Oct. 5, 1937. L. F. HESS 2,095,215

PSYCHROMETRIC CALCULATOR

Filed April 22, 1935 2 Sheets-Sheet 1

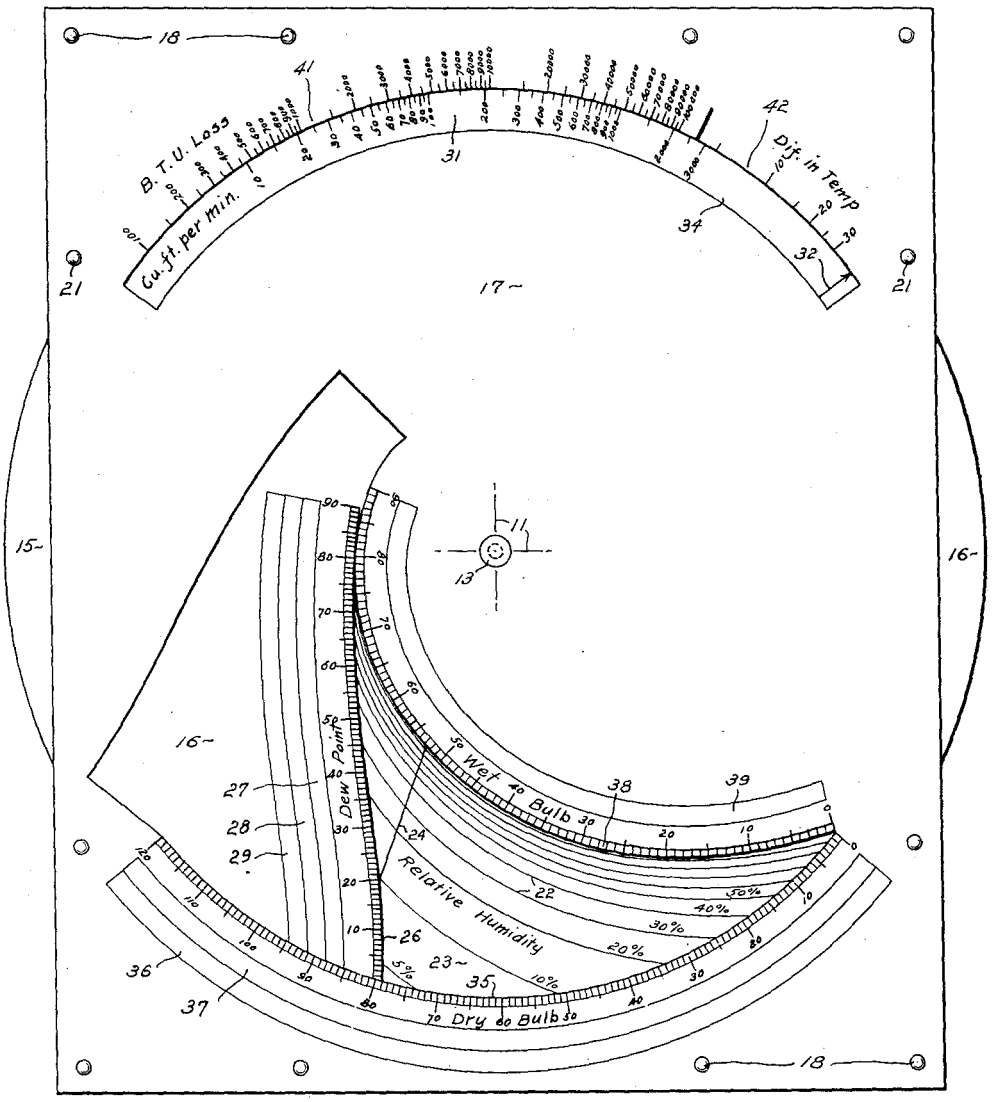

Fig. 1.

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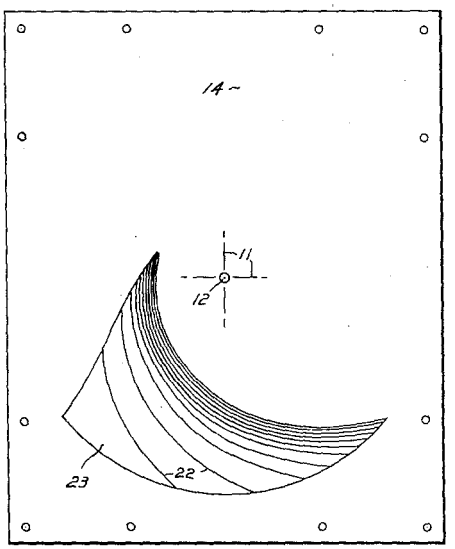

Fig. 2.

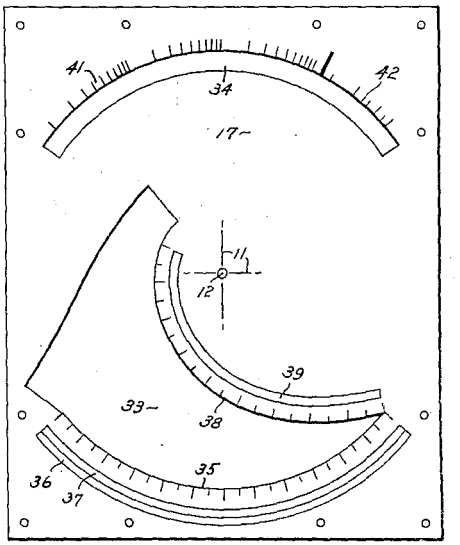

Fig. 5.

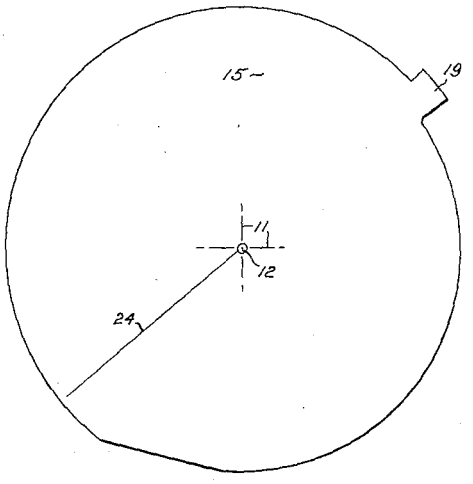

Fig. 3.

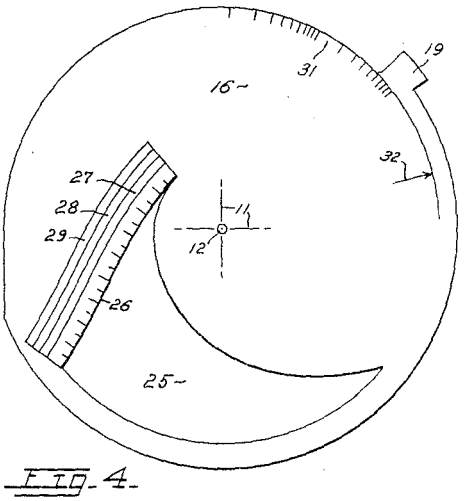

Fig. 4.

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PSYCHROMETRIC CALCULATOR

Louis F. Hess, Los Angeles, Calif.

Application April 22, 1935, Serial No. 17,689

4 Claims. (Cl. 235—83)

My invention relates to psychrometry, and particularly to means for solving psychrometric problems that are encountered in such arts as air-conditioning, and in the design and operation of cooling towers. Among its more important objects are; first, to provide improved means for the solution of problems of the general nature stated; second, to afford mechanical facilities for quickly determining the effect of altering the value of any of the variables that enter into psychrometric problems; third, to produce a psychrometric calculator that is well adapted for the stated purposes, as well as for quickly indicating the limit values of the variables that are involved; and, fourth, to accomplish the enumerated purposes by means of a relatively simple, inexpensive, and thoroughly practical calculating instrument.

My objects have been attained in the manner illustrated in the accompanying drawings, in which—

Figure 1 is a face view of an approved form of my psychrometric calculator, complete;

Figures 2 to 5 inclusive are face views of the respective elements of the device by themselves, these four figures being drawn to a much reduced scale; thus—

Figure 2 represents the rectangular base plate of the calculator;

Figure 3 is a rotatable index disk that is made of transparent material such as celluloid;

Figure 4 is an opaque rotatable disk with scales thereon, a portion of the surface being cut out to expose the underlying elements; and

Figure 5 is the rectangular face plate of the instrument with scales thereon, there being two cut out portions adapted to expose underlying elements.

Similar reference numerals refer to similar parts, throughout the several views.

All four elements of the device are assembled superposed, and they have a common axis at the intersection of dot and dash lines 11. Each element has a central hole 12, and a flanged-head pivot pin 13 extends through all of these holes. On top of base plate 14 is placed the transparent index disk 15. Next above is the opaque disk 16, and face place 17 is placed on top of the other three elements. The base plate and the face plate are fastened together near their margins, as by a number of rivets 18, in such a manner that disks 15 and 16 are free to be rotated between them, about the pivot pin 13.

Disks 15 and 16, although substantially circular in form, are made with approximately half of their circular peripheries of smaller radius than the other half. The larger radius peripheries extend beyond the limits of rectangular plates 14 and 17 at opposite sides thereof, as shown in Fig. 1. The smaller radius peripheries do not extend beyond these limits. Each disk is provided with a radial tab 19, to limit its angular movement, and rivets 21 extend through plates 14 and 17 in such positions as to serve as stops for these tabs.

Base plate 14 has a series of relative humidity curves 22 drawn thereon, within an exposable area 23, of which the lower margin is a circular arc centered at the axis of the instrument. The manner in which curves 22 are produced will be explained later.

Transparent index disk 15 has a radial line 24 thereon, in such position that it can be moved across the entire area 23 of the assembled instrument, when the disk is rotated.

Opaque disk 16 has a cut-out portion 25, exactly corresponding in shape and size to area 23, and adapted to exactly register therewith when the disk has been moved clockwise to its limiting position. This disk carries; a curvilinear dew-point scale 26, at the left-hand margin of its cut-out portion; areas 27, 28 and 29 at the left of the dew-point scale, for supplementary scales or data that relate to the dew-point; a circular logarithmic scale 31 at its upper periphery; and an index pointer 32 near the right hand margin; all as shown in Fig. 4. These scales, data areas, and pointer, will be described below.

Face plate 17 has a cut-out portion 33, exactly corresponding to, and adapted to exactly register with areas 23, 25, and 27 to 29 combined. It also has an arcuate cut-out portion 34 at the top, the larger radius of which is the same as, or slightly less than, the radius of logarithmic scale 31 of opaque disk 16. Thus logarithmic scale 31 and index pointer 32 will be exposed by the arcuate cut-out. The face plate carries; a circular dry-bulb scale 35 at the lower margin of cut-out area 33; arcuate areas 36 and 37 below the dry-bulb scale, for supplementary scales or data that relate to dry-bulb temperature; a curvilinear wet-bulb scale 38 at the upper margin of cut-out area 33; a curvilinear area 39 above the wet-bulb scale, for a supplementary scale or data that relates to wet-bulb temperature; and two logarithmic scales 41 and 42 at the upper margin of cut-out portion 34; all as shown in Fig. 5. These scales and data areas will be explained in detail below.

When the elements of the device have been as-

sembled in the manner described, the instrument will appear as shown in Fig. 1; and the following discussion will be limited to that figure almost exclusively. The curves, scales, data, and indexes, are based upon known, or generally accepted, psychrometric equations and data, such as those of Carrier; and the device is adapted, by properly positioning its movable parts, to serve the purposes of the invention that have been set forth supra. The instrument illustrated, is based upon ordinary sea-level data; and its range includes ordinary atmospheric temperatures from 0° to 120° Fahr.

Scale 35 is circular, with its center at the axis of the instrument, and it is proportionally divided. It indicates degrees of temperature as shown by the dry-bulb thermometer.

Scale 36 may assume a variety of forms; but it should be a smooth curve, and preferably a simple mathematical one that can be produced readily. The spiral form shown is quite satisfactory in many cases. This curve intersects the dry-bulb scale at zero, and diverges from the latter scale quite rapidly. Scale 36 indicates degrees of temperature, as shown by the wet-bulb thermometer.

After the form of scale 36 has been selected as the result of experience or preference, it is divided empirically with reference to scale 35, by the use of movable index line 24, or by some equivalent method. The result must be such that, in each and every position of this index line, the readings of the two scales at the respective visible ends of the index correspond to an accepted psychrometric relationship for an atmosphere of 100% relative humidity.

Relative humidity curves 22 are mathematically similar to the curve of scale 36, but they have different constants. They may be produced in a similar manner, and respectively represent various percentage of relative humidity in the atmosphere. As used herein, the term relative humidity is defined as the ratio, expressed as a percentage, of the amount of vapor that is present in the atmosphere, compared to the amount of vapor required to saturate the atmosphere at the same temperature. The curve of scale 36, as stated, is the 100% curve of the relative humidity curve series. The other curves of the series correspond to smaller percentages.

The curved dew point scale 26 is produced by plotting with respect to scales 35 and 36, both as to shape and graduations. The determining condition is that scale 26, in every position it may assume in the instrument, must intersect, or be tangent to, scales 35 and 36 at corresponding points. Thus, in Fig. 1, it will be seen; that scale 26 intersects scale 35 at 79; and that scales 26 and 36 are tangent to each other at the point 79 of each. It is not difficult to produce the dew point scale to meet these conditions. A satisfactory method is to insert a plain sheet of paper just below face plate 17, pivoted to be rotatable about the axis of the instrument. The zero of the dew point scale then is marked on the plain sheet at the point where the dry bulb and wet bulb scales intersect, i. e. zero of each. The plain sheet is then rotated clockwise until the just determined zero of the dew point scale is opposite 10 of the dry bulb scale, and point 10 of the wet bulb scale is marked on the plain sheet. The sheet is next moved until its zero is just opposite 20 of dry bulb scale, and point 20 of the wet bulb scale is marked thereon. The operation is repeated until all points from zero to 90 have been marked on the plain sheet. A smooth curve is then drawn through all these points, and the minor points are inserted by the same method. Such a scale is exact for all psychrometric calculations.

Area 27, adjacent the dew point scale on disk 16, may be utilized for inserting a scale or table relating to the dew point, such as grains of moisture per pound of dry air at saturation. Similarly area 28 may be utilized for inserting data such as grains of moisture per cu. ft. of dry air at saturation; and area 29 for inserting data such as the vapor pressure at saturation.

Area 36, adjacent the dry bulb scale on the face plate 17, may be utilized for inserting a scale or table relating to the dry bulb temperature, such as the volume in cu. ft. of one pound of dry air saturated; and area 37 for inserting data such as the volume in cu. ft. of one pound of dry air.

Area 39, adjacent the wet bulb scale on the face plate, may be utilized for inserting a scale or table relating to the wet bulb temperature, such as the total heat above zero of one pound of dry air saturated.

Logarithmic scales 31, 41 and 42, and index pointer 32, have no essential co-operative relationship to the other scales and features of the device that have been described; and, accordingly no claim as to them is made herein. They are, however, of great convenience in a psychrometric calculating device of the character herein disclosed; and, since this device is well adapted for their incorporation, they will be described briefly.

The just mentioned features afford a ready means for determining the volume of air that will have to be handled in particular cases. Scale 31 represents this volume of air in cu. ft. per min.; scale 41 represents the heat losses per hour, in B. t. u.; and scale 42 represents the difference between the temperature of the incoming air, and the temperature that is to be maintained, in degrees Fahr. Index pointer 32 is so positioned that when it is set at the proper point with reference to scale 42, the volume of air to be handled can be read directly on scale 31, opposite the proper point on the B. t. u. loss scale 41.

In dealing with psychrometric problems, there are four variables to be considered; i. e., dry bulb temperature, wet bulb temperature, dew point, and relative humidity. If the values of any two of these conditions are known or assumed, the values of the other two can be easily and quickly determined by the use of the above-described instrument. Thus, if the dry bulb temperature is known to be 79° F., and the wet bulb temperature is known to be 52½° F.; disk 16 is set so that the lower extremity of dew point scale 26 intersects the dry bulb scale 35 at 79°, and disk 15 is set so that the upper extremity of radial index line 24 is opposite 52½° on the wet bulb scale. The dew point is then read as 20° on scale 26, opposite the lower extremity of index line 24; and the relative humidity is read as 10% on the curves 22. These particular conditions, as shown by the settings of the instrument, are illustrated in Fig. 1.

It is to be noted that disk 16, in all its positions, serves to indicate maximum values for all of the conditions. For example, when the dry bulb temperature is 79°; the wet bulb tempera-

ture cannot exceed 79°, and the maximum dew point will also be at this same figure. If it should be attempted to set index line **24** at 79° of the wet bulb scale, it would become invisible. The relative humidity, therefore, is 100%, which is its maximum value.

It should be noted also that, when the lower extremity of index line **24** is set opposite the dry bulb temperature, the upper extremity of this line will indicate the minimum possible wet bulb temperature.

Finally it should be remarked that, in any setting of the instrument, the area bounded by scales **26**, **38**, and index line **24**, includes all of the possible conditions; that is, only the portions of scales **26** and **38** that are at the margins of this area indicate the range of possible values of the respective conditions.

The capacity of the instrument to thus quickly indicate maximum and minimum conditions, is of great importance, since it serves very conveniently to check computations, and to disclose errors that might prove to be expensive if not discovered in time.

It will be appreciated that my invention is capable of assuming a considerable variety of forms, and that it is not limited to the precise form that has been illustrated and described. Such variations will naturally occur to those familiar with the art involved, and are contemplated by me to meet particular conditions.

Having thus fully disclosed my invention in a manner that will enable it to be constructed and utilized, I claim:

1. A psychrometric calculator comprising; two fixed scales that intersect each other at a substantial angle; a scale that is movable in a predetermined manner to intersect the fixed scales concurrently; and an index line that is movable in a pre-determined manner to intersect the fixed scales concurrently, and to intersect one fixed scale and the movable scale concurrently; the fixed scales being so graduated that the respective intersections of the index line therewith will always indicate an accepted relationship between their graduations; and the movable scale being so shaped and graduated that its zero point will always be at its intersection with one of the fixed scales, and its value at its intersection with the other fixed scale will always be the same as the value on said other fixed scale at the last point of intersection.

2. A psychrometric calculator comprising; a fixed circular scale; a second fixed scale that intersects the first scale at a substantial angle; a third scale that is rotatable about the center of the circular scale and that is adapted to intersect the fixed scales concurrently; and a radial index line that is rotatable about said center to intersect the fixed scales concurrently, and to intersect the second and third said scales concurrently; the second scale being so graduated with reference to the first scale that the respective intersections of the index line will always indicate an accepted relationship between their graduations; and the third scale being so shaped and graduated that its zero point will be at its intersection with the first scale, and its value at its intersection with the second scale will always be the same as the value on said second scale at the last point of intersection.

3. A device of the character described, comprising; a stationary base plate having thereon a series of spaced lines to indicate relative humidity and positioned with respect to a central axial point; a transparent disk above the base plate, having a radial index line thereon, and rotatable about said point; an opaque disk that is rotatable about said point, above the transparent disk, having a cut-out portion adapted to register with the area occupied by said humidity lines, and a dew-point scale at the marginal portion of the cut-out that intersects said humidity lines; and a stationary face plate having a cut-out portion adapted to expose said humidity lines, said index line, and said dew-point scale; the face plate having a circular dry-bulb scale at a margin of its cut-out portion, and being centered at said axial point, and also having a wet-bulb scale that intersects the dry-bulb scale and that is geometrically similar to said humidity lines at another margin of its cut-out portion; the edge of the wet-bulb scale constituting the 100% humidity line of said series and being so graduated with reference to the dry-bulb scale that the respective intersections of the index line will always indicate an accepted relationship between their graduations; and the dew-point scale being so shaped and graduated that its zero point is at its intersection with the dry-bulb scale, and its value at its intersection with the wet-bulb scale will always be the same as the value on said wet-bulb scale at the last said point of intersection.

4. A psychrometric calculator comprising; a fixed circular dry-bulb scale; a fixed curvilinear wet-bulb scale which intersects the first said scale at a substantial angle at the zero point of both scales; a dew-point scale which is rotatable about the center of the dry-bulb scale, and which is adapted to intersect the wet-bulb scale; a radial index line which is rotatable about said center and adapted to intersect the three said scales; and a series of fixed relative humidity lines, which are adapted for intersection by said index line and said dew-point scale; said humidity lines being geometrically similar to the shape of the wet-bulb scale, but having different mathematical constants; the wet-bulb scale being so graduated with reference to the dry-bulb scale that the respective intersections of the index line will always indicate an accepted relationship between their graduations; and the dew-point scale being so shaped and graduated that its zero point is at its intersection with the dry-bulb scale, and its value at its intersection with the wet-bulb scale will always be the same as the value on the wet-bulb scale at the last said point of intersection.

LOUIS F. HESS.