height = Leg(j%).Height * hRatio
Leg(j%).Width = Leg(j%).Width * wRatio
Next

' fluxes
For j% = 0 To 5
OpLbl(j%).Top = OpLbl(j%).Top * hRatio
OpLbl(j%).Left = OpLbl(j%).Left * wRatio
OpLbl(j%).Height = OpLbl(j%).Height * hRatio
OpLbl(j%).Width = OpLbl(j%).Width * wRatio
Next

Dry.Top = Dry.Top * hRatio
Dry.Left = Dry.Left * wRatio
Dry.Height = Dry.Height * hRatio
Dry.Width = Dry.Width * wRatio

vap.Top = vap.Top * hRatio
vap.Left = vap.Left * wRatio
vap.Height = vap.Height * hRatio
vap.Width = vap.Width * wRatio

rad.Top = rad.Top * hRatio
rad.Left = rad.Left * wRatio
rad.Height = rad.Height * hRatio
rad.Width = rad.Width * wRatio

'dotted lines etc
For j% = 0 To 15
dots(j%).Top = dots(j%).Top * hRatio
dots(j%).Left = dots(j%).Left * wRatio
dots(j%).Height = dots(j%).Height * hRatio
dots(j%).Width = dots(j%).Width * wRatio
Next

For j% = 0 To 2
Brace(j%).Top = Brace(j%).Top * hRatio
Brace(j%).Left = Brace(j%).Left * wRatio
Brace(j%).Height = Brace(j%).Height * hRatio
Brace(j%).Width = Brace(j%).Width * wRatio
Next

'graph labels
For j% = 0 To 3
lbpH(j%).Top = lbpH(j%).Top * hRatio
lbpH(j%).Left = lbpH(j%).Left * wRatio
lbpH(j%).Height = lbpH(j%).Height * hRatio
lbpH(j%).Width = lbpH(j%).Width * wRatio
Next

For j% = 0 To 4
lbpT(j%).Top = lbpT(j%).Top * hRatio
lbpT(j%).Left = lbpT(j%).Left * wRatio
lbpT(j%).Height = lbpT(j%).Height * hRatio
lbpT(j%).Width = lbpT(j%).Width * wRatio
Next
For j% = 0 To 6
  lbpP(j%).Top = lbpP(j%).Top * hRatio
  lbpP(j%).Left = lbpP(j%).Left * wRatio
  lbpP(j%).Height = lbpP(j%).Height * hRatio
  lbpP(j%).Width = lbpP(j%).Width * wRatio
Next

label1.Top = label1.Top * hRatio
label1.Left = label1.Left * wRatio
l48.Top = l48.Top * hRatio
l48.Left = l48.Left * wRatio

sun_n.Top = sun_n.Top * hRatio
sun_n.Left = sun_n.Left * wRatio
q_n.Top = q_n.Top * hRatio
q_n.Left = q_n.Left * wRatio
J_n.Top = J_n.Top * hRatio
J_n.Left = J_n.Left * wRatio
Tot_n.Top = Tot_n.Top * hRatio
Tot_n.Left = Tot_n.Left * wRatio

End Sub

Sub Hgraph ()
' Draws humidity graph

  picture1.ForeColor = &HFF0000
  x1 = extnt(0): y1 = 80 * r(0) - 40
  picture1.DrawWidth = 2
  picture1.DrawLine = 0
dotflag = 0
  If r(0) >= .95 Then dotflag = 2

For j% = 1 To 8
  If Abs(r(j%) - r(j% - 1)) < .0001 Then slope = 10000 Else slope = (extnt(j%) - extnt(j% - 1)) / (r(j%) - r(j% - 1))
  x = extnt(j% - 1) + slope *.95 - r(j% - 1))
  a = Atn(1.3 / (slope * scl / 67.7 / (.3 + .7 * sizeflag)))
  sink = Cos(aa): cosk = Sin(aa):
  ex = sink: ey = cosk
  ' Coming down
  If (r(j% - 1) >= .95 And r(j%) < .95) Then
    If xs <= extnt(j%) Then x2 = scl * xs: y2 = 36: ex = sink: ey = cosk: Drawl: dotflag = 0
  ' Going up
  ElseIf (r(j% - 1) <= .95 And r(j%) > .95) Then
    If xs > extnt(j% - 1) Then x2 = scl * xs: y2 = 36: Drawl: dotflag = 2
End If
x2 = scl * extnt(j\%): y2 = 80 * r(j\%) - 40: Drawl
Next
image3(0).Top = -(7 + 11 * sizeflag)
image3(1).Top = -(7 + 11 * sizeflag)

End Sub

Sub Hleg ()  ' Adds legend & drip images to humidity graph

  lbpH(0).Visible = -1
  lbpH(1).Visible = -1
  lbpH(2).Visible = -1
  lbpH(3).Visible = -1

  picture1.DrawWidth = 1
  picture1.DrawStyle = 2
  For j\% = -40 To 40 Step 20
    picture1.Line (0, j\%)-(180, j\%), &H404080
  Next

  If whiteflag = 1 Then
    clipboard.SetData LoadPicture("c:\workshop\vbmodel\drop3.bmp")
    image1(0).Picture = clipboard.GetData()
    image1(1).Picture = clipboard.GetData()
    clipboard.SetData LoadPicture("c:\workshop\vbmodel\ttube2.bmp")
    image2(0).Picture = clipboard.GetData()
    image2(1).Picture = clipboard.GetData()
    clipboard.SetData LoadPicture("c:\workshop\vbmodel\plunger2.bmp")
    image3(0).Picture = clipboard.GetData()
    image3(1).Picture = clipboard.GetData()

  Else
    clipboard.SetData LoadPicture("c:\workshop\vbmodel\drop2.bmp")
    image1(0).Picture = clipboard.GetData()
    image1(1).Picture = clipboard.GetData()
    clipboard.SetData LoadPicture("c:\workshop\vbmodel\ttube3.bmp")
    image2(0).Picture = clipboard.GetData()
    image2(1).Picture = clipboard.GetData()
    clipboard.SetData LoadPicture("c:\workshop\vbmodel\plunger.bmp")
    image3(0).Picture = clipboard.GetData()
    image3(1).Picture = clipboard.GetData()

  End If
  For j\% = 0 To 7
    If qWet(j\%) > 0 Then drip
  Next

End Sub
Sub jGraph () ' Draws vapour flow graph

    picture1.ForeColor = &H5000
    x1 = extnt(0): y1 = Jv(0) * 2000 - 45
    picture1.DrawWidth = 1
    picture1.DrawLine = 1
    If r(0) >= .95 Then picture1.DrawLine = 0
    J_n.Width = 2000
    J_n = Str$(Int(100000000# * Jv(7)) * .00000001)
    J_n.Visible = -1
    For j% = 1 To 8
        x2 = scl * extnt(j%)
        y2 = Jv(j%) * 2000 - 45
        picture1.Line (x1, y1)-(x2, y2)
        x1 = x2: y1 = y2
    Next

End Sub

Sub Jloop () ' Vapour flow calculation

On Error GoTo escape:
    nj = 0: nt = nt + 1    ' increment Sunwit loop count

Do
    n% = n% + 1
    nj = nj + 1    ' Jloop count
    press(0) = po: Jv(0) = Jv0    ' set initial conditions

    dP = -Jv(0) * Gap(1) * (546.3 * tt) ^ .85 * 12410000# ' diffusion through 1st layer
    press(1) = press(0) + dP ' pressure drop to outer surface of layer 1

    Jv(1) = Jv0
    If qWet(1) > 0 Then ' condensation
        HL = 2500.9 - 2.37 * t(1)
        Jv(1) = Jv(1) - qWet(1) / HL1 ' remove condensed vapour
    End If

    kd = 1461900000# / (1 + Mvt)' 
    For i% = 1 To 5 Step 2 ' step through layers
        ' air gap
        dth = (th(i%) - th((i% + 1)) * .25
        thm1 = th(i%) - dth: thm = thm1 - dth: thm2 = thm - dth' intermediate temperatures
        pressm = press(i%) - Jv(i%) * Gap(i% + 1) * .5 * kd * thm1 ^ -.85 ' diffusion
        jLoss(i% + 1) = Vnt(i% + 1) * Gap(i% + 1) * (pressm / thm - press(8) / Ta)
        Jv(i% + 1) = Jv(i%) - jLoss(i% + 1)' bellows effect
        press(i% + 1) = pressm - Jv(i% + 1) * Gap(i% + 1) * .5 * kd * thm2 ^ -.85

SUBSTITUTE SHEET (RULE 26)
'fabric
If qWet(i% + 1) > 0 Then   'condensation
   HL = 2500.9 - 2.37 * t(i% + 1)
   Jv(i% + 1) = Jv(i% + 1) - qWet(i% + 1) / HL   'remove condensate
End If

   tt = 1 / (th(i% + 1) + th(i% + 2))
   dP = -Jv(i% + 1) * Gap(i% + 2) * (546.3 * tt) ^.85 * 12416000#
   press(i% + 2) = press(i% + 1) + dP   'pressure drop across fabric
If qWet(i% + 2) > 0 Then
   HL = 2500.9 - 2.37 * t(i% + 2)
   Jv(i% + 2) = Jv(i% + 1) - qWet(i% + 2) / HL   'remove condensate
Else Jv(i% + 2) = Jv(i% + 1)
End If

Next i%

delP = (press(7) - press(8))   'drop across boundary layer
Jv1 = delP * Transmittance   'vapour escape to atmosphere
   z = (Jv(7) - Jv1)   'error
   zcrit = .00001: If ssat > 0 Then zcrit = .001   'mismatch tolerance

If Abs(z) < zcrit Or nj > 49 Then Jv(8) = Jv1: Exit Do
   po = po + (.13 + .7 / nj) * z / Jv1 * delP  'if qWet = 0   'adjust p at skin
If po < 10 Then po = 10
   Loop
   escape: Exit Sub
End Sub

Sub NewEntry (ik As Integer)   'Checks name & files new combo box data
   news = 0
   nmS = combo1(ik).Text
   a$ = Left$(nmS, 1)
   a$ = UCase$(a$)
If a$ = "" Then Exit Sub
If Asc(a$) < 44 Or Asc(a$) > 96 Then Exit Sub
   nmS = a$ + LCase$(Mid$(nmS, 2))
   nmslim$ = nmS
   While InStr(nmslim$, " ") > 0
      blank% = InStr(nmslim$, " ")
      nmslim$ = Left$(nmslim$, blank% - 1) & Mid$(nmslim$, blank% + 1)
   Wend
   For i% = 1 To combo1(ik).ListCount - 1
      nnmslim$ = combo1(ik).List(i%)
   While InStr(nnmslim$, " ") > 0
      blank% = InStr(nnmslim$, " ")
   Wend
SUBSTITUTE SHEET (RULE 26)
nnmslim$ = Left$(nnmslim$, blank% - 1) & Mid$(nnmslim$, blank% + 1)
Wend
b$ = LCase$(Left$(nnmslim$, 7))
If b$ = LCase$(Left$(nnmslim$, 7)) Then Exit Sub
Next
combo1(ik).AddItem nm$

match% = 0
Open actfilnam$(ik) For Input As #(ik + 4)
Do Until EOF(ik + 4)
Line Input #(ik + 4), nnmslim$
While InStr(nnmslim$, " ") > 0
  blank% = InStr(nnmslim$, " ")
  nnmslim$ = Left$(nnmslim$, blank% - 1) & Mid$(nnmslim$, blank% + 1)
Wend
If LCase$(Left$(nnmslim$, 7)) = LCase$(Left$(nnmslim$, 7)) Then match% = 1
Line Input #(ik + 4), dummy$
Loop
  Close #(ik + 4)
  If match% = 0 Then
  Open actfilnam$(ik) For Append As #(ik + 4)
  Print #(ik + 4), nm$
  Select Case ik
    Case 0
      Print #(4), Val(tx(0).Text), Val(tx(1).Text), Val(tx(2).Text), Val(tx(3).Text), .01 * Val(tx(4).Text)
    Case 1
      Print #(5), Val(tx(5).Text), Val(tx(7).Text), Val(tx(3).Text)
    Case 2
  End Select
  Close #(ik + 4)
End If

End Sub

Sub Nosweat() ' Defines pressures if no vapour flow
For j% = 0 To 7 ' all surfaces
  press(j%) = press(8)
  Cmm = 4.936 * (1 + t(j%) * .00808) ^ 8.37
  r(j%) = press(8) / (t(j%) + 273) / Cmm
Next
End Sub
Sub OptN_click() ' Display solution numerically

    picture1.Visible = 0

If t(0) < 34.1 Then
    lblt(8).BackColor = &HFFFFFF80
Else lblt(8).BackColor = &H80FFFF
End If

For j% = 0 To 8

    If j% > 0 Then
        If t(j%) < 0 Then
            lblt(8 - j%).ForeColor = &HFF
            lblt(8 - j%).BackColor = &HFFFFFF80
        Else lblt(8 - j%).ForeColor = &H800000
            lblt(8 - j%).BackColor = &H80FFFF
        End If
    End If

    lblt(8 - j%) = " " + Str$(Int(t(j%) * 100 + .5) / 100)

If r(j%) > .95 Then
    lblh(8 - j%).ForeColor = &HFF
    lblh(8 - j%).BackColor = &H8080FF
    lblp(8 - j%).BackColor = &H8080FF
Else lblh(8 - j%).ForeColor = &H800000
    lblh(8 - j%).BackColor = &H80FFFF
    lblp(8 - j%).BackColor = &H80FFFF
End If

If r(0) > .7 Then lblh(8).BackColor = &H80FF&: lblp(8).BackColor = &H80FF&

    lblh(8 - j%) = " " + Str$(Int(r(j%) * 1000 + .5) / 10)

    kPa = press(j%) * .0004565
    a$ = Str$(Int(kPa * 100 + .5) / 100)
    If kPa < 1 Then a$ = " 0" + a$

    If Wetsum > 0 Then
        lblp(8 - j%) = " " + Str$(Int(qWet(j%) * 100) / 100)
        Hed(3).Caption = "dew"
    Else lblp(8 - j%) = " " + a$
        Hed(3).Caption = "kPa"
    End If

Next

For j% = 0 To 8

    If r(0) > 1 Then 'Q1 < 0 Or
        lblh(j%).BackColor = &H1D47F0
        lblp(j%).BackColor = &H1E67F0
        lblt(j%).BackColor = &H1E87F0
End If
Next

For j% = 3 To 7
  ix = Int(.5 * (j% + 15))
  If tx(ix).BackColor = 0 Or tx(ix + 4).BackColor = 0 Then
    lbli(j%).BackColor = 0
    lblih(j%).BackColor = 0
    lblihp(j%).BackColor = 0
    Leg(ix - 7).Visible = 0
    dots(ix - 7).Visible = 0
    If j% < 7 Then Brace(ix - 8).Visible = 0
  Else
    Leg(ix - 7).Visible = -1
    dots(ix - 7).Visible = -1
    If j% < 7 Then Brace(ix - 8).Visible = -1
  End If
Next
If greyflag = 1 Then Greyout

End Sub

Sub OptP_click () ' Display vapour pressure graph
  For j% = 0 To 4
    lbpt(j%).Visible = 0
  Next
  For j% = 0 To 3
    lbph(j%).Visible = 0
  Next
  For j% = 0 To 6
    lbp(j%).Visible = 0
  Next
  For j% = 0 To 1
    image1(j%).Visible = 0
    image2(j%).Visible = 0
    image3(j%).Visible = 0
    dripp1(j%) = 0
  Next
  picture1.Visible = -1
  picture1.Refresh
  Section
  Pleg
  Pgraph
End Sub
Sub OptR_click () 'Display relative humidity graph

For j% = 0 To 4
    lbpT(j%).Visible = 0
Next
For j% = 0 To 3
    lbpH(j%).Visible = 0
Next
For j% = 0 To 6
    lbpP(j%).Visible = 0
Next
dripflag(0) = 0
dripflag(1) = 0
picture1.Visible = -1
picture1.Refresh
Section
Hleg
Hgraph

End Sub

Sub OptS_click () 'Display all graphs

For j% = 0 To 4
    lbpT(j%).Visible = 0
Next
For j% = 0 To 3
    lbpH(j%).Visible = 0
Next
For j% = 0 To 6
    lbpP(j%).Visible = 0
Next
For j% = 0 To 1
    image1(j%).Visible = 0
    image2(j%).Visible = 0
    image3(j%).Visible = 0
dripflag(j%) = 0
Next
picture1.Visible = -1
picture1.Refresh

Section
Tgraph
Hgraph
Pgraph
qGraph

End Sub
Sub OptT_click()  ' Display temperature graph

For j% = 0 To 4
    lbpT(j%).Visible = 0
Next
For j% = 0 To 3
    lbpH(j%).Visible = 0
Next
For j% = 0 To 6
    lbpP(j%).Visible = 0
Next
For j% = 0 To 1
    image1(j%).Visible = 0
    image2(j%).Visible = 0
    image3(j%).Visible = 0
    driptflag(j%) = 0
Next
picture1.Visible = -1
picture1.Refresh

Section
Tleg
Tgraph

End Sub

Sub Pgraph()  ' Draw vapour pressure graph

picture1.ForeColor = 0
x1 = extnt(0): y1 = press(0) / 121.7 - 45
picture1.DrawWidth = 1
picture1.DrawStyle = 0
If r(0) >= .95 Then picture1.DrawStyle = 2
For j% = 1 To 8
    slope2 = (press(j%) - press(j% - 1)) / (extnt(j%) - extnt(j% - 1))
    slope1 = (r(j%) - r(j% - 1)) / (extnt(j%) - extnt(j% - 1))
    If slope1 = 0 Then slope1 = -.0001
    If (r(j% - 1) - .95) * (r(j%) - .95) < 0 Then
        xs = extnt(j% - 1) + (.95 - r(j% - 1)) / slope1
        ys = (press(j% - 1) + slope2 * (xs - extnt(j% - 1)))
        x2 = scl * xs: y2 = ys / 121.7 - 45
        picture1.Line (x1, y1)-(x2, y2)
        x1 = x2: y1 = y2
        picture1.DrawStyle = -2 * (r(j%) > .95)
End If
x2 = scl * extnt(j%)  
y2 = press(j%) / 121.7 - 45  
    picture1.Line (x1, y1)-(x2, y2)  
x1 = x2: y1 = y2

Next

End Sub

Sub Picture1_click () 'Toggle picture height

If q0 > 0 Then
    sizeflag = 3 - sizeflag
If sizeflag > 1 Then
    picture1.Top = 1622 * hRatio  
    picture1.Height = 5264 * hRatio  
    label54.Caption = "S k i n"  
    jump = 15
    finger = .8
Else picture1.Top = 3734 * hRatio  
    picture1.Height = 3068 * hRatio  
    label54.Caption = "S k i n"  
    jump = 12
    finger = 1.3

End If

If OptT.Value = -1 Then OptT_click
If OptR.Value = -1 Then OptR_click
If OptP.Value = -1 Then OptP_click
If OptS.Value = -1 Then OptS_click
End If

End Sub

Sub Picture1_Resize () 'Relocate labels for new picture height

If sizeflag < 2 Then

    lbpT(0).Top = 47
    For j% = 1 To 4
        lbpT(j%).Top = 11.55 * j% - 6.25
    Next

    lbpH(0).Top = 41.5
    For j% = 1 To 3
        lbpH(j%).Top = 23.3 * j% - 24.2
    Next
lbP(0).Top = 44.5
For j% = 1 To 6
    lbP(j%).Top = 10.45 * j% - 14.1
Next

image2(0).Top = 10.5
image2(1).Top = 10.5
image3(0).Top = 10
image3(1).Top = 10
End If

If sizeflag > 1 Then
    image2(0).Visible = 0
    image2(1).Visible = 0
    lbP(0).Top = 30
    For j% = 1 To 4
        lbP(j%).Top = 34.45 * j% - 119.2
    Next
    lbP(0).Top = 20
    For j% = 1 To 3
        lbP(j%).Top = 69.05 * j% - 171
    Next
    lbP(0).Top = 33.8
    For j% = 1 To 6
        lbP(j%).Top = 31.1 * j% - 142
    Next
    image2(0).Top = -85
    image2(1).Top = -85
    image3(0).Top = -86
    image3(1).Top = -86
End If

End Sub

Sub Pleg ()
    ' Display legend on vapour pressure graph
    For j% = 0 To 6
        lbP(j%).Visible = -1
    Next

    picture1.DrawWidth = 1
    picture1.DrawStyle = 2
    For j% = -45 To 45 Step 18
        picture1.Line (0, j%)-(180, j%), &H0000E0
    Next

End Sub

SUBSTITUTE SHEET (RULE 26)
Sub qGraph () ' Display dry heat flow graph

picture1.ForeColor = &HE000C0
x1 = extnt(0); y1 = q(0) / 1 - 45
picture1.DrawWidth = 1
picture1.DrawStyle = 3
If r(0) >= .95 Then picture1.DrawLine = 0

For j% = 1 To 8
  x2 = scl * extnt(j%)  
  y2 = q(j%) / 1 - 45  
  picture1.Line (x1, y1)-(x2, y2)
  x1 = x2; y1 = y2
Next

End Sub

Sub Qloop () ' Calculate dry heat flow

On Error GoTo out:
   nq = 0: nt = nt + 1  'increment Sunwit loop count
Do
   q(0) = q0
   nq = nq + 1  'increment Qloop counter
   q_n.Caption = Str$(Int(q(0)))
   For j% = 1 To 5 Step 2  'step through layers
     "Fabric"
     th(j%) = th(j% - 1) - q(j% - 1) * Tog(j%)  'temperature drop through fabric
     Tc = th(j%) - 273.15
     q(j%) = q(j% - 1) + qWet(j%) 'add heat of condensation
     'Gap
     xsj = th(j%) - Ta  'dT for bellows loss
     h = r(j%): If h = 0 Then h = .5
     CpRho = 1297.3 + 3.72 * h + Tc * (-4.804 + .258 * h + Tc * (.015 + .008 * h + Tc * (-0.001375 + .00001955 * h)))  'Heat capacity of moist air
     SpHt = Gap(j% + 1) * Vnt(j% + 1) * CpRho 'Heat capacity of exchanged air
     L1 = (L + .0000752 * xsj) * (1 + Mvt) 'conductivity

     kqz = 1 / ((1 + SpHt * Gap(j% + 1) / L1) * .25)
     For i% = 0 To 2  'iterative: temperature drop across gap
       qr1 = .5 * e * sigma * (.0033 * (th(j%) + th(j% + 1))) ^ 3 'radiant factor
       delTh = (q(j%) - .5 * SpHt * xsj * kqz) / (L1 * kqz / Gap(j% + 1) + qr1)
       th(j% + 1) = th(j%) - delTh
       Next
     qLoss(j% + 1) = .5 * SpHt * (xsj - .5 * Gap(j% + 1) / L1 * (q(j%) - qr1))
     q(j% + 1) = q(j%) + qWet(j% + 1) - qLoss(j% + 1) 'new value of dry heat flow

Next
out:
   End Do
End Sub

SUBSTITUTE SHEET (RULE 26)
'T at coat outer
th(7) = th(6) - q(6) * Tog(7)
q_n = th(7)
q(7) = q(6) + qWet(7)

'Q1 escape to surroundings
Q1 = L / d * (th(7) - Ta) * Nu

Convective
Q2 = e * sigma * 303 * ((.0033 * th(7))^4 - (.0033 * Tr)^4)  

Radiative
qTemp = Int(Q2 * 100) / 100
If Abs(qTemp) > 90 Then qTemp = Int(10 * qTemp) / 10
Q1 = Q1 + Q2
q(8) = Q1

85 z = Abs(q(7) - Q1) ' error
zcrit = .003: 'tolerance
If z < zcrit Or n% > 49 Then rad.Caption = Str$(qTemp): Exit Do
n% = n% + 1 'increment loop count
If n% < 12 Then ff = ff - .01 'decrease step size
If n% > 12 Then ff = .03

q0 = q0 + ff * (Q1 - q(7)) 'new guess at initial heat flow at skin.
If Qtot - q0 > 20 Then t(0) = 35 + Atan((Qtot - q0) / 40 - .5): th(0) = t(0) + 273.15

'let skin cool to conserve heat

Loop
out: Exit Sub
End Sub

Sub Rad_DblClick () 'Picture background = white
whiteflag = 1 - whiteflag
End Sub

Sub Section () ' Draw cross-sections of skin & fabrics at correct locations

picture1.ScaleTop = 50
picture1.ScaleLeft = -10
picture1.ScaleWidth = 200
picture1.ScaleHeight = -100

picture1.BackColor = &HC0C0C0 + whiteflag * &H3F3F3F
Skin.Visible = -1
label54.Visible = -1

scl = 180 / (extnt(8) - extnt(0))

For j% = 0 To 6 Step 2
w = 2.05 * Int(scl * (extnt(j% + 1) - extnt(j%))) + .6
picture1.DrawWidth = w

SUBSTITUTE SHEET (RULE 26)
\[ xx = 0.5 \times \text{scl} \times (\text{extnt}(j\%)+\text{extnt}(j\%+1)) \]
\[ \text{kcol} = \&H48B0B0 \]
\text{If} \( r(0) > 0.98 \) \text{Then}
\text{kcol} = \text{picture1.BackColor}
\text{Skin.Visible} = 0
\text{label54.Visible} = 0
\text{label1.Visible} = -1
\text{label1.ForeColor} = \&HFF
\text{label1.ZOrder} = 0
\text{l48.Visible} = -1: \text{l48} = \text{Str$(\text{Int}(100 \times r(0)) + " " + \text{Str$(\text{Int}(Q1))}$)
\text{End If}

\text{picture1.Line}(xx, -41)-(xx, 45), \text{kcol}
\text{Next}

\text{End Sub}

\textbf{Sub Sunwit()}

\text{\textit{\' Calculate total heat flow + condensation}}

\text{ns = 0: nt = nt + 1}
\text{X(1) = Val(tex(0).Text) \text{\' air temp}}
\text{X(2) = Val(tex(1).Text) \text{\' sky temp}}
\text{X(3) = Val(tex(3).Text) \text{\' wind}}
\text{X(4) = Val(tex(8).Text) \text{\' Togs, coat}}
\text{X(5) = Val(tx(9).Text) \text{\' " fleece}}
\text{X(6) = Val(tx(10).Text) \text{\' " shirt}}
\text{X(7) = Val(tx(11).Text) \text{\' " vest}}
\text{X(8) = Val(tx(19).Text) \text{\' Gap under coat}}
\text{X(9) = Val(tx(20).Text) \text{\' " " fleece}}
\text{X(10) = Val(tx(21).Text) \text{\' " " shirt}}
\text{X(11) = Val(tx(4).Text) * 0.01 \text{\' r.h.}}
\text{X(12) = Val(tx(5).Text) \text{\' Heat flux}}
\text{X(13) = Val(tx(12).Text) \text{\' WVTR, coat}}
\text{X(14) = Val(tx(13).Text) \text{\' " fleece}}
\text{X(15) = Val(tx(14).Text) \text{\' " shirt}}
\text{X(16) = Val(tx(15).Text) \text{\' " vest}}
\text{X(17) = Val(tx(22).Text) \text{\' Venting, under coat}}
\text{X(18) = Val(tx(23).Text) \text{\' " " fleece}}
\text{X(19) = Val(tx(24).Text) \text{\' " " shirt}}
\text{X(20) = Val(tx(2).Text) \text{\' Rain}}
\text{X(21) = Val(tx(7).Text) \text{\' Movement}}

\text{60 Cma} = \text{X(11) * 4.936 * (1 + X(1) * .00808) ^ 8.37}
\text{th(0) = 35.0047 + 273.15:}
\text{Tac} = \text{X(1): Ta} = \text{Tac + 273.15: press(8) = Ta * Cma}
\text{Trc} = \text{X(2): Tr} = \text{Trc + 273.15}
\text{v} = \text{X(3)}
\text{Tog(7) = X(4) / 10}
\[ R_f = X(5) / 10 \]
\[ Tog(3) = X(6) / 10 \]
\[ Tog(1) = X(7) / 10 \]
\[ Ag = X(8) / 1000 \]
\[ Gap(4) = X(9) / 1000 \]
\[ Gap(2) = X(10) / 1000 \]
\[ Q_{tot} = X(12) \]
\[ V_{nt}(6) = X(17) / 100 \]
\[ V_{nt}(4) = X(18) / 100 \]
\[ V_{nt}(2) = X(19) / 100 \]
\[ M_{vt} = X(21) * .1' * .05 \]
\[ Gap(7) = X(13) * .001 ' \]
\[ Gap(5) = X(14) * .001 ' \]
\[ Gap(3) = X(15) * .001 ' \]
\[ Gap(1) = X(16) * .001 ' \]

For \( ij\% = 0 \) To 1 ' blank out drip
image1(\( ij\% \)).Visible = 0
image2(\( ij\% \)).Visible = 0
image3(\( ij\% \)).Visible = 0
dripflag(\( ij\% \)) = 0
Next

\[ h = 50' \]
\[ e = .94 ' emissivity \]
\[ d = .33 ' nominal diameter \]
\[ rh = 1.29 + h * .00001 - .004141 * Tac - .0000065 * Tac * h \]
\[ L = .02405 + .000069 * Tac ' conductivity \]
\[ mu = 17.28 + .047 * Tac ' viscosity \]
\[ mu = .000001 * mu \]
\[ sigma = 1.5789 ' Stefan, SI units \]
\[ p = .707 * rh * v^2 ' wind pressure \]
\[ Tog(5) = Rf * (1 - .07 * Log(p + 1)) \]
If \( v <= 0 \) Then Tog(5) = Rf
\[ Thick3 = Thick(3) * Tog(5) / (Rf * wRatio) ' fleece thickness for graph \]
\[ Gap(6) = Ag * (1 - Attn(.15 * p) / 1.5708 * Sgn(v)) ' wind effect on outer gap \]
If Gap(6) < .003 Then Gap(6) = .003
\[ LRe = Log(Abs(v) * d * rh / mu) ' Reynolds no \]
\[ Nu = Exp(-.15 + .325 * LRe + .015 * LRe ^ 2) ' Nusselt no \]
\[ alpha = L * Nu / (e * sigma * d) \]
\[ Tn = .5 * (Tr + Ta) ' approach to neutral temperature \]
For \( j\% = 0 \) To 8
\[ Tn = (303 * (.0033 * Tr) ^ 4 + alpha * Ta) / ((.0033 * Tn) ^ 3 + alpha) \]
Next

17 q0 = 75 ' \( W/m^2 \) (guess) - dry heat
\[ C_{mo} = 1.5' \]
\[ po = 2500 ' \]
\[ r(0) = .2 ' guess skin humidity \]
If Tac > 34 And Trc > 34 Then q(0) = 0: Q2 = 0: GoTo 99 ' too hot

For j% = 0 To 8 ' condensation rates = zero
qWet(j%) = 0
Next
ssat = 1: mm% = 0
While ssat > 0 And r(0) < .98
ns = ns + 1:
n% = 0: ff = .13: mm% = mm% + 1
Qloop ' dry heat flow

99 If q0 > Qtot And th(0) > 303 Then th(0) = th(0) - .3: GoTo 17

Dry.BackColor = &H80FFFF ' display dry heat flow
qTemp = Int(100 * q0) / 100
If Abs(qTemp) > 90 Then qTemp = Int(10 * qTemp) / 10
Dry.Caption = Str$(qTemp)
sun_n = Int(100 * q(7)) / 100
If Qtot < q0 Then ' overcooling
  OpLbj(2).Caption = " Heat Deficit"
  vap.ForeColor = &HFF&
  vap.BackColor = &HFFFF80
Else OpLbj(2).Caption = " Vapour Flux"
  vap.ForeColor = &HFF0000
  vap.BackColor = &H80FFFF
End If

qTemp = Int(100 * (Qtot - q0)) / 100 ' display vapour flow
If Abs(qTemp) > 90 Then qTemp = Int(10 * qTemp) / 10
vap.Caption = Str$(qTemp)
If Abs(Qtot - q0) < 1 Then vap.Caption = " 0" ' ignore fractions
shap(7).Visible = (Qtot + 10 < q0)
shap(10).Visible = (Qtot + 10 < q0)
If Q2 < 0 Then ' negative radiation loss
  rad.ForeColor = &HFF&
  rad.BackColor = &HFFFF80
Else rad.ForeColor = &HFF0000
  rad.BackColor = &H80FFFF
End If
For j% = 0 To 7
  t(j%) = th(j%) - 273.15 ' define Celsius temperatures
Next
t(8) = Tac
td = .5 * (th(7) + Ta)

kJv = .975'
Transmittance = kJv * Nu * (td / 273) ^ .85 / (d * 12416000) to atmosphere
Qv = Qtot - qo' vapour flow at skin

s% = 0; kp = .0013' iteration step

HL = 2500.9 - 2.37 * (th(7) - 273) 'j/g @ surface temp

Jv0 = Qv / HL' g/m²:s' vapour flow equivalent to wet heat loss

ssat = 0 'no condensation

If Qv < 3 Then press(8) = Cma * Ta: Nosweat: GoTo 577 'no evaporation

n% = 0:

Jloop' vapour flow

577

If Q1 > 5 And Qv > 3 Then

For j% = 0 To 7 'step through layers

psv = Exp(18.927 - 5300 / th(j%))' saturated vapour pressure

Cmm = 2142 * psv / th(j%)' maximum vapour concentration

r(j%) = press(j%) / (2142 * psv)'fractional humidity

If r(0) > 1 Then 723' wet skin

If r(j%) > 1 Or (r(j%) < .999 And qWet(j%) > 0) Then

ssat = ssat + 1

Qj = qo: For i% = 0 To j%: Qj = Qj + qWet(i%) - qLoss(i% + 1):

Next

dq0 = HL * Jv0 * (press(j%) - 2142 * psv) * qo / ((press(j%) - press(8)) * Qj * (th(0) - th(j%)) / (th(j%) - Tn) + (th(0) - th(j%)) * HL * Jv0 * Cmm)

'increment to dry heat at skin

dq1 = dq0 * (1 + Qj / qo * (th(0) - th(j%)) / (th(j%) - Tn))'condensation change

dpo = dq0 * (Cmm * (th(0) - th(j%)) / qo + (po - Cm(j%) * th(j%)) / (HL * Jv0)) + th(j%) * (Cmm - Cm(j%))' vapour pressure change

qWet(j%) = qWet(j%) + dq1' adjust condensation rate

If qWet(j%) < 0 Then qWet(j%) = 0 'avoid negative condensation

q0 = qo - dq0 'adjust dry heat

Jv0 = Jv0 + dq0 / HL 'adjust vapour flow

po = po + dpo: If po < 10 Then po = 10 'adjust vapour pressure

723

j% = 8

End If

Next

End If

If mm% > 250 Then l48 Visible = -1: ssat = 0: Greyout' escape condensation loop

Wend

extnt(1) = Thick(1)'mm' x-values for graph display

extnt(2) = extnt(1) + 1000 * Gap(2)

extnt(3) = extnt(2) + Thick(2)

extnt(4) = extnt(3) + 1000 * Gap(4)

extnt(5) = extnt(4) + Thick(3)

extnt(6) = extnt(5) + 1000 * Gap(6)
extnt(7) = extnt(6) + Thick(4)
extnt(8) = extnt(7) + 7

\[ r(8) = \frac{Val(tx(4).Text)}{100} \]
Wetsum = 0
If Qv >= 3 Then
For j% = 0 To 7
If qWet(j%) > 0 Then Wetsum = Wetsum + 1
Next
End If
End Sub

Sub Tgraph () ' Draw temperature graph

picture1.DrawWidth = 2
picture1.PSet (scl * extnt(7) + 8, 2 * Tn - 576.3), &HFF
picture1.PSet (-9, 44) ' 2 * t(blood) - 30
For j% = 0 To 8
picture1.Line -(scl * extnt(j%), (2 * t(j%) - 30)), &HFF
Next
End Sub

Sub Timer1_Timer () ' Control text box pulsation & keep form centred

bc = -bc
If bc < 0 Then bbc = -bbc
If flashflag < 0 Then
If bc > 0 Then tx(inx).BackColor = &HFFFF80
If bc < 0 Then tx(inx).BackColor = &HC0C0&
Else tx(inx).BackColor = bb'&H40FFFF
End If
Left = (screen.Width - Width) / 2
Top = (screen.Height - Height) / 2
If i48.Visible = -1 Then
i48.Visible = 0
For j = 0 To 10000: Next
i48.Visible = -1
End If

End Sub
Sub Timer2_Timer () ' Cold warning flash: control rate of fall in 2nd drip

If shap(7).Visible < 0 Then
    For jx% = 0 To 2
        cb(jx%) = (cb(jx%) + 1) Mod 5
    Next
    If cb(0) = 2 Then shap(10).FillColor = &HFF0000
    If cb(0) = 0 Then shap(10).FillColor = &HFFFFFF
    If cb(1) = 2 Then shap(7).FillColor = &HFF0000
    If cb(1) = 0 Then shap(7).FillColor = &HFFFFFF
    If cb(2) = 2 Then shap(7).BorderColor = &HFF0000
    If cb(2) = 0 Then shap(7).BorderColor = &HFFFFFF
End If

If dripflag(1) < 0 Then
    image1(1).Top = image1(1).Top - jump
    If image1(1).Top < -25 Then
        image1(1).Visible = 0
        If image1(1).Top > -25 - jump Then
            image3(1).Top = image3(1).Top + finger + 2
            DoEvents
            image3(1).Top = image3(1).Top - 2
        If image3(1).Top > TopLim(1) Then image3(1).Top = TopLim(1)
    End If
End If
End If
End Sub

Sub Timer3_Timer () ' Control rate of fall in 1st drip display

If dripflag(0) < 0 Then
    image1(0).Top = image1(0).Top - jump
    If image1(0).Top < -25 Then
        image1(0).Visible = 0
        If image1(0).Top > -25 - jump Then
            image3(0).Top = image3(0).Top + finger + 2
            DoEvents
            image3(0).Top = image3(0).Top - 2
        If image3(0).Top > TopLim(0) Then image3(0).Top = TopLim(0)
    End If
End If
End If
End Sub
image1(0).Visible = -1
End If
End If

Sub Tleg ()  'Display legend on temperature graph

lbpT(0).Visible = -1
lbpT(1).Visible = -1
lbpT(2).Visible = -1
lbpT(3).Visible = -1
lbpT(4).Visible = -1
picture1.DrawWidth = 1
picture1.DrawStyle = 2
For j% = -30 To 30 Step 20
  picture1.Line (0, j%)-(180, j%), 0
Next
For j% = 30 To 44 Step 2
  picture1.Line (0, j%)-(10, j%), 0
Next
picture1.Line (0, 40)-(25, 40), 0

End Sub

Sub T1l_DblClick (Index As Integer)  'Pulsate active text box

flashflag = -flashflag

End Sub

Sub Tx_Change (ix As Integer)  'Accept input minus sign: alter text box colours

neg% = 1
If InStr(tx(ix).Text, "-") > 0 Then neg% = -1
tx(ix).ForeColor = &H7F * (1 - neg%)
bb = &H80FFFF
If neg% < 0 Then bb = &HFFFF80
tx(ix).BackColor = bb
command4.Visible = -1
greyflag = 1
Dry.BackColor = &HC0C0C0
vap.BackColor = &HC0C0C0
If Qtot < q0 Then vap.ForeColor = &HFF00FF
  rad.BackColor = &HC0C0C0
If Q2 < 0 Then rad.ForeColor = &HFF00FF
  command2.Enabled = 0

SUBSTITUTE SHEET (RULE 26)
command3.Enabled = 0
If OptN.Value = -1 Then Greyout

End Sub

Sub Tx_Click (ix As Integer) ' Define data group containing text entry
   ik = -1
   Select Case ix
      Case 0 To 4
         ik = 0
      Case 5 To 7
         ik = 1
      Case 19 To 24
         ik = 2
   End Select
   If ik > -1 Then
      command5(ik).Caption = ""
      combo1(ik).Text = ""
   End If

End Sub

Sub Tx_GotFocus (ix As Integer) ' Alter background colour: store text box contents
   Select Case ix
      Case 0 To 4
         Ttl(0).BackColor = &HFF00&
      Case 5 To 7
         Ttl(1).BackColor = &HFF00&
      Case 8 To 18
         Ttl(2).BackColor = &HFF00&
      Case 19 To 24
         Ttl(3).BackColor = &HFF00&
   End Select
   tx(ix).BackColor = &H40FFFF' A0FFFF'FF00&
a$ = tx(ix).Text
cr$% = 0: mant$ = "": crstc$ = ""
   inx = ix

End Sub
Sub Tx_KeyDown (ix As Integer, KC As Integer, As Integer) ' Trap "Delete" key

If KC = &H2E Then mant$ = ": crstc$ = "": tx(ix).Text = a$: ct% = 0

End Sub

Sub Tx_KeyPress (ix As Integer, ka As Integer) ' Validate & store input characters

If ka = 13 Then SendKeys "{TAB}\"
If ka < 45 Or ka > 57 Then ka = 0: Exit Sub
ct% = ct% + 1
If ct% = 1 Then tx(ix).Text = ""

Select Case ka

Case 48 ' zero
  If ct% = 1 Then ct% = 0: a$ = "0"
b$ = Left$(Trim$(mant$), 2)
If (Left$(b$, 1) <> "0" And b$ <> "-0") Or crstc$ > "" Then mant$ = mant$ + "0"

  If InStr(mant$, ".") > 0 Then crstc$ = crstc$ + "0"

Case 49 To 57 ' 1 to 9
  mant$ = mant$ + Chr$(ka)
crstc$ = ""

Case 45 ' minus
  neg% = -neg%
  ng$ = ": If neg% < 0 Then ng$ = "-"
  mant$ = ng$ + Mid$(mant$, 2)

Case 46 ' decimal
  If ct% = 1 Then mant$ = ""
  If InStr(mant$, ".") = 0 Then mant$ = mant$ + ".": crstc$ = ":"

End Select

ka = 0

If Val(mant$) <> 0 Or mant$ = "0" Then mant$ = Str$(Val(mant$)) + crstc$

tx(ix).Text = mant$

End Sub

Sub Tx_LostFocus (ix As Integer) ' Check that input data is within limits

Ttl(0).BackColor = &H37B38D
Ttl(1).BackColor = &H37B38D
If OptN.Value = -1 Or sizeflag = 1 Then Ttl(2).BackColor = &H37B38D
Ttl(3).BackColor = &H37B38D

    num1 = Val(tx(ix).Text)
If num1 > Ulim(ix) Then num1 = Ulim(ix)
If num1 < Llim(ix) Then num1 = Llim(ix): tx(ix).Text = " " + Str$(num1)
If num1 = 0 And InStr(tx(ix).Text, "0") = 0 Then
    tx(ix).Text = a$ 
Else tx(ix).Text = " " + Str$(num1)
End If

neg% = Sgn(Val(tx(ix).Text))
If neg% = 0 Then neg% = 1
tx(ix).BackColor = &H80FF80
tx(ix).ForeColor = &HFF &HFEFF01 * (neg% > 0)

Select Case ix
Case 0 'Ambient
    command5(0).Caption = ""
    combo1(0).Text = ""
Case 1 'Sky
    command5(0).Caption = ""
    combo1(0).Text = ""
Case 2 'Rain
    If Val(tx(2).Text) <= 0 Then Check1.Value = 0: tx(2).Text = " 0"
Case 3 'Wind
    If Abs(Val(tx(3).Text)) < .5 Then tx(3).Text = " " + Str$(neg% / 2)
    command5(0).Caption = ""
    combo1(0).Text = ""
Case 4 'rh%
    If Val(tx(4).Text) < 0 Then tx(4).Text = " 0"
    If Val(tx(4).Text) > 99 Then tx(4).Text = " 100"
    command5(0).Caption = ""
    combo1(0).Text = ""
Case 5 'Heat generated
    tx(6).Text = Str$(.01 * Int(Val(tx(5).Text) / 1.05 + .5))
    tx(6).BackColor = &HC0C0C0
    command5(1).Caption = ""
    combo1(1).Text = ""
Case 6 'Met
    tx(5).Text = Str$(Int(Val(tx(6).Text) * 105 + .5))
    tx(5).BackColor = &HC0C0C0
    command5(1).Caption = ""
    combo1(1).Text = ""
Case 7 'Movement
    If Val(tx(7).Text) < 0 Then tx(7).Text = " 0"
    command5(1).Caption = ""
    combo1(1).Text = ""

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Case 8  'Togs, coat
        If Val(tx(8).Text) <= .01 Then tx(8).Text = " .01"
Case 9 To 11  'Togs, other
        If Val(tx(ix).Text) <= 0 Then
            tx(ix).Text = " .0001"
            tx(ix).BackColor = 0
            tx(ix + 4).Text = " .0001"
            tx(ix + 4).BackColor = 0
            Thick(12 - ix) = .01
        If ix < 11 Then
            tx(ix + 11).Text = " .0001"
            tx(ix + 11).BackColor = 0
            tx(ix + 14).Text = " 
            tx(ix + 14).BackColor = 0
        End If
        End If
    If Val(tx(ix).Text) > .001 And Thick(12 - ix) < .011 Then Thick(12 - ix) = Val(tx(ix).Text) * 4.5
Case 12  'Turl, coat
        If Val(tx(12).Text) < 1 Then tx(12).Text = " 1"
Case 13 To 15  'Turl, other
        If Val(tx(ix).Text) <= 0 Then
            tx(ix).Text = " .0001"
            tx(ix).BackColor = 0
            tx(ix - 4).Text = " .0001"
            tx(ix - 4).BackColor = 0
            Thick(16 - ix) = .01
        If ix < 15 Then
            tx(ix + 7).Text = " .0001"
            tx(ix + 7).BackColor = 0
            tx(ix + 10).Text = " 
            tx(ix + 10).BackColor = 0
        End If
        End If
    Case 19 To 21  'Gaps
        If Val(tx(ix).Text) <= .0001 Then tx(ix).Text = " .0001"
    Case 22 To 24  'Vent
End Select

Sub Vap_dblclick ()  ' Black out picture
    picture1.BackColor = &H314142
    label54.Visible = 0
    Skin.Visible = 0
    For i% = 0 To 1
        image1(i%).Visible = 0
        image2(i%).Visible = 0
End Sub
image3(i,j).Visible = 0
dripflag(i,j) = 0
Next
picture1.Cls

End Sub
List of Subroutines (Alphabetical)

Alignlabels  (Initial heights for numerical display & drip-tube)
Check1_Click  {Dry / Rainy option: no effect at present}
Combo1_Change (Sets flag on Weather etc lists)
Combo1_Click  (Select list box entry)
Combo1_KeyDown (Delete current data line from list in memory)
Combo1_LostFocus (Label command button)
Command1_Click (Exit)
Command2_Click (Print)
Command3_Click [Save]
Command4_Click (Run)
Command5_Click (Open Weather etc list boxes for entry)
Command6_Click [Get fabric details from database]
Declarations
Drawl  (Draw line graph of r.h. etc)
Drip  (Show drip-tube & falling drops)
Form_click [Alter data files on Weather etc]
Form_Load (Startup data)
Greyout (Makes number fields grey if input data changed)
Grow  (Expands display to fill screen)
Hgraph (Draw humidity graph)
Hleg (Legend for humidity graph)
jGraph (Vapour flow graph)
Jloop (Vapour flow calculations)
NewEntry (Enter screen data on Weather etc into files)
Nosweat (Default r.h. & p conditions if vapour flow ~ 0)
OptN_click (Display numerical data: \(\theta, r.h., p\))
OptN_LostFocus [Dodo] = Refresh / show picture
OptP_click (Display p data as graph)
OptR_click (Display r.h. data as graph)
OptS_click (Display all data on one graph)
OptT_click (Display \(\theta\) data as graph)
Pgraph (Vapour pressure graph)
Picture1_click (Toggle picture height)
Picture1_Resize (Adjust components to picture height)
Pleg (Legend for vapour pressure graph)
qGraph (Heat flow graph)
Qloop (Dry heat flow calculations)
Rad_DblClick (Toggle graph contrast)
Section (Sketch skin / fabric positions on graph)
Sunwit (Main flow / condensation loop)
Tgraph (Temperature graph)
Timer1_Timer (Pulsates text field: flashes error label)
Timer2_Timer (Cold warning flash: second falling drop / splash)
Timer3_Timer (First falling drop / splash)
Tleg (Legend for temperature graph)
<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ttl_DblClick</td>
<td>(Toggle pulsation of active text field)</td>
</tr>
<tr>
<td>Tx_Change</td>
<td>(Check sign of new entry: set field colours)</td>
</tr>
<tr>
<td>Tx_Click</td>
<td>(Define Group Index for text entry)</td>
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<tr>
<td>Tx_GotFocus</td>
<td>(Change group title colour: store old text value)</td>
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<tr>
<td>Tx_KeyDown</td>
<td>(Delete text)</td>
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<td>Tx_KeyPress</td>
<td>(Vet new text)</td>
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<tr>
<td>Tx_LostFocus</td>
<td>(Check within limits: reset commands: 'remove' layers)</td>
</tr>
<tr>
<td>Vap_dblclick</td>
<td>(Blackout picture)</td>
</tr>
</tbody>
</table>
List of Subroutines by function

Declarations

*Startup:* -
- **Form_Load** (Initial data)
- **Alignlabels** (Initial heights for numerical display & drip-tube)
- **Grow** (Expands display to fill screen)

*Text Entry:* -
- **ComboBox_Change** (Sets flag on Weather etc lists)
- **ComboBox_Click** (Select list box entry)
- **ComboBox_KeyDown** (Delete current data line from list in memory)
- **ComboBox_LostFocus** (Label command button)
- **Tx_Change** (Check sign of new entry: set field colours)
- **Tx_Click** (Define Group Index for text entry)
- **Tx_GotFocus** (Change group title colour: store old text value)
- **Tx_KeyDown** (Delete text)
- **Tx_KeyPress** (Vet new text)
- **Tx_LostFocus** (Check within limits: reset commands: 'remove' layers)
- **Greyout** (Makes number fields grey if input data changed)

*Text Entry Filing:* -
- **Form_click** [Alter data files on Weather etc] [proposed]
- **NewEntry** (Enter screen data on Weather etc into files)

*Commands:* -
- **Check1_Click** {Dry / Rainy option: no effect at present}
- **Command1_Click** (Exit)
- **Command2_Click** (Print)
- **Command3_Click** [Save]
- **Command4_Click** (Run)
- **Command5_Click** (Open Weather etc list boxes for entry)
- **Command6_Click** [Get fabric details from database]

*Display Options:* -
- **OptN_click** (Display numerical data: $\theta$, r.h., p)
- **OptP_click** (Display p data as graph)
- **OptR_click** (Display r.h. data as graph)
- **OptS_click** (Display all data on one graph)
- **OptT_click** (Display $\theta$ data as graph)

*Screen Options:* -
- **Picture1_click** (Toggle picture height)
- **Picture1_Resize** (Adjust components to picture height)
- **Rad_DblClick** (Toggle graph contrast)
- **Ttl_DblClick** (Toggle pulsation of active text field)
- **Vap_dblclick** (Blackout picture)

SUBSTITUTE SHEET (RULE 26)
Calculations: -
Sunwit (Main flow / condensation loop)
Nosweat (Default r.h. & p conditions if vapour flow ~ 0)
Jloop (Vapour flow calculations)
Qloop (Dry heat flow calculations)

Graphical Displays: -
Drawl (Draw line graph of r.h. etc)
Drip (Show drip-tube & falling drops)
Section (Sketch skin / fabric positions on graph)
Hgraph (Draw humidity graph)
Hleg (Legend for humidity graph)
jGraph (Vapour flow graph)
Pgraph (Vapour pressure graph)
Pleg (Legend for vapour pressure graph)
qGraph (Heat flow graph)
Tgraph (Temperature graph)
Tleg (Legend for temperature graph)

Timer Controls: -
Timer1_Timer (Pulsates text field: flashes error label)
Timer2_Timer (Cold warning flash: second falling drop / splash)
Timer3_Timer (First falling drop / splash)
List of Variables: declared variables in Bold Type.

aa  Slope argument in graph line segment
a$  File name / Text box entry / Table heading
actfilnam$() name of "Typical Data" file
Ag  Air Gap (under coat) - text entry.

b$  Transfer string (file name or data entry)
b  Colour (Flash)
bbc Do
bc Do
blank% Space in file name

C()  Colour index for blue flash
cc  Colour (Flash)
Cm  Vapour concentration
Cm() Vapour concentration at surface
Cma Do, atmosphere
Cmm Saturated vapour concentration
Cmo Vapour concentration at skin
cosk Slope indicator, line graph
cp  Specific heat of air
crsteS Data field, decimal point to end
c%  No of characters in data field
d  Body diameter
(d) (redundant?)
delp pressure interval, coat to ambient
delTh Temperature difference between interfaces
dotflag Dotted v continuous graph (flag)
dP  Pressure increment between interfaces
dpo Increment in pressure at skin
dq0 Initial guess, heat flow
dq1 Heat loss to ambient
driplflag() Flags condensation (two points max)
driplim() Scale for display of condensation
dth Temperature interval (1/4 gap)

e  Emissivity
ex, eex Line graph cross - section
ey, eey "
extnt() Distance from skin to interface

fall() Time index for drip
ff  Feedback factor, (Q)
finger Drip display; level rise per drop
flashflag [Pulsating text box]
<table>
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<tr>
<th>Term</th>
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<td>Gap()</td>
<td>Air gap (m) (&amp; equivalent for fabric)</td>
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<td>greyflag</td>
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<tr>
<td>h</td>
<td>Humidity</td>
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<tr>
<td>HL</td>
<td>Latent heat of evaporation</td>
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<tr>
<td>hRatio</td>
<td>Height ratio, screen / form</td>
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<tr>
<td>i%</td>
<td>Running index</td>
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<tr>
<td>ik</td>
<td>Index for text boxes</td>
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<tr>
<td>inx</td>
<td>&quot; &quot; &quot;</td>
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<td>ix</td>
<td>&quot; &quot; &quot;</td>
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<td>image1()</td>
<td>Drip</td>
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<tr>
<td>image2()</td>
<td>Test tube</td>
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<tr>
<td>image3()</td>
<td>Height of condensate</td>
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<tr>
<td>initflag</td>
<td>[First time round (Align labels)]</td>
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<tr>
<td>j%</td>
<td>Running index</td>
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<td>Vapour loss from internal convection</td>
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<td>Timing count</td>
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<tr>
<td>jx%</td>
<td>&quot; &quot; &quot;</td>
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<tr>
<td>jump</td>
<td>Drip display limit</td>
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<tr>
<td>Jv0</td>
<td>Initial vapour flow</td>
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<tr>
<td>Jv1</td>
<td>Vapour loss from coat</td>
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<tr>
<td>Jv()</td>
<td>Vapour flow at interface</td>
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<tr>
<td>ka</td>
<td>Keypress entry</td>
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<tr>
<td>KC</td>
<td>&quot;Delete&quot; key trap</td>
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<tr>
<td>kcol</td>
<td>Colour, graph display</td>
</tr>
<tr>
<td>kd</td>
<td>Compound parameter, vapour flow</td>
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<tr>
<td>kJv</td>
<td>Schmidt / Prandtl fudge</td>
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<tr>
<td>kp</td>
<td>Iteration step</td>
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<tr>
<td>kPa</td>
<td>Tabulated vapour pressure</td>
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<tr>
<td>kqz</td>
<td>Compound parameter, heat flow</td>
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<td>L</td>
<td>Heat conductance</td>
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<td>n%</td>
<td>Loop count (Qloop + jLoop)</td>
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<tr>
<td>neg%</td>
<td>[Flag for minus sign]</td>
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<tr>
<td>news</td>
<td>[Flag for new file entry]</td>
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</table>

**SUBSTITUTE SHEET (RULE 26)**
ng$  Minus sign character
nj  Loop count (jLoop)
nm$, nmm$  Name of file
nmslim$, nmslim$  " "
nq  Loop count - tracer only
ns  " " " "
nt  " " " "
Nu  Nusselt no
num1  Text box value

p  Wind pressure
po  Vapour pressure at skin
press()  Vapour pressure at interface
pressm  Mid-gap vapour pressure
psv  Saturated vapour pressure

q()  Dry heat flow at interface
Qo  Dry heat flow at skin
Q1  Dry heat loss to atmosphere
Q2  Radiative heat loss to ambient
Qj  Updated value of Q (redundant)
qLoss()  Convective heat loss between layers
qr1  Radiative heat transfer between layers
qtemp  Q value (to 6 significant figures)
Qtot  Total metabolic heat production
Qv  Heat flow transported as vapour
qWet()  Heat of condensation at interface

r()  Relative humidity at interface
Rain  Rainfall in mm/hr (not used)
rf  Initial Tog value of fleece
rh  Density of air

s%  Sign of z (redundant)
scl  Horizontal scale of graph display
Sf  Dummy argument ("Keypress")
sigma  Stefan's constant (x 303^2)
sink  Slope indicator
sizeflag  ["Tall" v "Short" graph display flag]
slope  Tangent of angle of line segment
slope1  Humidity slope
slope2  Vapour pressure slope
SpHt  Heat capacity of convected air
ssat  [Supersaturation flag]

t()  Temperature °C
Ta  Ambient temperature °K
Tac  Ambient temperature °C
Tc   Working temperature °C
td   Mean boundary layer temperature
th() Temperature °K
Thick() Fabric thickness
Thick3 Initial thickness of fleece
thm  Mid-gap temperature
thm1 Intermediate temperature in gap
thm2  Ditto
Tn   "Neutral temperature" of coat
Tog() Thermal resistance of fabric
Toplim() Upper limit of dripped water level
Tr   Radiant temperature °K
Trc  Radiant temperature °C
Transmittance Vapour flow compliance at outer surface
tt  2 / mid-gap temperature °K

Ulim() Upper limit for text data

v Wind speed
Vnt() Rate of air exchange with atmosphere

w Line width representing fabric thickness
Wetsum No. of condensation sites
whiteflag High contrast display
wRatio Width ratio, screen / form

x() Value of input data parameter
x1  Line segment start
x2  Line segment end
xDrip x position of displayed drip
xs  Point of change from continuous to dot display
xsj Temperature excess of gap over ambient
xx  x - position of fabric on graph

y1   (As x)
y2
ys

z  Mismatch tolerance, heat
zS  Separator character in filed headings
zcrit Mismatch tolerance, vapour
List of Controls

Form 1
List boxes (4)  (potential, for fabric input)
Text boxes: Tbl(0)-(24)  (for input data)
Command Buttons 1-5(0-2)&6  (Exit, Save, Print, Run, Open combo boxes, Recall)
Check box  (Wet / Dry option)
Combo boxes 0-2  (Lists of 'Weather', 'Work', 'Fit' data)
Frame  (base for Option buttons)
Images(0-3)*2:  (Drip display components, gray or white background)
Option buttons  (OptN, P, R, S, T )
Shapes {Shap(0-9) + 'skin'}  (Panels for Group Data, Image mounts etc)
Picture box  (Main graphical display)
Timers 1-3  (Control flash rates & speed of drop fall)

LABELS:  
{Weather} = Tbl(0); wLbl(0)-(9)  (Text labels in top left panel)
{Work} = Tbl(1); aLbl(0)-(4)  (Text labels in top left panel)
{Fabric} = Tbl(2); fLbl(0)-(4), IHed(0)-(3)  (Text labels in centre left panel)
{Fit} = Tbl(3); fLbl(0)-(2)  (Text labels in centre right panel)
{Options} = OPTBl(0)-(3)  (T, r.h., p, N markers)
{Table} = Leg(0)-(5), Hed(0)-(3)  (Text labels for tabular output)
(Results) = lblH(0)-(8), tblH(0)-(8), lbp(0)-(8)  (Numerical data output)
{Fluxes} = OpLbl(0)-(5)  (Legend for Results)
(Results) = Dry, Vap, Rad  (Dry Heat Flow, Vapour Flow, Radiation Input)
{Picture}  lbpH(0)-(3), lbpT(0)-(4), lbpP(0)-(6), llabel1, llabel54  (Graph Legend)
{Dots}  dots(0)-(5), Brace(0)-(2)  (dotted lines & braces on Table legend)

"  (6)-(12),  (dotted lines in Fabric panel)
"  (13)-(15),  (dotted lines in Fit panel)
CLAIMS

1. A method for steady state modelling of temperature and humidity levels in a clothing ensemble worn by a wearer comprising the steps of:-
   defining a steady state heat output of the wearer;
   defining the heat transfer resistances and water vapour transfer resistances of the layers of clothing in said clothing ensemble;
   defining air gap functions between the clothing layers and between the wearer and a first layer of clothing;
   calculating the dry heat flow and water vapour flow through the layers of clothing and the air gaps in accordance with the transfer resistances and air gap functions, and thereby calculating the total clothing ensemble heat output;
   comparing the total clothing ensemble heat output with the steady state heat output of the wearer; and
   using the comparison to prescribe a clothing ensemble such that the heat outputs correspond in a desired manner.

2. A method according to claim 1 in which iteration of the steady state heat output is performed until the steady state heat output substantially matches the total clothing ensemble heat output.

3. A method according to claim 1 in which iteration of the clothing ensemble is performed until the steady state heat output substantially matches the total clothing ensemble heat output.

4. A method according to claim 2 in which the iteration comprises adjustment of skin temperature and/or sweating rates.
5. A method according to any of claims 1 to 4 in which the calculation of total clothing ensemble heat flow comprises calculation of convective and radiative heat losses to the atmosphere.

6. A method according to any previous claim in which at least four layers of clothing can be modelled.

7. A method according to claim 6 in which the layers comprise vest, shirt, fleece and coat layers.

8. A method according to claim 7 in which the heat and water vapour resistance of the fleece layer varies as a function of wind pressure.

9. A method according to any previous claim in which the outermost layer of clothing is airtight but water vapour permeable.

10. A method according to any previous claim in which the layers of clothing are radiation impervious.

11. A method according to any previous claim in which the ambient atmospheric conditions are inputted into the model.

12. A method according to any previous claim in which the calculation of water vapour flow includes the effects of condensation.

13. A method according to any previous claim in which the effects of internal air convection are included in the calculations of dry heat flow and water vapour flow.
14. A method according to any previous claim in which data from temperature and/or humidity sensors are included in the model.

15. A computer adapted to perform a method according to any of claims 1 to 14.

16. An experimental apparatus adapted for testing a model of temperature and humidity levels in a clothing ensemble worn by a wearer comprising:
   - sensor means having an electrical output;
   - a sensor body containing sensor output transduction means yielding data and data storage means therefor; and
   - cable connecting said sensor means and said sensor body, permitting said sensor means to be deployed at desired locations within the ensemble and the sensor body to be carried on or by the wearer.

17. An apparatus according to claim 16 in which the measurements are made on the body of the wearer or between layers of clothing.

18. An apparatus according to claim 16 to claim 17 in which the stored data comprise measurements made at predefined intervals over a predefined period of time.

19. An apparatus according to any of claims 16 to 18 in which the sensor means comprises a temperature sensor.

20. An apparatus according to any of claims 16 to 19 in which the sensor means comprises a humidity sensor.

21. An apparatus according to claim 19 in which the temperature sensor is a thermistor or a platinum sensor.
22. An apparatus according to any of claims 16 to 21 in which the sensor body comprises digital data storage means.

23. An apparatus according to claim 22 in which data is transferable, via interfacing means, to a computer.

24. An apparatus according to claim 23 in which the computer is used to input sensor arrangement operation characteristics.

25. An apparatus according to claim 24 in which an apparatus operation characteristic is the length of time between successive measurements.

26. An arrangement according to any of claims 22 to 25 in which the sensor body comprises a modified Tinytalk™ datalogger.

27. An apparatus according to any of claims 16 to 26 in which temperature and humidity measurements are taken.

28. A method for making measurements within a clothing ensemble worn by a wearer comprising the steps of:

   providing an apparatus according to any of claims 16 to 27;
   deploying the sensor means at a desired location within the ensemble;
   disposing the sensor body on the wearer or within the ensemble; and
   using the apparatus to make said measurements.

29. A method according to claim 28 in which measurements are made on the body of the wearer, or between layers of clothing.
30. A method according to claim 28 or claim 29 in which temperature and/or humidity measurements are made.
FIG. 1

SUBSTITUTE SHEET (RULE 26)
FIG. 2
### INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC 6 G01N33/36  G01N25/20  G01N25/56

According to international Patent Classification (IPC) or to both national classification and IPC

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**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practical, search terms used):

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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"X" Further documents are listed in the continuation of box C.  
"X" Patent family members are listed in annex.

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Date of the actual completion of the international search: 14 November 1997  
Date of mailing of the international search report: 25/11/1997

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NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx 31 651 apo ni,  
Fax: (+31-70) 340-3016

Authorized officer: Bosma, R

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Form PCT/ISA/217 (second sheet) (July 1992)
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