TM 11-2422

WAR DEPARTMENT TECHNICAL MANUAL

U.S. Dept. of Army

PSYCHROMETRIC CALCULATOR

ML-322/UM

WAR DEPARTMENT 24 MARCH 1945

WAR DEPARTMENT TECHNICAL MANUAL
TM 11-2422

PSYCHROMETRIC CALCULATOR ML-322/UM

WAR DEPARTMENT *24 MARCH 1945*

WAR DEPARTMENT,
WASHINGTON 25, D. C., 24 MARCH 1945.

TM 11-2422, Psychrometric Calculator ML-322/UM, is published for the information and guidance of all concerned.

[A. G. 300.7 (14 Sep 44).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
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The Adjutant General.

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T/O & E:1-627 (3); 1-637 (3); 1-638 (3); 11-107 (3); 11-127 (3); 11-237 (3); 11-587 (3); 11-592 (3); 11-597 (3).

(For explanation of symbols see FM 21-6.)

TECHNICAL MANUAL

PSYCHROMETRIC CALCULATORS ML–322/UM AND ML–322A/UM

CHANGES No. 1

U.S. DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *16 June 1950*

TM 11–2422, 24 March 1945, is changed as follows:
The title of the manual is changed to read:

PSYCHROMETRIC CALCULATORS ML–322/UM AND ML–322A/UM

In the following places in the manual the phrase "index arrow on the θ scale" is changed to read—index arrow on the **innermost** scale:

Paragraph	*Line*	*Paragraph*	*Line*
6*a*	17	7*a*	15
6*a*	44	7*b*	23
6*b*	6	8*b*	21
6*b*	18	8*c*	29

PART ONE

INTRODUCTION

Note (added). Information in this manual pertaining to Psychrometric Calculator ML–322/UM applies equally to Psychrometric Calculator ML–322A/UM except where otherwise specified in these changes. The scales of Psychrometric Calculator ML–322/UM were computed using vapor pressure values measured over a surface of water at wet-bulb temperatures above freezing and over a surface of ice at wet-bulb temperatures below freezing. The scales of Psychrometric Calculator ML–322A/UM were computed using vapor pressure values measured over a surface of water at wet-bulb temperatures both above and below freezing. Thus, when the dew-point temperature and/or dry-bulb temperature are below 0° C. or 32° F., the dew-point temperatures and/or relative humidities computed by the two calculators will differ.

---

1. General

* * * * * * *

c. (Added.) Psychrometric Calculators ML–322/UM purchased on certain order numbers bear incorrect scale and graduation labels.

(1) Psychrometric Calculators ML–322/UM purchased on Order Nos. 1887–MPD–45, 28933–Phila–45–09, 654–EGSA–45,

* These changes supersede TB 11–2422–1, June 1945.

AGO 2495B—June 851746°—50

and 1470–Day–44–05 have some of the graduations of the t—t'° F. scale on the Fahrenheit-inches-of-mercury side incorrectly labeled. The division marks labeled .06, .07, and .09 should read 0.6, 0.7, and 0.9, respectively.

(2) Psychrometric Calculators ML–322/UM purchased on some of the order numbers indicated in (1) above have one of the labels denoting the innermost, or θ° F., scale on the Fahrenheit-inches-of-mercury side incorrectly labeled as 0° F.

(3) Psychrometric Calculators ML–322/UM purchased on some of the order numbers indicated in (1) above do not show clearly the minus sign before the figure 40 at the end of the minus portion of the t'° C. scale on the centigrade-millibar side of the calculator. This division mark should read —40.

3. Characteristics of Psychrometric Calculators ML–322/UM and ML–322A/UM (figs. 2 and 2.1)

* * * * * * *

b. Both sides of * * * appear on them. The side which bears the nomenclature and order number of the calculator has scales for temperature data in degrees Fahrenheit (θ° F.) and for pressure in inches of mercury (P in. Hg.). The opposite side has scales which are labeled in degrees centigrade (θ° C.) of temperature and in millibars of pressure (P mb). The temperature ranges covered by **Psychrometric Calculator ML–322/UM** extend from —60° to +120° F. and from —40° to +50° C., **except on the DP° C. scale where the range is from —50° C. to +50° C. The temperature ranges covered by Psychrometric Calculator ML–322A/UM extend from —60° F. to +120° F. and —40° C. to +50° C. for wet-bulb temperatures and from —67° F. to +120° F. and —54° C. to +50° C. for dry-bulb temperatures and dew points.** The pressure range * * * 1,100 to 100 millibars.

c. Reading from the * * * (wet-bulb temperature). On the small disks **of Psychrometric Calculator ML–322/UM,** reading from the outermost scale, the scales are arranged as follows: t—t' (wet-bulb depression), P **in. Hg** (atmospheric pressure), and θ (used for both wet- and dry-bulb temperatures). **On the small disks of Psychrometric Calculator ML–322A/UM, reading from the outermost scale the scales are arranged as follows: t—t' (wet-bulb depression), P in. Hg (atmospheric pressure), θ (used for wet-bulb temperature), and T (used for dry-bulb temperature).** The scale labels * * * scales are expressed.

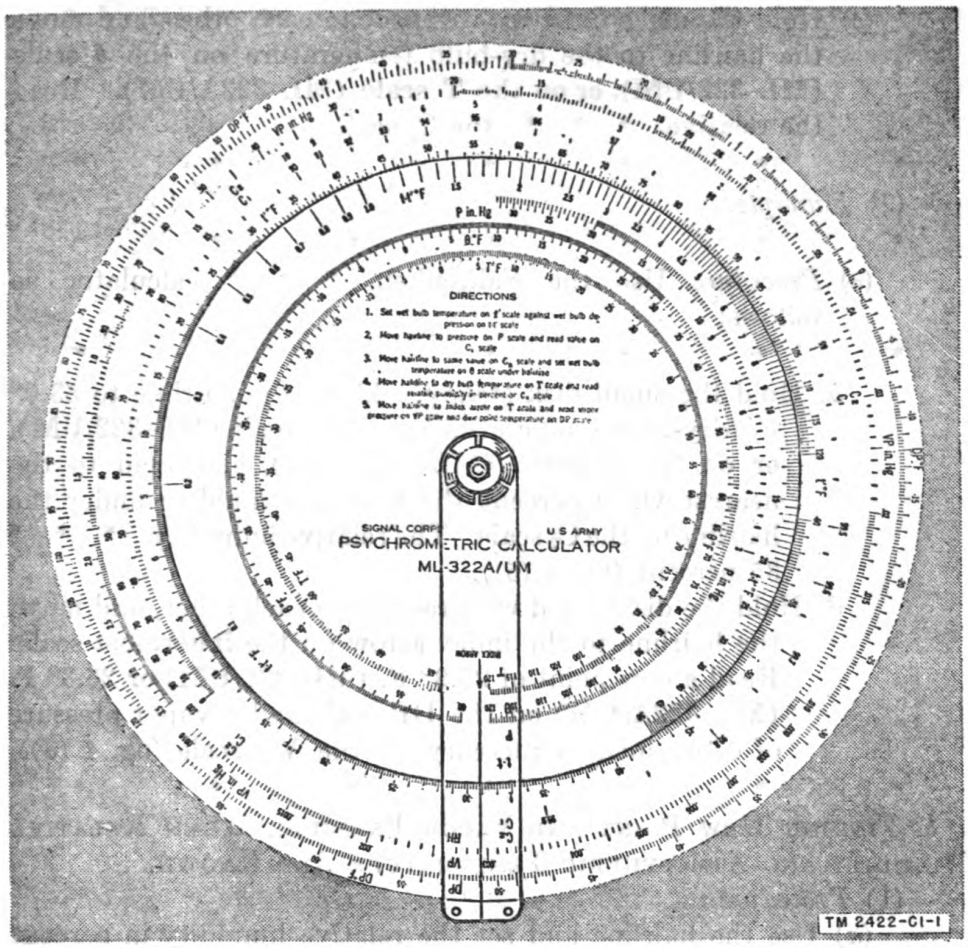

Figure 2.1 (added). *Psychrometric Calculator ML-322A/UM, front.*

4. Reading Scale

* * * * * * *

b. Temperature Scales. The temperature scales (DP, t′, t—t′, and θ) of **Psychrometric Calculator ML–322/UM and the temperature scales (DP, t′, t—t′, θ, and T) of Psychrometric Calculator ML–322A/UM** are divided into degrees and fifths of a degree (0.2°) for the most part. Some of these * * * entire temperature range.

* * * * * * *

6. Use of Psychrometric Calculators ML–322/UM and ML–322A/UM

a. Computing Relative Humidity, Dew Point, and Vapor Pressure from Given Values of Wet- and Dry-Bulb Temperatures and Atmospheric Pressure.

(1) *Procedure.*

* * * * * * *

(*e*) Hold the disks fixed with respect to each other, and move the hairline to the dry-bulb temperature on the θ scale **(ML–322/UM), or on the T scale (ML–322A/UM).** Read the relative * * * the C_2 scale.

* * * * * * *

(2) *Example.*

* * * * * * *

(*c*) *Procedure.* Use the Fahrenheit * * * calculator as follows:

* * * * * * *

5. Hold the small disk steady. Move the hairline to 53.0° F. (dry-bulb temperature) on the θ scale **(ML–322/UM), or on the T scale (ML–322A/UM),** and read to the nearest whole percent the relative humidity under the hairline on the C_2 scale. The relative humidity * * * 35 percent (fig. 4 (5)).

6. Hold the disks fixed with respect to each other, and move the hairline to the index arrow on the **innermost** scale. Read a dew point of 26.9° F. **(ML–322/UM) or 26.3° F. (ML–322A/UM)** on the DP scale and a vapor pressure of 0.143 inch of mercury on the VP scale (fig. 4 (6)).

* * * * * * *

b. Finding Dew Point and Vapor Pressure When Relative Humidity and Atmospheric Temperature Are Known.

(1) *Procedure.*

(*a*) Use the hairline and set the relative humidity in percent on the C_2 scale against the atmospheric temperature on the θ scale **(ML–322/UM), or on the T scale (ML–322A/UM).**

* * * * * * *

(2) *Example.*

* * * * * * *

(*c*) *Procedure.* Use the Fahrenheit- * * * the following manner:

1. Use the hairline, and set 46 percent (relative humidity) on the C_2 scale against 27.4° F. (atmospheric temperature) on the θ scale **(ML–322/UM), or on the T scale (ML–322A/UM).**

2. Move the hairline to the index arrow on the innermost scale, and read a dew point of 11.3° F. **(ML–322/UM), or 10.2° F. (ML–322A/UM)** on the DP scale and a vapor pressure of **0.067 (ML–322/UM), or 0.072 (ML–322A/UM)** inch of mercury on the VP scale.

Note. **If the dew * * * the C_2 scale. The dew point is then read under the hairline on the θ scale (ML–322/UM), or on the T scale (ML–322A/UM).**

c. Determining Saturation Vapor Pressure for a Given Temperature. Saturation vapor pressure * * * the temperature alone. The relation between temperature and saturation vapor pressure (over water at temperatures above freezing and over ice below freezing **for ML–322/UM, and over water at temperatures above and below freezing for ML–322A/UM**) is expressed in the relationship of the DP and VP scales on the **calculators.** The DP scale * * * with dew point.

* * * * * * *

d. Converting Fahrenheit Temperature to Centigrade Temperature.

(1) *Procedure.* In the following * * * in this instance.

* * * * * * *

(*d*) Hold the small disk steady on the Fahrenheit-inches-of-mercury side of the calculator, and move the hairline to any desired Fahrenheit temperature on the Fahrenheit θ scale **(ML–322/UM), or on the T scale (ML–322A/UM).** Read the corresponding * * * centigrade DP scale.

(2) *Example.*

* * * * * * *

(*c*) *Procedure.*

* * * * * * *

3. Hold the small disk steady, and move the hairline to −14.8° F. on the θ° F. scale **(ML–322/UM, fig. 5 (3)), or on the T° F. scale (ML–322A/UM).**

* * * * * * *

e. Converting Centrigrade Temperature to Fahrenheit Temperature. The following procedure * * * units are reversed.

(1) *Procedure.*

* * * * * * *

(*c*) Hold the hairline steady with respect to the large disk, and rotate the small disk on the centigrade-millibar side to bring 0° C. on the θ scale under the hairline.

(*d*) Hold fixed the small disk on the centigrade-millibar side of the calculator, and move the hairline to the desired centigrade temperature on the θ° C. scale **(ML–322/UM), or on the T° C scale (ML–322A/UM).**

* * * * * * *

(2) *Example.*

* * * * * * *

(*c*) *Procedure.*

* * * * * * *

3. Hold the disks steady, and move the hairline to —26.0° C. on the θ° C. scale **(ML–322/UM), or on the T° C. scale (ML–322A/UM).**

* * * * * * *

7. Use of Psychrometric Calculators ML–322/UM and ML–322A/UM with Aerographs

The relative humidity * * * free air temperature (t_2).

a. PROCEDURE.

* * * * * * *

(3) Hold the hairline fixed with respect to the large disk, and rotate the small disk to bring the aerograph indicated temperature (t_1) on the θ scale **(ML–322/UM), or on the T scale (ML–322A/UM),** under the hairline.

(4) Move the hairline to the free air temperature (t_2) on the θ scale **(ML–322/UM), or on the T scale (ML–322A/UM),** and read the corrected relative humidity (humidity of the free air) under the hairline on the C_2 scale.

* * * * * * *

b. EXAMPLE.

Note (added). The indicated relative humidity in the following example is measured with respect to ice for calculations made with ML–322/UM and with respect to water for calculations made with ML–322A/UM.

* * * * * * *

(3) *Procedure.* Use the centigrade-millibar side of the calculator.

* * * * * * *

(*c*) Hold the hairline fixed with respect to the large disk, and rotate the small disk to bring —10.3° C. (indicated temperature) on the θ scale **(ML–322/UM), or on the T scale (ML–322A/UM),** under the hairline.

(*d*) Hold the small disk steady, and move the hairline to —14.8° C. (free air temperature) on the θ scale **(ML–322/UM), or on the T scale (ML–322A/UM),** Read 96 percent **(ML–322/UM) or 93 percent (ML–322A/UM)** corrected or free air relative humidity on the C_2 scale.

(*e*) Hold the small disk firmly in place, and move the hairline to the index arrow on the innermost scale **(ML–322/UM), or on the T scale (ML–322A/UM.)** Read —15.2° C. **(ML–322/UM) or —15.7° C. (ML–322A/UM)** (dew point) on the DP scale and 1.62 millibars **(ML–322/UM) or 1.80 millibars (ML–322A/UM)** (vapor pressure) on the VP scale.

Note. **The dew point may be read on the θ scale (ML–322/UM), or on the T scale (ML–322A/UM), if, after setting the disks as in (*c*) above, the hairline is moved to 100 on the C_2 scale.**

8. Use of Psychrometric Calculators ML–322/UM and ML–322A/UM with Aircraft Psychrometers

Psychrometric Calculator ML–322/UM, * * * ML–322/UM as follows:

* * * * * * *

b. SIMPLIFIED PROCEDURE. The two sets * * * procedure as follows:

* * * * * * *

(7) Move the hairline to the true dry-bulb temperature (free air temperature) on the θ scale **(ML–322/UM,) or on the T scale (ML–322A/UM).** Read the true * * * the C_2 scale.

* * * * * * *

c. EXAMPLE.

* * * * * * *

(3) *Procedure.* Use the centigrade- * * * proceed as follows:

* * * * * * *

(*g*) Move the hairline to 8.0° C. (true dry-bulb temperature) on the θ scale **(ML–322/UM), or on the T scale (ML–322A/UM),** and read 92 percent (true relative humidity) under the hairline on the C_2 scale.

* * * * * * *

13. Design of Psychrometric Calculators ML–322/UM and ML–322A/UM

a. BASIS FOR DESIGN.

(1) *Psychrometric Calculator ML–322/UM.* The design of * * * pp 710–713.

(2) (Added.) *Psychrometric Calculator ML–322A/UM.* The design of ML–322A/UM is based upon a definite psychrometric formula (Annual Report of the Chief Signal Officer, 1886, app. 24, pp 233–259) and upon saturation vapor pressure values over *water.* The equation for these values is found on page 133 of the final report of the 12th Conference of Directors of the International Meteorological Organization, 22 September through 11 October 1947.

b. FERREL'S FORMULA. Ferrel's formula for * * * t, t′, and P.

c. COMPUTATION OF SCALES.

(1) *Psychrometric Calculator ML–322/UM.* The vapor pressure * * * surface of ice. **It has been** standard practice in the United States **to compute** relative humidity by the formula RH-e/E, **where e is** the actual vapor pressure, as

determined by Ferrel's equation, **and E is** the saturation vapor pressure over water if the dry-bulb temperature is above 0° C., and the saturation vapor pressure over ice, if the dry-bulb temperature is below 0° C.

(2) (Added.) *Psychrometric Calculator ML–322A/UM.* The actual vapor pressure is computed in exactly the same manner as with Psychrometric Calculator ML–322/UM. However, in accordance with the recommendations of the International Meteorological Organization, page 136 of the report mentioned in *a* (2) above, the relative humidities and dew points at temperatures both above and below 0° C. or 32° F. are computed with respect to water.

[AG 300.7 (3 Jun 50)]

BY ORDER OF THE SECRETARY OF THE ARMY:

OFFICIAL:
EDWARD F. WITSELL
Major General, USA
The Adjutant General

J. LAWTON COLLINS
Chief of Staff, United States Army

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For explanation of distribution formula, see SR 310–90–1.

AGO 2495B
U. S. GOVERNMENT PRINTING OFFICE: 1950

QUICK INDEX

TABLE OF CONTENTS

DESTRUCTION NOTICE

WHY —To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN —When ordered by your commander.

HOW —1. Smash —Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

2. Cut —Use axes, handaxes, machetes.

3. Burn —Use gasoline, kerosene, oil, flame throwers, incendiary grenades.

4. Explosives —Use firearms, grenades, TNT.

5. Disposal —Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT —1. Smash —Cursor, disks.

2. Cut —Disks.

3. Burn —Disks.

4. Bend —Cursor, disks.

5. Bury or scatter — Any or all of the above after destroying their usefulness.

DESTROY EVERYTHING

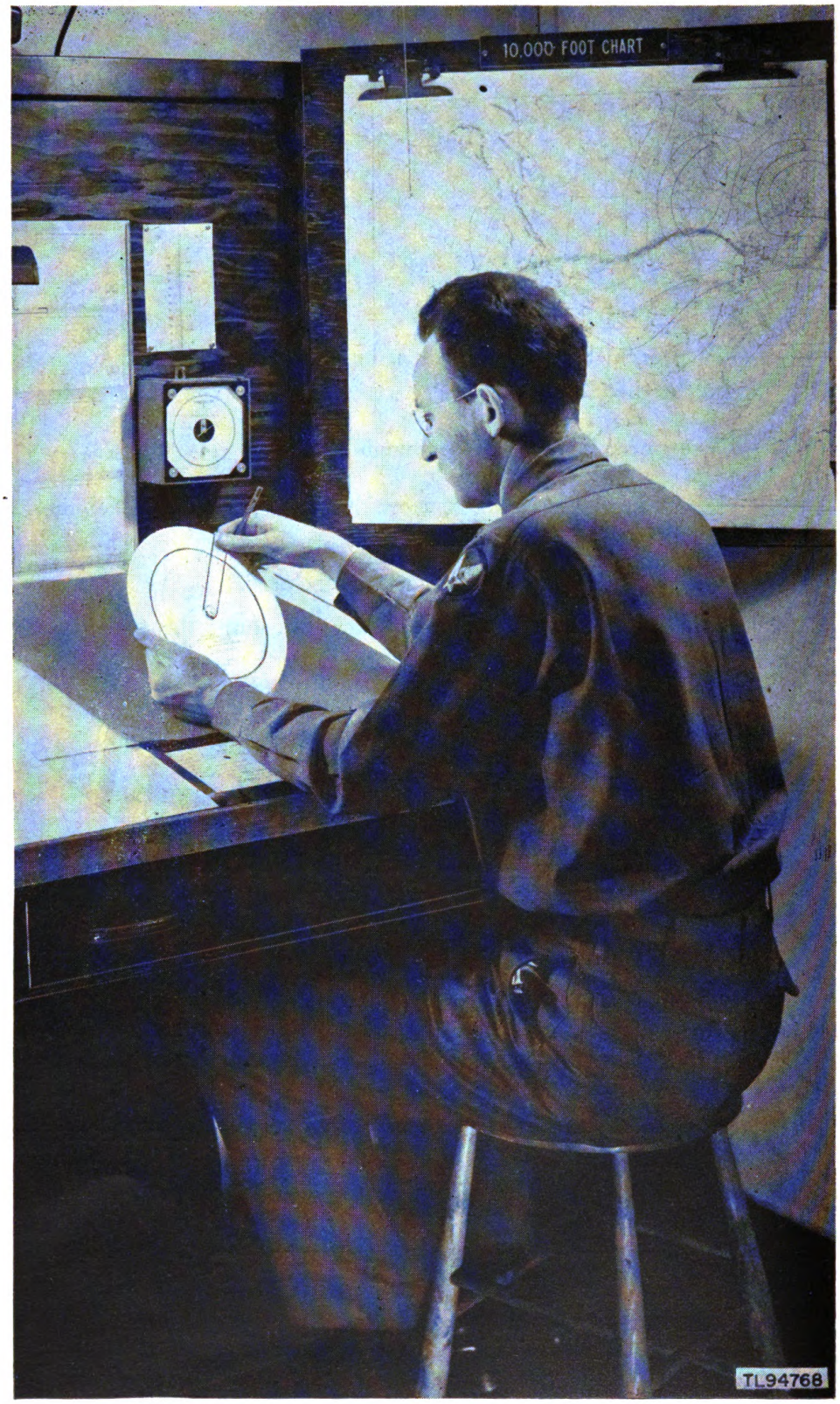

Figure 1. Psychrometric Calculator ML–322/UM in use.

PART ONE

INTRODUCTION

SECTION I. DESCRIPTION OF PSYCHROMETRIC CALCULATOR ML-322/UM

1. GENERAL.

a. Psychrometric Calculator ML-322/UM is a circular slide-rule device which is used primarily to compute relative humidity, dew point, and vapor pressure from observed values of dry- and wet-bulb temperatures and atmospheric pressure. The calculator, when used with aircraft humidity-measuring devices, is also designed to correct the indicated values of humidity for the dynamic effects of air speed.

b. Psychrometric Calculator ML-322/UM reduces the arithmetic ordinarily involved in using psychrometric tables or in applying the psychrometric formula to psychrometric data. The calculator is self-sufficient. All data and answers are read directly from its scales. An operator instructed in the use of the calculator can solve a problem in less than 1 minute.

2. APPLICATION.

Psychrometric Calculator ML-322/UM is used to make routine humidity and related computations, and computations pertaining to the use of airborne humidity-measuring instruments.

a. The calculator can be used for the following routine humidity and related computations:

(*1*) Determination of relative humidity, dew point, and vapor pressure from given values of wet- and dry-bulb temperatures and atmospheric pressure (par. 6a).

(*2*) Determination of dew point and vapor pressure from given values of relative humidity and atmospheric temperature (par. 6b).

(*3*) Determination of saturation vapor pressure for any temperature (par. 6c).

(*4*) Conversion of temperature in degrees Fahrenheit to temperature in degrees centigrade (par. 6d).

(*5*) Conversion of temperature in degrees centigrade to temperature in degrees Fahrenheit (par. 6e).

(*6*) Conversion of pressure in inches of mercury to pressure in millibars (par. 6f).

(*7*) Conversion of pressure in millibars to pressure in inches of mercury (par. 6g).

(*8*) Conversion of pressure in millimeters of mercury to pressure in millibars (par. 6h).

(*9*) Conversion of pressure in millibars to pressure in millimeters of mercury (par. 6h).

(*10*) Multiplication (par. 6i).

(*11*) Division (par. 6i).

b. The following computations pertaining to airborne meteorological instruments can also be made by the calculator:

(*1*) Conversion of the relative humidity, indicated by an aerograph (the value being influenced by the dynamic pressure and temperature effects of air speed) to the relative humidity of the free air at the level of flight, and the determination of the equivalent dew point and vapor pressure (par. 7).

(*2*) Determination of relative humidity, dew point, and vapor pressure of the free air at the level of flight from psychrometric data obtained with an aircraft psychrometer (par. 8).

3. CHARACTERISTICS OF PSYCHROMETRIC CALCULATOR ML-322/UM (fig. 2).

a. The calculator consists of three concentric disks of white vinyl chloride-acetate, one disk 10 inches in diameter inserted between two disks each 7¾ inches in diameter. Each disk revolves independently about a common center. A transparent cursor with hairline is mounted on each side of the device and is held in place by the center pivot. The two cursors are joined by rivets at the outer edge of the large disk and move simultaneously about the center pivot.

b. Both sides of the calculator are the same except for the units of the scales which appear on them. The side which bears the nomenclature and order number of the calculator has scales for temperature data in degrees Fahrenheit (0° F) and for pressure in inches of mercury (P in. Hg.). The opposite side has scales which are labeled in degrees centigrade (0° C) of temperature and in millibars of pressure (P mb). The temperature range covered by the calculator extends from −60° to +120° F and from −40° to +50° C. The pressure range extends from 32.5 to 3.0 inches of mercury and from 1,100 to 100 millibars.

c. Reading from the outermost scale, the scales on the large disk are arranged in the following order: DP (dew point), VP (vapor pressure), $C_2 - C_1$ (upon which the relative humidity is read), and t′ (wet-bulb temperature). On the small disks, reading from the outermost scale, the scales are arranged as follows: $t - t'$ (wet-bulb depression), P (atmospheric pressure), and θ (used for both wet- and dry-bulb temperatures). The scale labels also include the units in which the scales are expressed.

POOR	FAIR	GOOD	

ORIGINATING OFFICER

TYPED NAME, GRADE, AND ORGANIZATION	SIGNATURE

FIRST ENDORSEMENT

TO CHIEF	TECHNICAL SERVICE	OFFICE	
NAME, GRADE, AND STATION		STATION	DATE

Instructions

1. It is imperative that the chief of technical service concerned be advised at the earliest practical moment of any constructional, design, or operational defect in matériel. This form is designed to facilitate such reports and to provide a uniform method of submitting the required data.
2. This form will be used for reporting manufacturing, design, or operational defects in matériel, petroleum fuels, lubricants, and preserving materials with a view to improving and correcting such defects, and for use in recommending modifications of matériel.
3. This form will not be used for reporting failures, isolated material defects or malfunctions of matériel resulting from fair-wear-and-tear or accidental damage nor for the replacement, repair or the issue of parts and equipment. It does not replace currently authorized operational or performance records.
4. Reports of malfunctions and accidents involving ammunition will continue to be submitted as directed in the manner described in AR 750–10 (change No. 3).
5. It will not be practicable or desirable in all cases to fill all blank spaces of the report. However, the report should be as complete as possible in order to expedite necessary corrective action. Additional pertinent information not provided for in the blank spaces should be submitted as inclosures to the form. Photographs, sketches, or other illustrative material are highly desirable.
6. When cases arise where it is necessary to communicate with a chief of service in order to assure safety to personnel, more expeditious means of communication are authorized. This form should be used to confirm reports made by more expeditious means.
7. This form will be made out in triplicate by using or service organization. Two copies will be forwarded direct to the technical service; one copy will be forwarded through command channels.
8. Necessity for using this form will be determined by the using or service troops.

W. D., A. G. O. Form No. 468
30 August 1944

This form supersedes W. D., A. G. O. Form No. 468, 1 December 1943, which may be used until existing stocks are exhausted.

U. S. GOVERNMENT PRINTING OFFICE 16—41546-1

WAR DEPARTMENT
UNSATISFACTORY EQUIPMENT REPORT

FOR	TECHNICAL SERVICE: MATÉRIEL		DATE
FROM	ORGANIZATION		STATION
TO	NEXT SUPERIOR HEADQUARTERS	STATION	TECHNICAL SERVICE

COMPLETE MAJOR ITEM

NOMENCLATURE	TYPE	MODEL	
MANUFACTURER	U. S. A. REG. No.	SERIAL No.	DATE RECEIVED
EQUIPMENT WITH WHICH USED *(if applicable)*			

DEFECTIVE COMPONENT—DESCRIPTION AND CAUSE OF TROUBLE

PART No.	TYPE	MANUFACTURER	DATE INSTALLED
DESCRIPTION OF FAILURE AND PROBABLE CAUSE *(If additional space is required, use back of form)*			

DATE OF INITIAL TROUBLE	TOTAL TIME INSTALLED			TOTAL PERIOD OF OPERATION BEFORE FAILURE					
	YEARS	MONTHS	DAYS	YEARS	MONTHS	DAYS	HOURS	MILES	ROUNDS

BRIEF DESCRIPTION OF UNUSUAL SERVICE CONDITIONS AND ANY REMEDIAL ACTION TAKEN

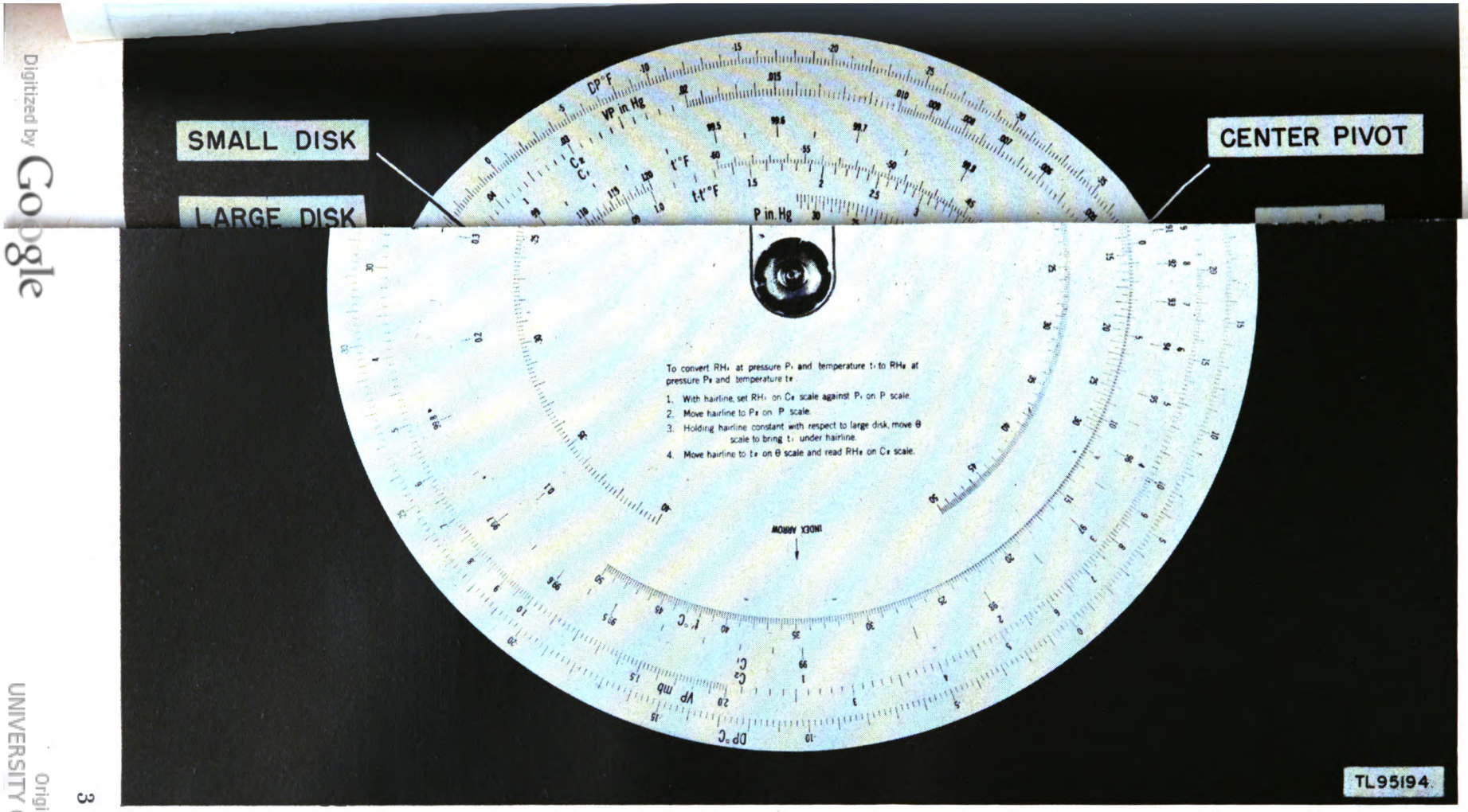

Figure 2. Psychrometric Calculator ML–322/UM, front and rear.

PART TWO

OPERATING INSTRUCTIONS

NOTE: For information on destroying this equipment to prevent enemy use, see the destruction notice at the front of this manual.

SECTION II. OPERATION OF PSYCHROMETRIC CALCULATOR ML-322/UM

4. READING SCALE.

a. General. Reading the scales of Psychrometric Calculator ML-322/UM is similar to reading the scale of an ordinary ruler. On the calculator scales, the units are designated ordinarily at certain intervals by numbers printed above the longer, or primary division, marks. Smaller or intermediate values between these intervals are generally indicated by shorter division marks of secondary length and are unnumbered. Still smaller values may be estimated by eye between the division marks of secondary length. Thus, on the DP° F scale, the primary divisions are labeled in intervals of 5° F. Each of the smaller intermediate divisions has a value of 0.2° F in the lower range or 0.5° F in the upper range. Steps of 1° F between labeled divisions are unnumbered, but are indicated by marks of primary length.

b. Temperature Scales. The temperature scales (DP, t′, t—t′, and θ) of the calculator are divided into degrees and fifths of a degree (0.2°) for the most part. Some of these scales at their extremes, however, are graduated to tenths of a degree or to half degrees. If estimates are made between the marked divisions, the temperature scales can be read to the nearest tenth of a degree (0.1°) throughout the entire temperature range.

c. Atmospheric Pressure Scales.

(*1*) The atmospheric pressure scale (P) on the Fahrenheit-inches-of-mercury side of the calculator is graduated from 3 to 20 inches of mercury by intervals of 0.2 inch of mercury and from 20 to 32.5 inches of mercury by intervals of 0.5 inch of mercury. The scale can be read to the nearest 0.1 inch of mercury.

(*2*) The atmospheric pressure scale (P) on the centigrade-millibar side of the calculator is divided into intervals of 10 millibars throughout its range. Values on this P scale can be read to at least the nearest 5 millibars.

d. Vapor Pressure Scales. The vapor pressure (VP) scales both in inches of mercury and in millibars can be read to three significant figures.

e. $C_1 - C_2$ Scale. C_1 and C_2 values are marked on the same scale, the C_1 values being those immediately above the scale markings. C_1 values range from 0 to 99.9; C_2 values range from 100 to 1. Relative humidity in percent can be read on the C_2 scale to the nearest whole percent value (which is accurate enough for most humidity computations), or to fractions thereof by estimations between the divisions. When the $C_1 - C_2$ scale is used to convert from a C_1 value to a C_2 value (an operation required in certain computations), the scale must be read with as great an accuracy as interpolation permits.

f. Accuracy of Readings. Mathematical handling of data can lead to an apparent accuracy in results that is unwarranted by the accuracy of the initial data. Psychrometric Calculator ML-322/UM is based upon a strict mathematical application of the psychrometric formula (par. 13), and the scales are so arranged that they can be read precisely. The usual wet- and dry-bulb temperature measurements are not accurate enough to take full advantage of the accuracy of the calculator. Two good rules to observe are:

(*1*) Use the calculator with the most accurate data available.

(*2*) Read the results of

relative humidity	— to the nearest whole percent.
dew point	— to the nearest tenth of a degree.
vapor pressure	— to three significant places.

NOTE: In the commercial reproduction and manufacture of the calculator, slight distortions and irregularities in certain portions of the scales may be present. This results in errors of approximate ±1 percent in relative humidity, ±0.2° dew point, and ±5 in the third significant figure of vapor pressure. The accuracy of the calculator is greatest at low humidities and temperatures where the values are most critical.

5. PRECAUTIONS ON HANDLING PSYCHROMETRIC CALCULATOR ML-322/UM.

a. Be sure that the disks do not slip out of position when the hairline is moved during a computation. Be sure that the hairline is not moved out of position when the disks are moved during a computation.

b. Do not allow the calculator to be exposed for long periods of time to sunlight. Long exposure to sunlight may cause slight discoloration of the exposed surfaces of the calculator. Exposure to temperatures in excess of 140° F will cause permanent deformation of the disks. Do not leave the calculator near radiators or other heated surfaces.

c. Never use acetone, benzine, or lacquer thinners to clean the calculator

because these materials mar the plastic surfaces. Avoid abrasive cleaners also because they scratch the surface.

d. Do not bend the calculator.

6. USE OF PSYCHROMETRIC CALCULATOR ML-322/UM.

a. Computing Relative Humidity, Dew Point, and Vapor Pressure from Given Values of Wet- and Dry-bulb Temperatures and Atmospheric Pressure.

(*1*) *Procedure.*

(*a*) Set the wet-bulb temperature on the t′ scale against the wet-bulb depression on the t — t′ scale.

(*b*) Move the cursor hairline to the atmospheric pressure on the P scale, and read the value under the hairline on the C_1 scale.

(*c*) Move the hairline to the same value on the C_2 scale as read on the C_1 scale in subparagraph (b) above.

(*d*) Hold the hairline steady with respect to the large disk and rotate the small disk to bring the wet-bulb temperature on the θ scale under the hairline.

(*e*) Hold the disks fixed with respect to each other, and move the hairline to the dry-bulb temperature on the θ scale. Read the relative humidity in percent under the hairline on the C_2 scale.

(*f*) Move the hairline to the index arrow on the θ scale, and read the dew point on the DP scale and the vapor pressure on the VP scale. Be sure not to move the disks during this operation.

(*2*) *Example.*

(*a*) Given. Dry-bulb temperature = 53.0° F.
Wet-bulb temperature = 41.5° F.
Wet-bulb depression = 11.5° F.
Atmospheric pressure = 28.2 inches of mercury.

(*b*) *To Find.* Relative humidity in percent.
Dew point in degrees Fahrenheit.
Vapor pressure in inches of mercury.

(*c*) *Procedure.* Use the Fahrenheit-inches-of-mercury side of the calculator as follows:

1. Set 41.5° F wet-bulb temperature on the t′ scale against 11.5° F wet-bulb depression on the t — t′ scale (fig. 3(1)).

2. Hold the disks fixed with respect to each other, and move the hairline to 28.2 inches of mercury on the P scale. Read 54.4 on the C_1 scale (fig. 3(2)).

3. Move the hairline to 54.4 on the C_2 scale (fig. 3(3)).

4. Hold the hairline steady with respect to the large disk and rotate the small disk to bring 41.5° F (wet-bulb temperature) on the θ scale under the hairline (fig. 3(4)).

5. Hold the small disk steady. Move the hairline to 53.0° F (dry-bulb temperature) on the θ scale, and read to the nearest whole percent the relative humidity under the hairline on the C_2 scale. The relative humidity has a value of 35 percent (fig. 4(5)).

6. Hold the disks fixed with respect to each other, and move the hairline to the index arrow on the θ scale. Read a dew point of 26.9° F on the DP scale and a vapor pressure of 0.143 inches of mercury on the VP scale (fig. 4(6)).

NOTE: If the observed values are in millibars and in degrees centigrade, use the centigrade-millibar side of the calculator and follow the procedure outlined above. If the temperatures and pressures are not in the same system, change the temperature units (subpars. e and f below) to conform with the pressure units, or change the pressure units (subpars. g and h below) to conform with the temperature units.

b. Finding Dew Point and Vapor Pressure When Relative Humidity and Atmospheric Temperature Are Known.

(*1*) *Procedure.*

(*a*) Use the hairline and set the relative humidity in percent on the C_2 scale against the atmospheric temperature on the θ scale.

(*b*) Move the hairline to the index arrow on the θ scale, and read the dew point on the DP scale and the vapor pressure on the VP scale.

(*2*) *Example.*

(*a*) *Given.* Relative humidity = 46 percent.
Atmospheric temperature = 27.4° F.

(*b*) *To Find.* Dew point in degrees Fahrenheit.
Vapor pressure in inches of mercury.

(*c*) *Procedure.* Use the Fahrenheit-inches-of-mercury side of the calculator in the following manner:

1. Use the hairline, and set 46 percent (relative humidity) on the C_2 scale against 27.4° F (atmospheric temperature) on the θ scale.

2. Move the hairline to the index arrow on the θ scale, and read a dew point of 11.3° F on the DP scale and a vapor pressure of 0.671 inches of mercury on the VP scale.

NOTE: If the dew point alone is to be determined from known values of relative humidity and temperature, set the disks according to subparagraph (1) above, and then move the hairline to 100 on the C_2 scale. The dew point is then read under the hairline on the θ scale.

c. Determining Saturation Vapor Pressure for a Given Temperature.

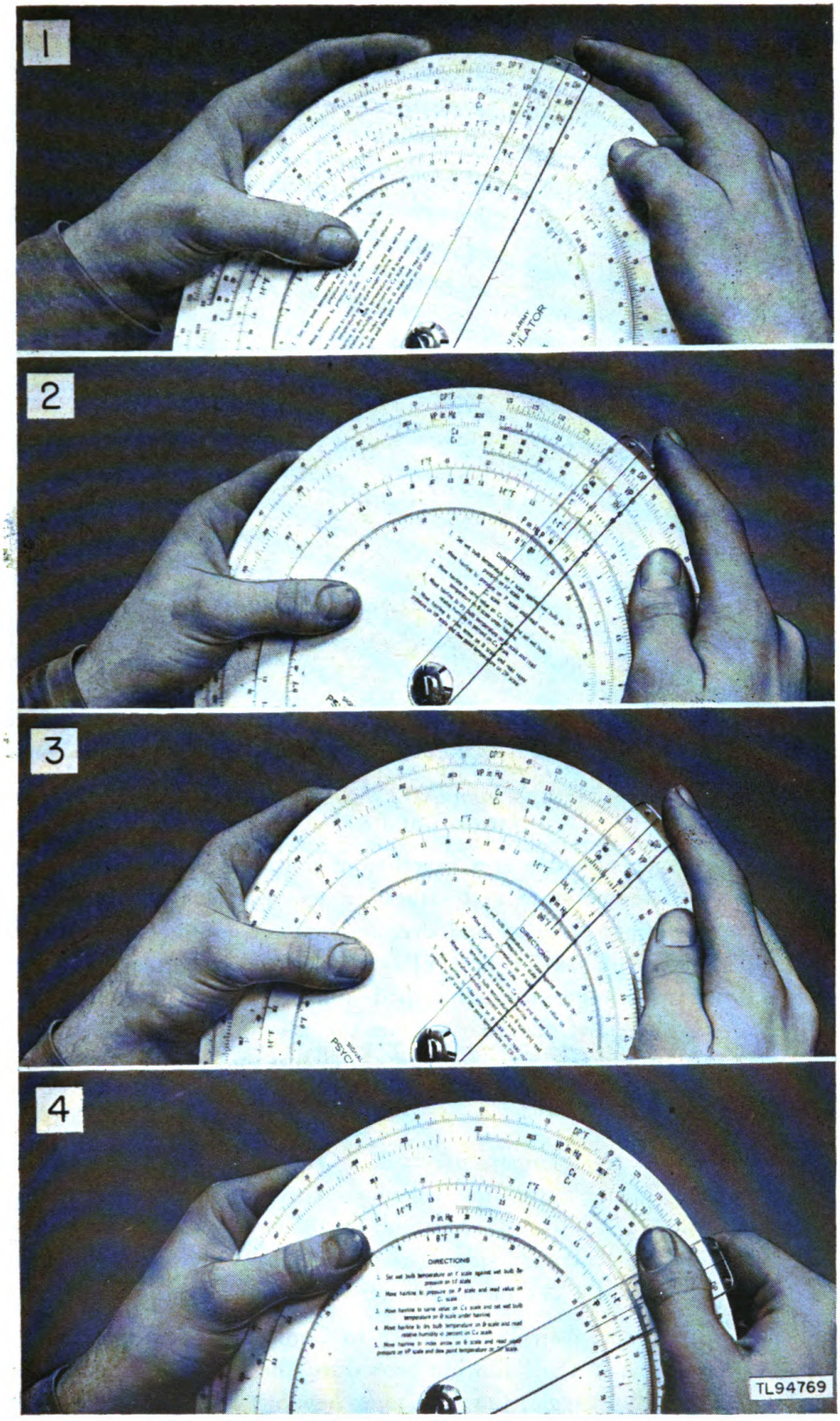

Figure 3. Computing relative humidity, dew point, and vapor pressure (steps 1, 2, 3, and 4).

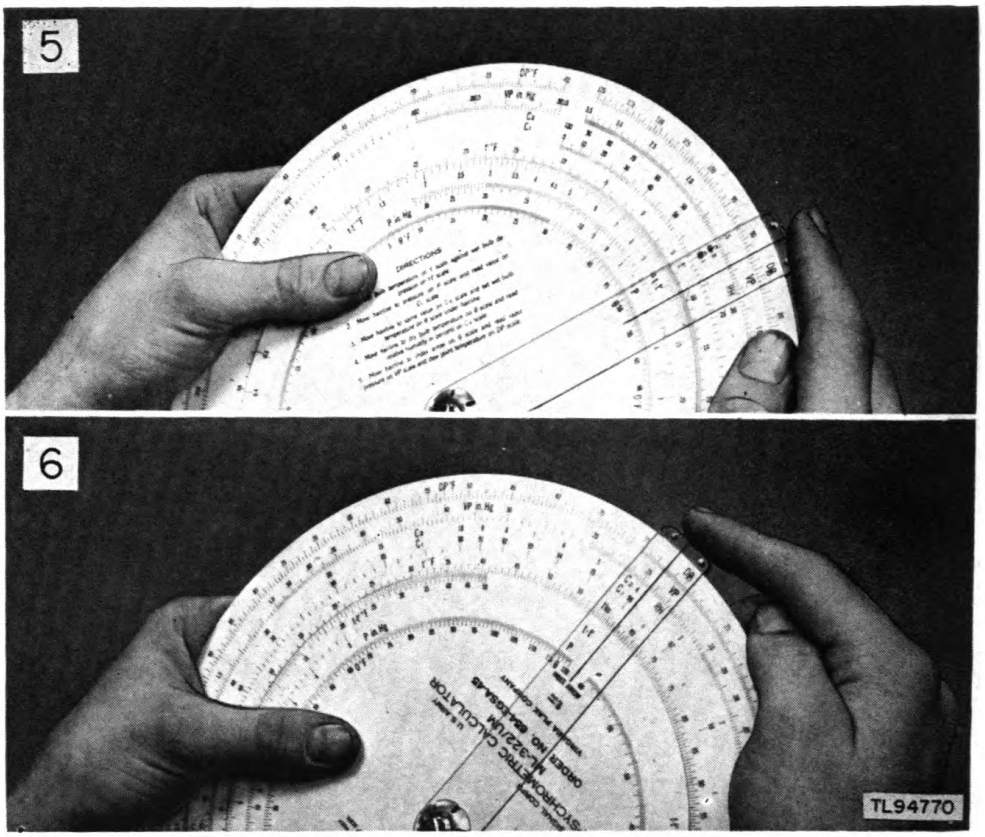

Figure 4. Computing relative humidity, dew point, and vapor pressure (steps 5 and 6).

Saturation vapor pressure is a function of the temperature alone. The relation between temperature and saturation vapor pressure (over water at temperatures above freezing and over ice below freezing) is expressed in the relationship of the DP and VP scales on the calculator. The DP scale in this case is not concerned with dew point.

(*1*) *Procedure.* Set the hairline on the given temperature on the DP scale, and read the saturation vapor pressure under the hairline on the VP scale.

(*2*) *Example.*

(*a*) *Given.* Temperature = 85.0° F.

(*b*) *To Find.* Saturation vapor pressure in inches of mercury.

(*c*) *Procedure.* Set the hairline on 85.0° F on the DP scale (Fahrenheit-inches-of-mercury side of the calculator), and read a saturation vapor pressure of 1.214 inches of mercury on the VP scale.

d. Converting Fahrenheit Temperature to Centigrade Temperature.

(*1*) *Procedure.* In the following procedure, the DP scale is used as a centigrade temperature scale; the scale units have no relation to dew point in this instance.

(*a*) Set the hairline at 0° C on the DP scale of the centigrade-millibar side of the calculator.

(*b*) Without moving the position of the hairline, turn the calculator over to the front side.

(*c*) Hold the hairline steady with respect to the large disk, and rotate the small disk on the Fahrenheit-inches-of-mercury side to bring 32° F on the θ scale under the hairline (a reading of 32° F is equivalent to 0° C).

(*d*) Hold the small disk steady on the Fahrenheit-inches-of-mercury side of the calculator, and move the hairline to any desired Fahrenheit temperature on the Fahrenheit θ scale. Read the corresponding centigrade temperature under the hairline on the centigrade DP scale.

(*2*) *Example.*

(*a*) *Given.* Temperature = —14.8° F.

(*b*) *To Find.* Equivalent temperature in degrees centigrade.

(*c*) *Procedure.*

1. Set the hairline at 0° C on the DP° C scale (fig. 5(1)).

2. Hold the hairline fixed with respect to this setting, and rotate the small disk on the Fahrenheit-inches-of-mercury side of the calculator to bring 32° F under the hairline on the θ scale (fig. 5(2)).

3. Hold the small disk steady, and move the hairline to —14.8° F on the θ° F scale (fig. 5(3)).

4. Turn the calculator over and read —26.0° C equivalent temperature under the hairline on the DP° C scale (fig. 5(4)).

e. Converting Centigrade Temperature to Fahrenheit Temperature. The following procedure is the same as that described in subparagraph d above except that the scale units are reversed.

(*1*) *Procedure.*

(*a*) Set the hairline at 32° F on the DP scale of the Fahrenheit-inches-of-mercury side of the calculator.

(*b*) Without moving the hairline, turn the calculator over.

(*c*) Hold the hairline steady with respect to the large disk, and rotate the small disk on the centigrade-millibar side to bring 0° C on the scale under the hairline.

(*d*) Hold fixed the small disk on the centigrade-millibar side of the calculator, and move the hairline to the desired centigrade temperature on the θ° C scale.

(*e*) Read the corresponding Fahrenheit temperature under the hairline on the Fahrenheit DP scale.

(*2*) *Example.*

(*a*) *Given.* Temperature = —26.0° C.

(*b*) *To Find.* Equivalent temperature in degrees Fahrenheit.

(*c*) *Procedure.*

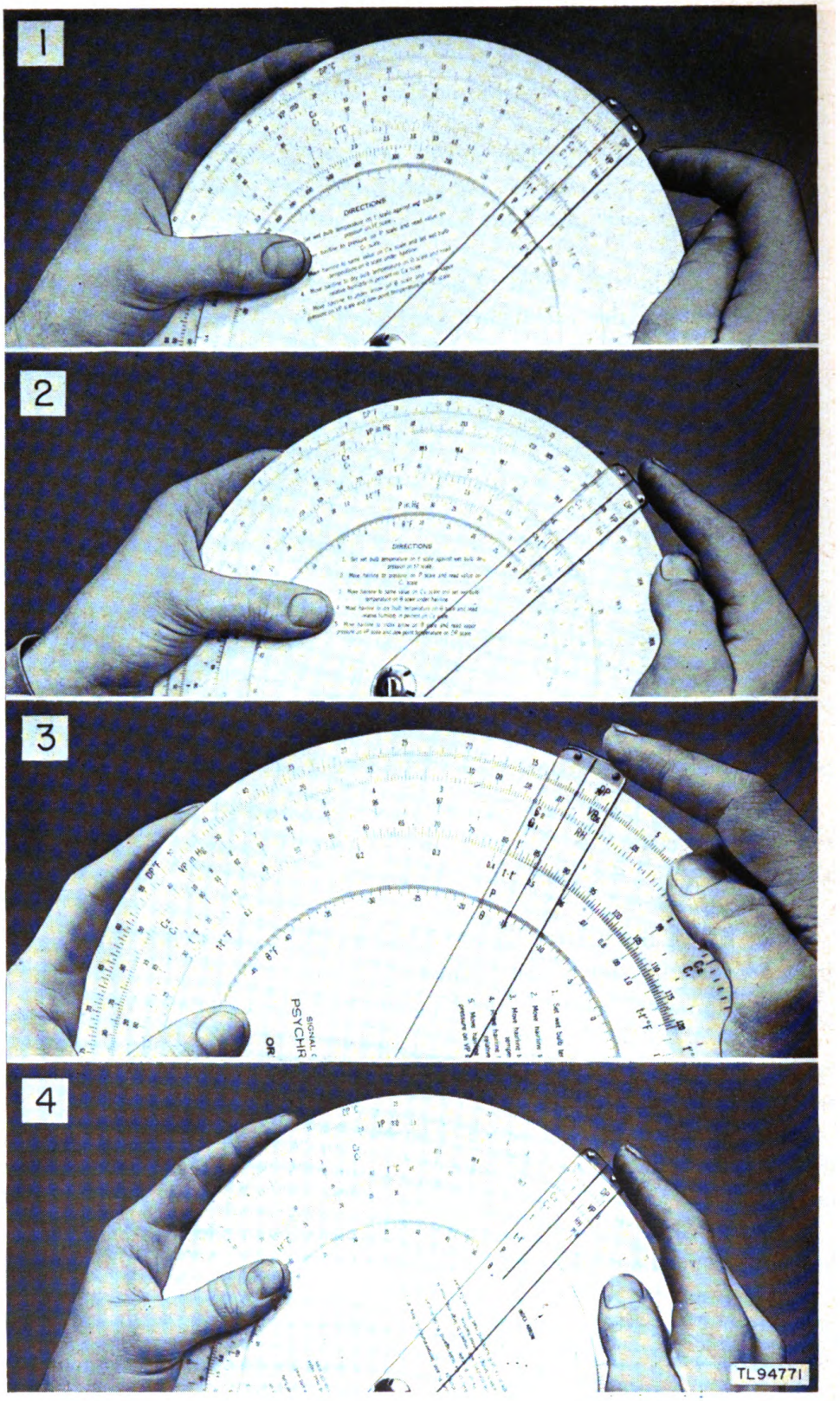

Figure 5. Converting Fahrenheit temperature to centigrade temperature.

1. Set the hairline at 32° F on the DP° F scale.

2. Hold the hairline fixed with respect to the setting, turn the calculator over to the back and rotate the small disk on the centigrade-millibar side to bring O° C under the hairline on the θ° C scale.

3. Hold the disks steady, and move the hairline to —26.0° C on the θ° C scale.

4. Turn the calculator over to the front side and read —14.8° F equivalent temperature under the hairline on the DP scale.

f. Converting Pressure in Inches of Mercury to Pressure in Millibars.

(*1*) *Procedure.* To convert pressure in inches of mercury into millibars (or from millibars into inches of mercury), use the C_2 and P scales on the centigrade-millibar side of the calculator. Consider that the C_2 scale is graduated in inches of mercury pressure units.

(*a*) Use the hairline and set 30 inches of mercury on the C_2 scale against 1,016 millibars on the P scale. A reading of 30 inches of mercury is equal to 1,016 (more exactly 1,015.9) millibars.

(*b*) Without moving the disks, move the hairline to the given pressure value in inches of mercury on the C_2 scale, and read the corresponding pressure in millibars under the hairline on the P scale.

(*2*) *Example.*

(*a*) *Given.* Pressure = 15.6 inches of mercury.

(*b*) *To Find.* Equivalent pressure in millibars.

(*c*) *Procedure.* Use the centigrade-millibar side of the calculator, and proceed as follows:

1. Use the hairline and set 30 inches of mercury on the C_2 scale against 1,016 millibars on the P scale.

2. Move the hairline to 15.6 inches of mercury on the C_2 scale, and read 528 millibars equivalent pressure on the P scale.

g. Converting Pressure in Millibars to Pressure in Inches of Mercury.

(*1*) *Procedure.* The procedure for converting pressure in millibars to pressure in inches of mercury is the same as the procedure described in paragraph f(1) above, except that the pressure in inches of mercury is read on the C_2 scale from settings of the hairline in millibars on the P scale.

(*2*) *Example.*

(*a*) *Given.* Pressure = 600 millibars.

(*b*) *To Find.* Equivalent pressure in inches of mercury.

(*c*) *Procedure.* Use the centigrade-millibar side of the calculator and proceed as follows:

1. Use the hairline and set 30 inches of mercury on the C_2 scale against 1,016 millibars on the P scale.

2. Move the hairline to 600 millibars on the P scale and read an

equivalent pressure of 17.7 inches of mercury on the C_2 scale.

NOTE: In the procedure of subparagraphs f and g above, the VP scale may be used instead of the C_2 scale if desired.

h. Converting Pressure in Millimeters of Mercury to Pressure in Millibars.

(*1*) *Procedure.* To convert pressure in millimeters of mercury into pressure in millibars (or from pressure in millibars to pressure in millimeters of mercury) use the VP and P scales on the centigrade-millibar side of the calculator. Consider the labeled units on the VP scale to be pressure in centimeters of mercury, where centimeters of mercury equal 0.1 times the equivalent pressure in millimeters of mercury.

(*a*) Use the hairline and set 7.5 on the VP scale against 100 on the P scale. A reading of 7.5 centimeters of mercury or 75 millimeters of mercury equals 100 millibars.

(*b*) Hold the disks fixed with respect to each other, and move the hairline to the given value of pressure in centimeters of mercury on the VP scale. Read the corresponding pressure in millibars under the hairline on the P scale.

NOTE: When converting from pressure in millibars to pressure in millimeters of mercury, proceed as above except that pressures in centimeters of mercury are read on the VP scale from settings of the hairline in millibars on the P scale. Multiply the pressure in centimeters of mercury by 10 to get the value in millimeters of mercury.

(*2*) *Example.*

(*a*) *Given.* Pressure = 540 millimeters of mercury.

(*b*) *To Find.* Equivalent pressure in millibars.

(*c*) *Procedure.*

1. Use the hairline and set 7.5 on the VP scale against 100 on the P scale (centigrade-millibar side of the calculator).

2. Mentally multiply 540 millimeters of mercury by 0.1 to obtain 54.0 centimeters of mercury.

3. Move the hairline to 54.0 on the VP scale, and read 720 millibars equivalent pressure on the P scale.

i. Multiplication and Division. To perform multiplication and division with Psychrometric Calculator ML-322/UM, use the C_2 and P scales on the centigrade-millibar side of the calculator. Disregard the decimal point in the C_2 and P scale numbers when performing multiplication and division. Thus 150 on the P scale can represent 1.5, 15.0, 0.0015, 150,000, or any other value whose principal digits are 1 and 5. The position of the decimal point in the final answer is based upon a rough calculation.

(*1*) *Multiplication Procedure.*

(*a*) Use the hairline and set the multiplicand (disregarding the decimal point) on the C_2 scale against either the index 100 or the index 1,000 on the P scale (whichever is better in completing the operation in subpar. (b) below). Sometimes setting the 100 index on the P scale

opposite the multiplicand on the C_2 scale locates the multiplier on the P scale beyond the limit of the C_2 scale where the product is to be read. In that case, use the 1,000 index; the product then appears on the C_2 scale opposite the number on the P scale representing the multiplier.

(*b*) Move the hairline to the multiplier on the P scale (disregarding the decimal point), and read the answer under the hairline on the C_2 scale.

(*c*) Determine the position of the decimal point in the answer by a rough calculation of the product.

(*2*) *Example of Multiplication.* Find the product of 45 x 6.4. Proceed as follows:

(*a*) *Given.* Multiplicand = 45.
Multiplier = 6.4.

(*b*) *To Find.* Product of 45×6.4.

(*c*) *Procedure.* Use the centigrade-millibar side of the calculator and proceed as follows:

1. Use the hairline and set 45 on the C_2 scale against 1,000 on the P scale. (The use of the 100 index is unsatisfactory (subpar. (1) (a) above).)

2. Move the hairline to 640 on the P scale and read 28.8 under the hairline on the C_2 scale.

3. By rough calculation ($50 \times 6 = 300$) the decimal place is determined, and the product is therefore 288.

(*3*) *Division Procedure.*

(*a*) Use the hairline and set the dividend on the C_2 scale against the divisor on the P scale.

(*b*) Move the hairline to 100 or 1,000 on the P scale and read the answer on the C_2 scale. Use that index value on the P scale which gives a reading on the C_2 scale nearest the high end of that scale.

(*4*) *Example in Division.* Find the quotient of $287 \div 82$.

(*a*) *Given.* Dividend = 287.
Divisor = 82.

(*b*) *To Find.* Quotient of $287 \div 82$.

(*c*) *Procedure.*

1. Use the hairline and set 28.7 on the C_2 scale against 820 on the P scale.

2. Move the hairline to 1,000 on the P scale, and read 35 on the C_2 scale.

3. A rough calculation of the quotient $(240 \div 80)$ is 3. The quotient desired, therefore, is 3.5.

NOTE: In the procedures for multiplication and division (subpar. i above), the VP scale may be used instead of the C_2 scale if desired.

7. USE OF PSYCHROMETRIC CALCULATOR ML-322/UM WITH AEROGRAPHS.

The relative humidity indicated by the hygrometric element of an aerograph must be corrected for the dynamic effects of air speed. The pressure and temperature affecting the hygrometer are greater than the static or ambient pressure and free air temperature. The relative humidity of the free air can be determined with Psychrometric Calculator ML-322/UM if the following values are known:

aerograph indicated relative humidity (RH_1),
aerograph effective pressure (P_1),
static or ambient pressure (P_2),
aerograph indicated temperature (t_1),
free air temperature (t_2).

a. Procedure.

(*1*) Use the hairline and set the indicated relative humidity in percent (RH_1) on the C_2 scale against the effective pressure (pressure at the hygrometer or P_1) on the P scale.

(*2*) Hold the disks steady, and move the hairline to the static pressure (P_2) on the P scale.

(*3*) Hold the hairline fixed with respect to the large disk, and rotate the small disk to bring the aerograph indicated temperature (t_1) on the θ scale under the hairline.

(*4*) Move the hairline to the free air temperature (t_2) on the θ scale, and read the corrected relative humidity (humidity of the free air) under the hairline on the C_2 scale.

NOTE: To find the dew point and vapor pressure of the free air, hold the setting of the calculator as in subparagraph (4) above, and move the hairline to the index arrow on the θ scale. Read the dew point under the hairline on the DP scale and the vapor pressure on the VP scale.

b. Example.

(*1*) *Given.* Aerograph indicated relative humidity = 68 percent.
Aerograph effective pressure = 637 millibars.
Static or ambient pressure = 600 millibars.
Aerograph indicated temperature = —10.3° C.
Free air temperature = —14.8° C.

(*2*) *To Find.* Corrected or free air relative humidity in percent.
Free air dew point in degrees centigrade.
Free air vapor pressure in millibars.

(3) *Procedure.* Use the centigrade-millibar side of the calculator.

(*a*) Use the hairline and set 68 percent (indicated relative humidity) on the C_2 scale against 637 millibars (effective pressure) on the P scale.

(*b*) Move the hairline to 600 millibars (static or ambient pressure) on the P scale.

(*c*) Hold the hairline fixed with respect to the large disk, and rotate the small disk to bring —10.3° C (indicated temperature) on the θ scale under the hairline.

(*d*) Hold the small disk steady, and move the hairline to —14.8° C (free air temperature) on the θ scale. Read 96 percent corrected or free air relative humidity on the C_2 scale.

(*e*) Hold the small disk firmly in place, and move the hairline to the index arrow on the θ scale. Read —15.2° C (dew point) on the DP scale and 1.62 millibars (vapor pressure) on the VP scale.

NOTE: The dew point may be read on the θ scale if, after setting the disks as in subparagraph (c) above, the hairline is moved to 100 on the C_2 scale.

8. USE OF PSYCHROMETRIC CALCULATOR ML-322/UM WITH AIRCRAFT PSYCHROMETERS.

Psychrometric Calculator ML-322/UM, when used with an airborne psychrometer, simplifies the correction of observed data by the rapid and accurate evaluation of the humidity of the air at the point of wet- and dry-bulb temperature measurement (indicated relative humidity) and the conversion of that value to the true humidity of the free air at the level of flight. The humidity indication of the psychrometer is influenced by the increased pressure and temperature at the thermometers caused by the adiabatic compression and friction which occur when the psychrometer disturbs the air flow. When the indicated wet- and dry-bulb temperatures, the effective and static pressures, and the free air temperatures are known, the relative humidity, dew point, and vapor pressure of the free air may be determined with Psychrometric Calculator ML-322/UM as follows:

a. Procedure.

(*1*) Determine the indicated relative humidity from the known values of indicated wet- and dry-bulb temperatures and effective pressure (pressure at the thermometers) by the general method described in paragraph 6a.

(*2*) Convert the indicated relative humidity to the true relative humidity, dew point, and vapor pressure by following the directions of paragraph 7. Use the given values of relative humidity as RH_1, effective pressure as P_1, static pressure as P_2, indicated dry-bulb temperatures as

t_1, and free air temperatures as t_2, and solve for RH_2, the true relative humidity, and for the equivalent dew point and vapor pressure of the free air.

b. Simplified Procedure. The two sets of computations described in subparagraph a above are printed on the centigrade-millibar side of Psychrometric Calculator ML-322/UM. It is possible, however, to combine several of the steps and to simplify the combined procedure as follows:

(*1*) Set the indicated wet-bulb temperature on the t′ scale against the indicated wet-bulb depression on the t — t′ scale.

(*2*) Hold the disks in position and move the hairline to the effective pressure on the P scale. Read the value under the hairline on the C_1 scale.

(*3*) Move the hairline to the same value on the C_2 scale as read on the C_1 scale.

(*4*) Hold the hairline fixed with respect to the large disk and rotate the small disk to bring the effective pressure on the P scale again under the hairline.

(*5*) Move the hairline to the static pressure on the P scale.

(*6*) Hold the hairline fixed with respect to the large disk, and rotate the small disk to bring the indicated wet-bulb temperature on the θ scale under the hairline.

(*7*) Move the hairline to the true dry-bulb temperature (free air temperature) on the θ scale. Read the true relative humidity of the free air on the C_2 scale.

(*8*) Move the hairline to the index arrow on the θ scale, and read the true dew point on the DP scale and the true vapor pressure on the VP scale.

c. Example.

(*1*) *Given.*
Indicated dry-bulb temperature = 12.2° C.
Indicated wet-bulb temperature = 9.4° C.
Indicated wet-bulb depression = 2.8° C.
True dry-bulb temperature = 8.0° C.
Effective pressure = 766 millibars.
Static or ambient pressure = 728 millibars.

(*2*) *To Find.*
True relative humidity in percent.
True dew point in degrees centigrade.
True vapor pressure in millibars.

(*3*) *Procedure.* Use the centigrade-millibar side of the calculator and proceed as follows:

(*a*) Set 9.4° C (indicated wet-bulb temperature) on the t′ scale against 2.8° C (indicated wet-bulb depression) on the t — t′ scale.

(*b*) Move the hairline to 766 millibars (effective pressure) on the P scale, and read 87.8 on the C_1 scale.

(*c*) Move the hairline to 87.8 on the C_2 scale.

(*d*) Hold the hairline fixed with respect to the large disk and rotate the small disk to bring 766 millibars (effective pressure) on the P scale under the hairline.

(*e*) Move the hairline to 728 millibars (static or ambient pressure) on the P scale.

(*f*) Hold the hairline fixed with respect to the large disk, and rotate the small disk to bring 9.4° C (indicated wet-bulb temperature) on the θ scale under the hairline.

(*g*) Move the hairline to 8.0° C (true dry-bulb temperature) on the θ scale, and read 92 percent (true relative humidity) under the hairline on the C_2 scale.

(*h*) Move the hairline to the index arrow on the θ scale, and read 6.7° C (true dew point) on the DP scale and 9.83 millibars (true vapor pressure) on the VP scale.

PART THREE

PREVENTIVE MAINTENANCE

SECTION III. PREVENTIVE MAINTENANCE TECHNIQUES

9. MEANING OF PREVENTIVE MAINTENANCE.

Preventive maintenance may be defined as a systematic series of operations performed periodically on equipment in order to maintain top efficiency in performance, to minimize unwanted interruptions in service, and to eliminate major break-downs. To appreciate the meaning of the term *preventive maintenance*, it is necessary to distinguish between preventive maintenance, trouble shooting and repair. The primary function of preventive maintenance is to prevent major break-downs and the consequent necessity of repair. In sharp contrast, the primary function of trouble shooting and repair is to locate and correct existing defects. The importance of preventive maintenance cannot be overemphasized. The usefulness of an entire meteorological system depends upon each piece of meteorological equipment in the system being ready to operate at peak efficiency when needed. Consquently, it is vitally important that operators and repairmen of meteorological equipment maintain their equipment properly.

NOTE: The operations in section III are considered first and second echelon (organization operators and repairmen) maintenance.

10. DESCRIPTION OF PREVENTIVE MAINTENANCE TECHNIQUES.

a. Most of the parts of any meteorological equipment require routine preventive maintenance. Those requiring maintenance differ in the kind and amount required. The six basic maintenance operations are FEEL, INSPECT, TIGHTEN, CLEAN, ADJUST, and LUBRICATE. The lettering system adopted for this system is as follows:

F — Feel
I — Inspect
T — Tighten
C — Clean
A — Adjust
L — Lubricate

The first two operations establish the need for the other four. The selection

of operations is based on a general knowledge of field requirements. Field use without continuous inspection and the continuous performance of necessary tightening, cleaning, and lubricating will result in most equipment becoming operationally erratic, undependable, and subject to breakdown when it is most needed.

b. Psychrometric Calculator ML-322/UM requires only routine inspection (I) and cleaning (C).

SECTION IV. PREVENTIVE MAINTENANCE ITEMS

11. COMMON MATERIALS.

Have the following items on hand before beginning maintenance work; paper, blotter, soap and water, a soft cloth or chamois, and Solvent, Dry Cleaning, Federal spec No. P-S-661a.

12. PREVENTIVE MAINTENANCE OF PSYCHROMETRIC CALCULATOR ML-322/UM.

a. Inspect (I). Inspect the exposed parts of the calculator for dirt and oil or grease stains. Lift the small disks and inspect the spaces between them and the large disk for particles of dirt. Inspect the cursor for accumulations of dirt.

b. Clean (C).

(*1*) To remove accumulations of dirt or other foreign matter from the spaces between the disks, draw a piece of paper between the disks while applying a slight pressure to the disks.

(*2*) To remove dirt from the spaces under the cursor, slip a piece of paper under the cursor, and draw the paper back and forth until the under side of the cursor is clean. To remove accumulations of grease from the spaces under the cursor, insert a blotter moistened with the dry-cleaning solvent under the cursor and move the blotter back and forth.

NOTE: Leaded gasoline will not be used as a cleaning fluid for any purpose. Solvent, Dry Cleaning, Federal spec No. P-S-661a, is available, as a cleaning fluid, through established supply channels. Oil, Fuel, Diesel, U. S. Army spec No. 2-102B, may be used for cleaning purposes when dry-cleaning solvent is not at hand. Since unleaded gasoline is available only in limited quantities, and in certain locations, it should be used for cleaning purposes only when no other agent is available. Carbon tetrachloride, or fire-extinguishing liquid (carbon tetrachloride base), will be used, if necessary, *only on contact parts of electronic equipment.*

(*3*) To remove dirt, oil, and grease from the exposed surfaces of the calculator, clean the surfaces with a soft cloth or chamois, soap and water. Never use acetone, benzine, lacquer thinners, or abrasives on the calculator (par. 5c). The dry-cleaning solvent may also be used effectively.

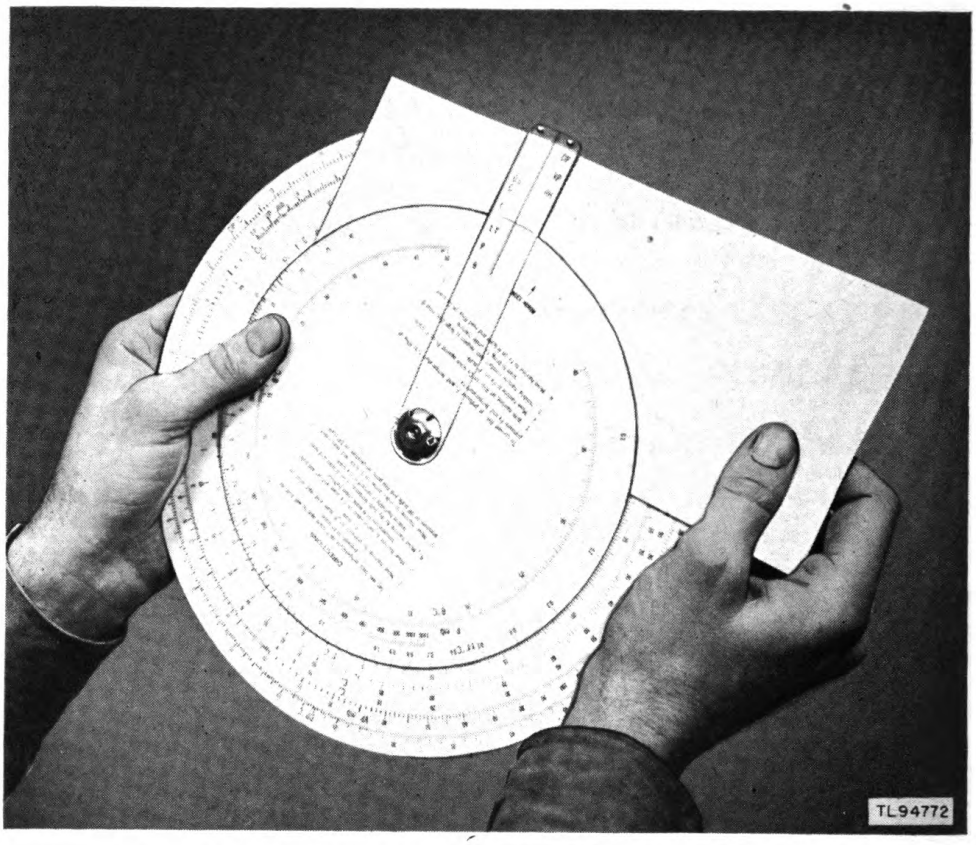

Figure 6. Cleaning Psychrometric Calculator ML–322/UM.

SECTION V. LUBRICATION

NOTE: Lubrication is not required for Psychrometric Calculator ML-322/UM.

SECTION VI. MOISTUREPROOFING AND FUNGIPROOFING

NOTE: Moistureproofing and fungiproofing is not required for Psychrometric Calculator ML-322/UM.

PART FOUR

AUXILIARY EQUIPMENT

(NOT USED)

PART FIVE

REPAIR INSTRUCTIONS

NOTE: Failure or unsatisfactory performance of equipment used by Army Air Forces will be reported on Army Air Forces Form No. 54 (unsatisfactory report).

SECTION VII. THEORY OF EQUIPMENT

13. DESIGN OF PSYCHROMETRIC CALCULATOR ML-322/UM.

a. The design of the psychrometric calculator is based upon a definite psychrometric formula (Annual Report of the Chief Signal Officer, 1886, Appendix 24, pp 233 — 259); upon vapor pressure values for temperatures below the ice point (American Society of Heating and Ventilating Engineers, Journal Section, Heating, Piping, and Air Conditioning, January 1942), and for temperatures above 0° C as determined by the Third International Conference on Steam Tables, (Mechanical Engineering, November 1935, pp 710 — 713).

b. Ferrel's formula for temperatures in degrees Fahrenheit is expressed as follows:

$$e = e' - 0.000367\ P\ (t - t')\ \left(1 + \frac{t' - 32}{1571}\right)$$

For temperatures in degrees centigrade, the formula is expressed as follows:

$$e = e' - 0.00066\ P\ (t - t')\ (1 + 0.00115\ t')$$

In the above formulas, t is the dry-bulb temperature, t′ the wet-bulb temperature, P the barometric pressure of the atmosphere, e′ the saturation vapor pressure (in the same units as P) at the wet-bulb temperature, and e the vapor pressure (also in the same units as P) corresponding to the given conditions of t, t′, and P.

c. The vapor pressure values introduced into Ferrel's psychrometric formula for computing the scales of the calculator are those measured over a surface of water for wet-bulb temperatures above freezing. For wet-bulb temperatures below freezing, the vapor pressure values are measured over a surface of ice. In keeping with standard practice in the United States for computing relative humidity by the formula RH = e/E, the actual vapor pressure (e), as determined by Ferrel's equation, is referred to the saturation vapor pressure (E) over water if the dry-bulb temperature is above 0° C, and to the saturation vapor pressure (E) over ice, if the dry-bulb temperature is below 0° C.

SECTION VIII. REPAIR

14. GENERAL REPAIR.

If a disk is cut, deformed, badly defaced, or otherwise damaged, order a new Psychrometric Calculator ML-322/UM (Signal Corps stock No. 7A5895-322). If the cursor arm is broken or otherwise damaged, order a new calculator. Psychrometric Calculator ML-322/UM requires no adjustments and no replacement of parts.

APPENDIX

SECTION IX. MAINTENANCE PARTS

15. MAINTENANCE PARTS FOR PSYCHROMETRIC CALCULATOR ML-322/UM.

A maintenance parts list is not required as a part of the technical manual for this equipment because of the nature and use of the equipment involved. The equipment should be replaced as a unit in the event of failure.

SECTION X. REFERENCES

16. FORMS AND OTHER TECHNICAL PUBLICATIONS.

Army Air Forces Form No. 54 (unsatisfactory report).
Annual Report of the Chief Signal Officer, 1886, Appendix 24.
American Society of Heating and Ventilating Engineers, Journal Section, Heating, Piping, and Air Conditioning, January 1942.
Mechanical Engineering, November 1935.

17. ABBREVATIONS.

C	— centigrade
DP	— dew point
F	— Fahrenheit
Hg	— mercury
mb	— millibar
P	— atmospheric pressure
RH	— relative humidity
t	— dry-bulb temperature
t′	— wet-bulb temperature
t — t′	— wet-bulb depression
VP	— vapor pressure
θ	— theta (temperature)

18. GLOSSARY.

The following glossary contains information in explanation of the technical meteorological terms used in this manual.

Abrasive. Any grinding material.

Acetone. An inflammable liquid (CH_3COCH_3) with a bitter taste, obtained by the destructive distillation of certain wood, acetates, and various organic compounds.

Adiabatic. Any process in which compression or expansion of a gas takes place without the loss or gain of heat or energy.

Aerograph. An instrument designed for installation in aircraft to measure the temperature, pressure, and humidity of the upper air.

Benzine. A mixture of several of the lighter constituents of petroleum. Obtained by the fractional distillation of petroleum. Used as a solvent.

Centimeter. A measure of length in the metric system equal to the one-hundredth part of a meter. It is equal to 0.3937 inch.

Concentric. Having a common center.

Conversion. The act of changing from one form, substance, or thing to another.

Dew point. The temperature to which the air can be cooled at constant pressure without causing condensation. It is the temperature for which the saturation vapor pressure is identical with the pressure of the vapor in the air.

Dividend. A number or quantity to be subjected to the operation of division by another number or quantity.

Divisor. The number or quantity by which another (the dividend) is divided.

Effective pressure. The mean pressure which exists at the surface of a detecting or measuring element of an aircraft meteorological instrument.

Free air temperature. The temperature of the undisturbed air at the level of flight.

Hygrometer. An instrument designed to measure and indicate the atmospheric humidity.

Millibar. A unit of atmospheric pressure. Equal to 1/1,000 bar or 1,000 dynes per square centimeter. One millibar equals 0.0295299 inch of mercury.

Multiplicand. The number or quantity to be multiplied by another (the multiplier).

Multiplier. The number or quantity in multiplication which shows how many times another number is to be increased.

Product. The result obtained by multiplying two or more quantities together.

Psychrometer. An instrument used to measure atmospheric humidity. It consists of two thermometers, the bulb of one of which is kept moistened. By means of suitable formula the readings of the dry- and wet-bulb thermometers can be converted to various forms of the atmospheric humidity.

Quotient. The result of the process of division.

Relative humidity. The ratio, expressed as a percentage, of the actual vapor pressure in a given volume to the water vapor pressure which would be present if the space were saturated (saturation vapor pressure) at the same temperature.

Saturation vapor pressure. If a surface of water is exposed within a confined space, some of the water will vaporize into the space. At any given temperature, there is a definite upper limit to the amount of water that can vaporize. When this limit is reached, the space is said to be saturated, and the pressure of the vapor within the space is the saturation vapor pressure for that temperature. Saturation vapor pressure increases with temperature.

Vapor pressure. The pressure exerted by the vapor of a liquid. In meteorology, the term is usually used to designate the vapor pressure of water.

Vinyl chloride-acetate. A chemical plastic. Properties are toughness, adhesiveness, imperviousness to moisture, and stability toward light and heat.

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