ALTIMETRY MANUAL

AND

OPERATING INSTRUCTIONS

FOR

W & T SURVEYING ALTIMETERS

Instruction Book No. FIA-112-1-3

WALLACE & TIERNAN
COMPANY INC.
25 MAIN ST., BELLEVILLE 9, N. J.

ALTIMETRY MANUAL

and

OPERATING INSTRUCTIONS

for

WALLACE & TIERNAN

SURVEYING ALTIMETERS

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WALLACE & TIERNAN CO., INC.
BELLEVILLE 9, NEW JERSEY
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FORM NO. 2232-1

ILLUSTRATIONS

CONTENTS

INTRODUCTION

Wallace & Tiernan Surveying Altimeters are intended for use in obtaining elevations for supplementary vertical control of aerial photographs used in topographic mapping, pipe line and highway location, geological and geophysical exploration, and similar requirements.

The basic principle of altimetry is that the pressure caused by the weight of the column of air above the observer decreases as the observer rises in altitude. The relationship between pressure and altitude is not constant since air is compressible. Furthermore, changes in air density caused by variations in temperature, relative humidity, and gravity will change the pressure versus altitude ratio.

In order to eliminate the need for converting pressure readings to altitude, aneroid barometers are calibrated in feet and the mechanism is designed so that the pointer will deflect the same amount for equal changes in altitude. This provides a linear scale and when calibrated in this fashion, the instrument is properly called an altimeter. In order to calibrate an altimeter, a standard pressure-altitude relationship is used. Because altitude is relative to pressure, it should be stressed that the altimeter can be used only to <u>measure differences</u> in elevation with respect to some base or reference station, preferably a point of known elevation.

The pressure-altitude relationship holds good only for certain standard conditions. If these conditions do not exist while the survey is being made, then corrections have to be applied. Temperature has the greatest effect on the density of the air and is, therefore, the most significant. A correction for relative humidity is required only when high humidity occurs with high temperature. The temperature and humidity corrections are obtained from a chart supplied with altimeters. The correction for gravity is insignificant and is rarely applied.

The air temperature correction described above should not be confused with the instrument temperature correction. The altimeter indication may change if the instrument temperature is altered even though the atmospheric pressure remains constant. Wallace & Tiernan altimeters are compensated so that the correction is small and need not be applied unless temperatures at successive stations differ widely.

Barometric pressure changes will affect the altimeter just as altitude changes do. Since the atmosphere is continually changing, it is necessary to take the pressure changes into consideration. The success with which pressure changes are evaluated, determines the accuracy of the altimeter survey. During inclement weather and when there are high, gusty winds, atmospheric conditions are very unstable and altimetry will not yield accurate results.

If reasonable limitations and precautions are observed, a majority of the elevations will be found correct within 2 or 3 feet and the maximum error will not exceed 8 feet.

Three methods of precision altimetry are described later. The old Single-Base Method requires a minimum of altimeters and observers. The Two-Base Method has become the accepted standard for accuracy. The new Leapfrog Method appears to yield results comparable to the Two-Base Method.

GENERAL DESCRIPTION OF THE SURVEYING ALTIMETER

The Wallace & Tiernan Surveying Altimeter consists essentially of a precision aneroid mechanism shock-mounted in its case. The mechanism includes a pressure sensitive element, a low-inertia movement, a balanced pointer, and a custom calibrated dial. Flexure pivots, a backlash eliminator, and a jewel bearing are used to insure sensitivity. A mirrored ring is provided to eliminate parallax when reading the pointer. The dial window is shatterproof. An adjusting screw for zero setting allows the instrument to be set to correspond to available standards or other altimeters. A revolution indicator shows the observer whether to read the inner or outer ring of graduations. Carrying means are provided.

Types FA-112, FA-181 and FA-185 all have the same mechanism, and dials approximately 5" in diameter.

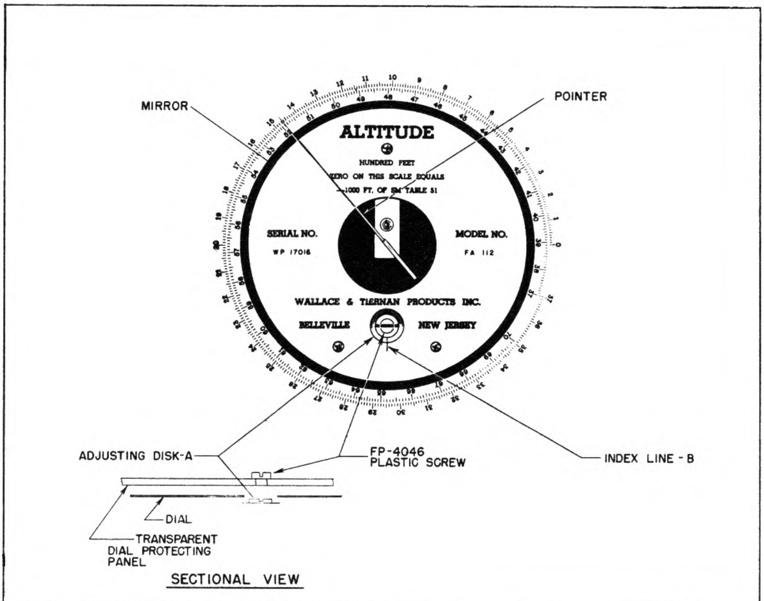


FIG. 1

Typical Altimeter Dial

Figure 1, is a facsimile of a dial on an altimeter. In order that the graduations on the dial face may be fairly wide spaced and legible, the instrument has been designed so that the pointer travels nearly two revolutions in covering the complete range. This provides a long scale, approximately twenty-nine (29) inches in length. The dial is graduated from 0 to 70, each major graduation representing one hundred (100) feet, the minor graduation, ten (10) feet intervals. Zero on the scale is equal to - 1,000 feet on Smithsonian Meteorological Table 51; 70 being equal to 6,000 feet. The outer scale is calibrated from 0 to the mid-thirties; the inner scale from the mid-thirties to 70. Two other standard ranges for altimeters are 0-16,000 feet, with zero equal to minus 1,000 feet on Smithsonian Meteorological Table 51, and 0 to 4,000 feet with zero equal to minus 1,000 on the same tables. In some instances altimeters are calibrated to special order and will cover other ranges. (See Fig. 18 and Fig. 19 for Smithsonian Meteorological Table 51.)

Type FA-176 is a more sensitive instrument having a narrow range of -500 to 1500 feet per Smithsonian Meteorological Table 51 (-150 to 500 meters) with graduations of 5 feet (1 meter). The single revolution dial is about 8 1/2" in diameter with a scale 20" long. A desiccant is provided in a container in the side of the case. A canvas carrying case with lid is provided. (See Figs. 2 and 3).

The type FA-112 surveying altimeter has a square, wooden case with hinged lid. The mechanism is attached to the dial plate, which is fastened to the case, by means of rubber shock absorbers. The lid may be removed, for wall mounting of the instrument, by pressing up on the hinge latch and sliding the lid hinges out of engagement. (See Fig. 4 and Fig. 5). The canvas carrying case has a pocket suitable for an armored thermometer.

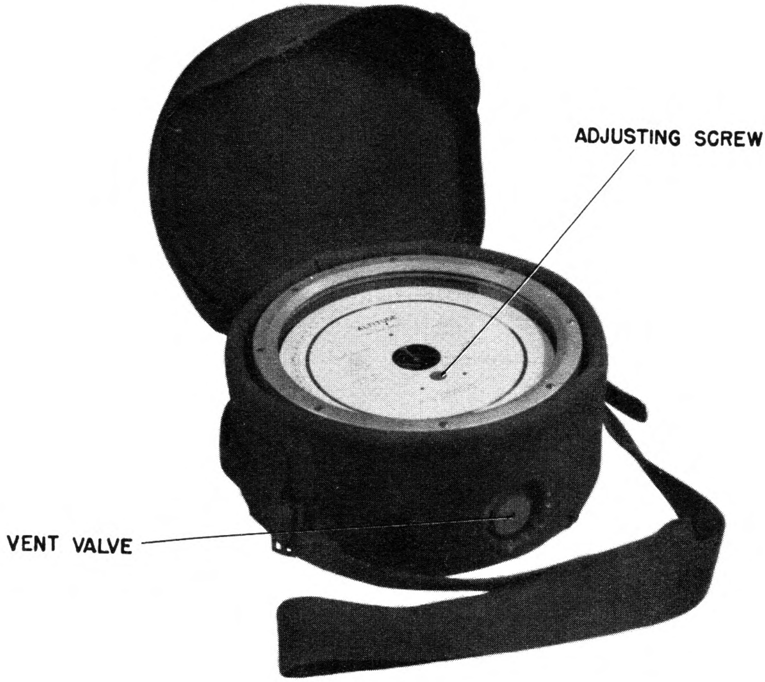


FIG. 2

Wallace & Tiernan Surveying Altimeter Type FA-176 in Carrying Case.

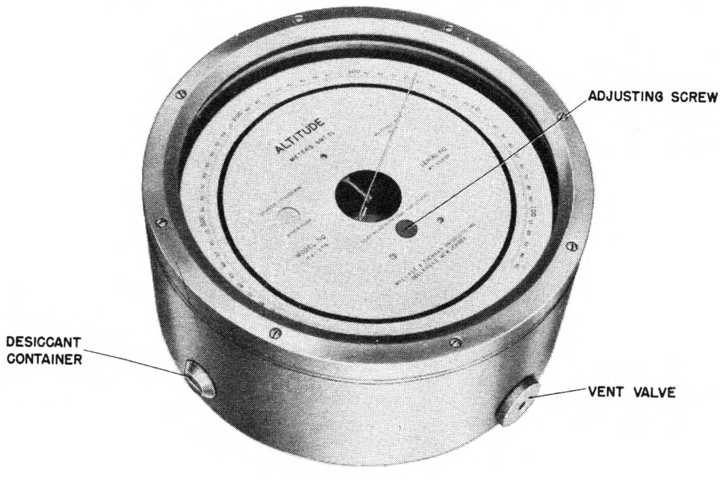


FIG. 3

Wallace & Tiernan Surveying Altimeter Type FA-176

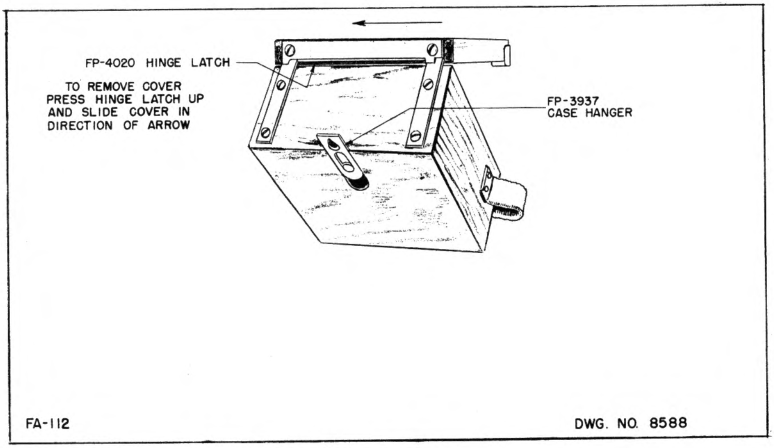


FIG. 4

Cover Removal Procedure for FA-112

The type FA-181 is a military model with its round aluminum case serving also as the carrying case. The hinged aluminum lid has space under the folding chart for a small screw driver and a folding sling psychrometer. The lid may be removed for wall mounting the instrument. A desiccant (silica gel) is provided in a tubular container inserted in the side of the case; it should be dried out or renewed when the blue indicating disc on the dial turns pink. (See Fig. 6).

The type FA-185 has a round aluminum case with no lid. A leather carrying case with hinged lid is provided. An armored thermometer is housed in the side of the case. (See Fig. 7).

In type FA-112, the window closure is dust tight but not air tight. Type FA-181 has a rubber vent cap in the lid which may be positioned to close the small vent tube, projecting thru the window, when the lid is shut. The case is then air tight. The type FA-185 case is made air tight by replacing the screwplug having the hole in it, which is in the window over the adjusting screw, by the blank plug. The spare plug is stored by screwing it in the hole provided in the bezel. Type FA-176 is sealed or vented by turning the disc handle of the valve which projects thru the side of the case.

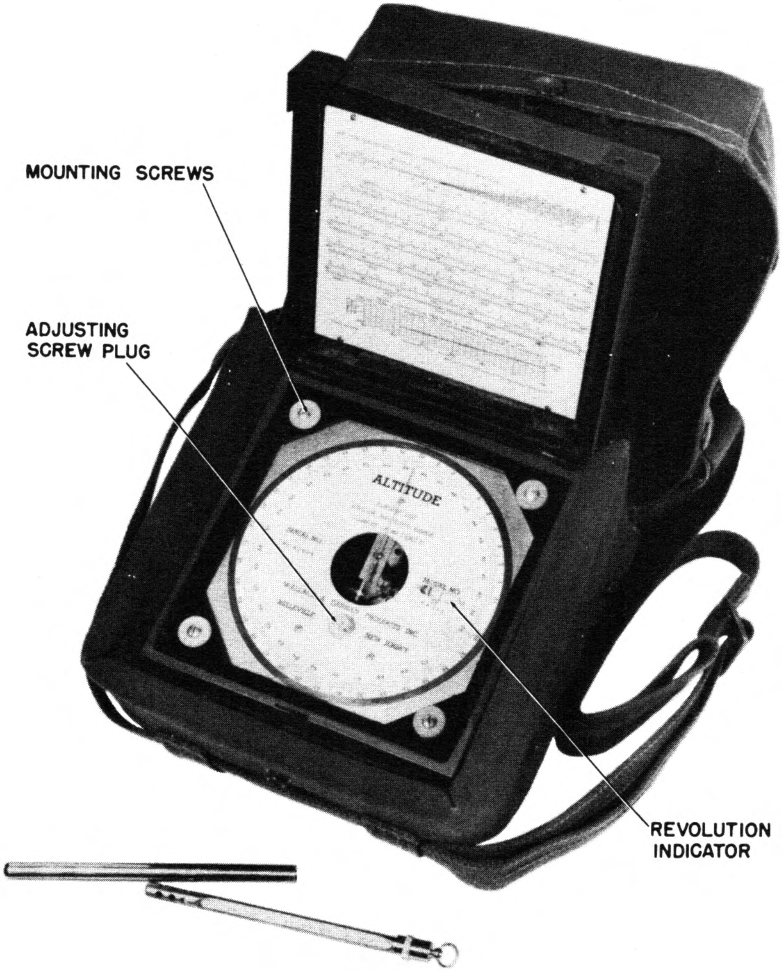


FIG. 5

Type FA-112 in carrying case

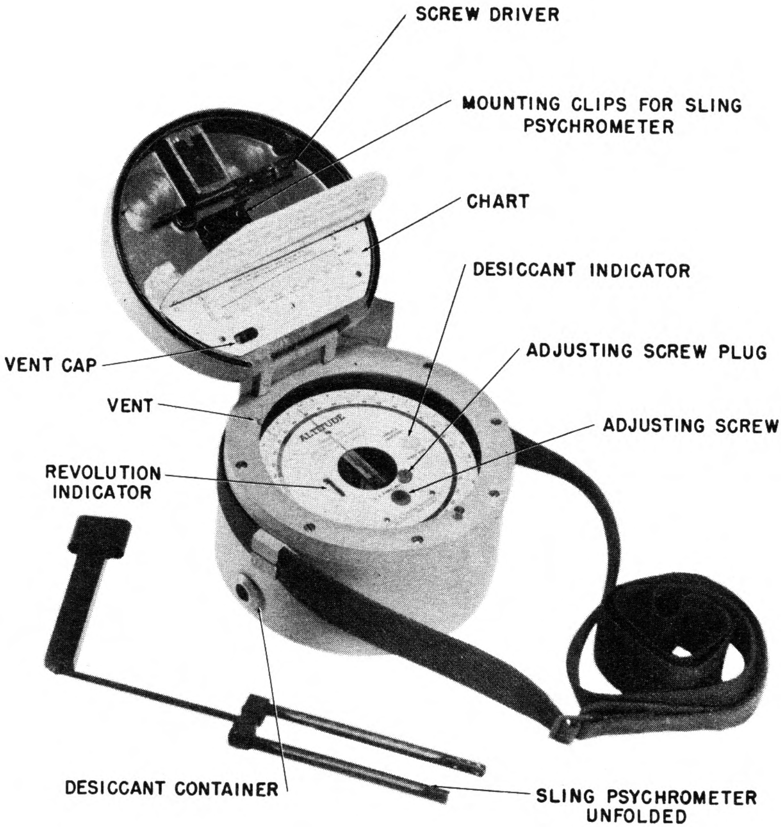


FIG. 6

Wallace & Tiernan Surveying Altimeter Type FA-181 with Folding Sling Psychrometer

Located inside the cover of the surveying altimeters is a printed form containing three charts: (1) Air Temperature and Relative Humidity Correction Factor for Altitude, (2) A scale for converting the altitude reading in feet to the pressure equivalent in millibars or inches of mercury, and (3) Temperature correction curve for that particular instrument. Referring to scale (2), on instruments where the zero has been shifted to avoid negative values, correct the altimeter reading to the true value before entering the conversion scale.

FIG. 7

Wallace & Tiernan Surveying Altimeter Type FA-185

CARE OF INSTRUMENT

The surveying altimeter is a precision instrument. It has been constructed just as ruggedly as the service for which it is intended will permit. However, in an instrument as sensitive and accurate as this altimeter, delicate parts must be used. The altimeter is to be handled with care.

The instrument window is made of clear plastic approximately 1/4" thick. This material is relatively soft and scratches easily. It should not be wiped with a soiled or gritty cloth. An occasional coat of wax, well rubbed on with a clean soft cloth will provide a protective film.

The mechanism of the altimeter does not require oil. Oil will only interfere with proper functioning and introduce serious errors in readings. It cannot be too strongly stressed - - - DO NOT USE OIL ON THE MECHANISM.

OPERATION

When used as a portable altimeter for surveying it should be held as nearly level as possible, with dial horizontal and the lid back. Some models have a removable lid to permit wall mounting when used for meteorological purposes.

Make sure that the instrument case is open to atmosphere. FA-112 and FA-181 are ready to read when the lid is open. FA-185 must have the blank shipping plug replaced by the screw plug having the hole thru it and which is stored in the extra hole in the bezel. FA-176 must have the manual (disc handle) valve open. This valve is located on the side of the case.

When reading, to avoid parallax error, position the eye so that the pointer and its image in the annular mirror coincide.

A revolution indicator is provided to denote whether the pointer should be read with reference to the outer or inner ring of graduations. The subsidiary scale for the revolution indicator has marks for the high limit of the main scale, the change-over point, and the low limit.

To set the altimeter to agree with another one or a known standard (zero setting) insert blade of screwdriver in the slot of the adjusting disc in the face of the dial. Turn screw to give the desired setting; a clockwise rotation causes a counterclockwise movement of the pointer. The adjustment is limited to approximately 800 feet (200 feet in FA-176).

AIR TEMPERATURE AND RELATIVE HUMIDITY CORRECTION INSTRUCTIONS

This correction is required when using the Single Base or Leapfrog methods of altimetry. The altitude correction chart combines the correction factors for air temperature and relative humidity as they appear respectively in Tables 52 and 54 of the Fifth Revised Edition, Smithsonian Meteorological Tables. This chart is shown in Fig. 8

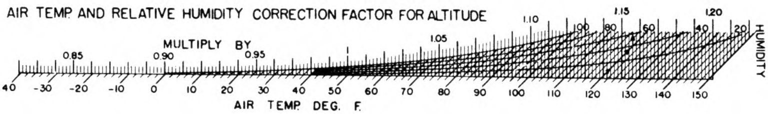


FIG. 8

and inside the lid of the case. Both ambient temperature and percentage of relative humidity are required when using the above methods. The latter may be obtained with a sling psychrometer and a psychrometric chart. A folding sling psychrometer is stowed in the case lid of type FA-181, and a psychrometric chart is included in this manual. (See Fig. 9).

WET BULB TEMPERATURE °F

DRY BULB TEMPERATURE °F	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
50	5	16	27	38	49	61	74	87	100																														
52		9	19	29	40	51	63	75	87	100																													
54		3	12	22	32	42	53	64	76	88	100																												
56			7	16	25	34	44	55	65	76	88	100																											
58			1	10	18	27	37	46	56	66	77	89	100																										
60				5	13	21	30	39	48	58	68	78	89	100																									
62					8	16	24	32	41	50	59	69	79	89	100																								
64					4	11	18	26	34	43	51	60	70	79	90	100																							
66						7	14	21	29	36	44	53	61	71	80	90	100																						
68						3	10	16	23	31	38	46	54	62	71	80	90	100																					
70							6	12	19	25	33	40	48	55	64	72	81	90	100																				
72							3	9	15	21	28	34	42	49	57	65	73	82	91	100																			
74								5	11	17	23	29	36	43	50	58	65	74	82	91	100																		
76								3	8	13	19	25	31	38	44	51	59	66	74	82	91	100																	
78									5	10	16	21	27	33	39	46	53	60	67	75	83	91	100																
80									3	7	12	18	23	29	35	41	47	54	61	68	75	83	91	100															
82										4	10	14	20	25	30	36	42	48	55	61	69	76	84	92	100														
84										1	7	12	16	21	26	32	37	43	49	56	62	69	76	84	92	100													
86											5	9	14	18	23	28	33	39	44	50	57	63	70	77	84	92	100												
88											3	7	11	15	20	25	30	35	40	46	51	57	64	70	77	85	92	100											
90											1	5	9	13	17	22	26	31	36	41	47	52	58	65	71	78	85	92	100										
92												3	7	11	15	19	23	28	32	37	42	48	53	59	65	72	78	85	92	100									
94													5	9	12	16	20	24	29	33	38	43	49	54	60	66	72	79	85	93	100								
96													3	7	10	14	18	22	26	30	35	39	44	50	55	61	66	73	79	86	93	100							
98													1	5	8	12	15	19	23	27	32	36	40	45	50	55	61	67	73	79	86	93	100						
100														3	7	10	13	17	21	24	28	33	37	41	46	51	56	62	68	73	80	86	93	100					
102														1	5	8	11	15	18	22	26	30	34	38	42	47	52	57	62	68	74	80	86	93	100				
104															3	7	10	13	16	20	23	27	31	35	39	43	48	53	58	63	69	74	80	87	93	100			
106																5	8	11	14	17	21	24	28	32	36	40	44	49	53	58	64	69	75	81	87	93	100		
108																3	7	10	12	16	19	22	25	29	33	37	41	45	49	54	59	64	70	75	81	87	93	100	
110																	5	8	11	14	17	20	23	26	30	34	38	42	46	50	55	60	65	70	75	81	87	93	100
112																	4	7	9	12	15	18	21	24	27	31	35	38	42	47	51	55	60	65	70	76	81	87	94
114																		6	8	11	13	16	19	22	25	28	32	35	39	43	47	52	56	61	66	71	76	82	88
116																			7	9	12	14	17	20	23	26	29	33	36	40	44	48	52	57	61	66	71	76	82
118																			6	8	11	13	16	18	21	24	27	30	34	37	41	45	49	53	57	62	67	72	77
120																				6	9	12	14	17	19	22	25	28	31	34	38	41	45	49	53	58	62	67	72
122																					8	10	13	15	18	20	23	26	29	32	35	39	42	46	50	54	58	63	67
124																					7	9	11	14	16	18	21	24	27	30	33	36	39	43	47	50	54	59	63
126																						8	10	12	15	17	19	22	25	27	30	33	37	40	44	47	51	55	59
	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110

% RELATIVE HUMIDITY TABLE (Barometric Pressure 29.92. Air Velocity 600 feet (or more) per minute.)

FIG. 9

Psychrometric Chart

To measure relative humidity, proceed as follows. Remove sling psychrometer from lid. Slide handle off thermometers as far as it will go. Rotate thermometer head 180^{o} on its link, swing handle 90^{o} on its end of link. Saturate the sock on the wet bulb thermometer with water. Holding the handle of the psychrometer in one hand, with the link and thermometer assembly at right angles, rapidly revolve the thermometers. About two revolutions per second or more will be equivalent to 600 linear feet per minute specified in the tables, this radius of revolution being 10 inches. Revolve for at least one minute. Immediately read temperature of both thermometers. The one with the wet sock gives the "wet bulb", the other gives the "dry bulb" temperature. Find on the psychrometric chart the intersection of the appropriate temperatures and read off the percentage of relative humidity.

Knowing the air temperature (dry bulb) and relative humidity find the altitude correction from the chart above. The long horizontal lines, curving upward, represent relative humidity from 0 to 100%. The straight lines at approximately 45^{o}, represent air temperature from -40 to +150^{o}F.. The straight vertical lines represent the correction factor to be applied, from 0.82 to 1.22. For example, assume air temperature 120^{o}F., and relative humidity 40%. Three small arrows are shown on the chart to aid in explanation. Locate the 120^{o}F. air temperature line and follow it on the 45^{o} angle to where it intersects the curving 40% relative humidity line. At this point, lay a line straight up, and read correction factor directly. In this example, it is 1.156. The observed difference of altitude as read on the altimeter multiplied by this factor will give the true altitude difference. For an observed difference of altitude of 290 feet at 120^{o}F. and 40% relative humidity, the true difference of altitude is thus 290 x 1.156 or 335.24 feet.

INSTRUMENT TEMPERATURE CORRECTION INSTRUCTIONS

Under normal survey conditions, it is not necessary to apply the instrument temperature correction to the altitude reading. The reason for this is that the altimeters are used to obtain relative readings and they will respond in the same manner to changes in temperature. It may be advisable to make the correction when altimeters in a group are operating under widely different temperatures, say 20°F. difference. Where an altimeter is used to obtain an absolute value of pressure (altitude), then the instrument temperature correction should be applied to the altimeter reading as follows.

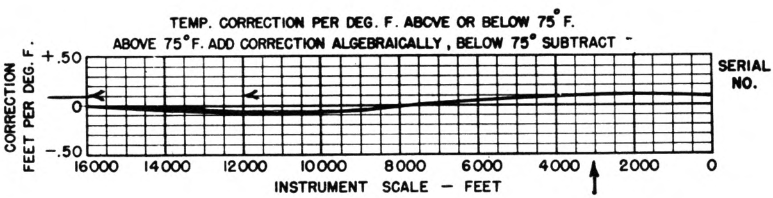


FIG. 10

Instrument Temperature Correction Chart

If the instrument temperature differs from the temperature at which it was calibrated (75°F.), correct the instrument reading by means of the BOTTOM CHART in the lid. (See Fig. 10). Find the altimeter reading along the bottom line of the chart. Go up in a straight line to the curved line. Go to the left in a straight line and read the correction per degree Fahrenheit. Multiply this value by the difference between instrument temperature and 75°F. to obtain the total correction noting whether it is a plus or minus correction. If the instrument temperature is above 75°F., add the correction algebraically to the altimeter reading. If the instrument temperature is below 75°F., subtract the correction algebraically from the altimeter reading.

EXAMPLE: The altimeter reads 3000 feet, the thermometer reads 60°F. What is the corrected reading?

Step 1: Read on instrument dial 3000'.
Step 2: Find 3000' on chart.
Step 3: Follow up to correction curve.
Step 4: Go left to edge and read correction per degree F. In this case the correction is plus 0.10 feet per degree F.
Step 5: Since the temperature is 60° which is 15° less than 75°F. subtract (plus 0.10 x 15) from 3000'. 3000 - (plus 0.10 x 15) = 3000 - 1.5 = 2998.5 feet which is the corrected reading.

PRECAUTIONS AND LIMITATIONS TO BE OBSERVED WHEN ESTABLISHING ELEVATIONS WITH ALTIMETERS

1. Observe station and field altimeters under similar conditions outdoors, but protect from sun and strong wind. Between stations the altimeter should be shaded.

2. Altimeter must be in horizontal position when observed, preferably on a level and stable support.

3. Cushion the altimeter against road shock, and avoid sudden jarring at all times.

4. Avoid midday observations. Best results may be obtained two to four hours after sunrise or before sunset.

5. Avoid observations during thunderstorms, whirlwind, or squall conditions.

6. If practicable, the initial and final readings of any run should not be over four hours apart.

7. Prior to field work all altimeters to be used on a survey should be observed simultaneously at intervals over a period of at least one day.

8. Station and field watches must be synchronized.

9. The movement of the pointer adjustment is limited; do not force this adjustment beyond its stops.

10. If possible, the difference in elevation between bases should be 250 feet or less.

11. The base stations should be within 12 miles or less of each other.

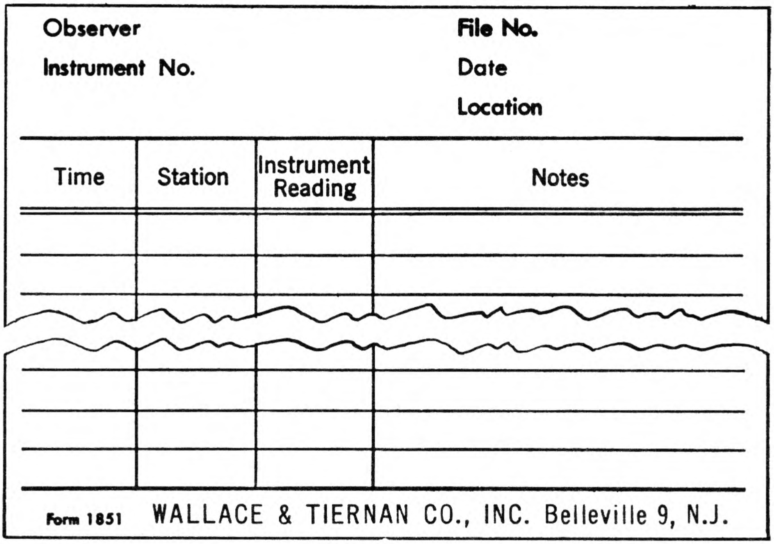
12. Observations outside the range of the base stations may not be reliable.

13. If possible, readings should be taken at several check or tie points in the area.

SINGLE-BASE METHOD OF ALTIMETRY

FIELD PROCEDURE: A point of known elevation, centrally located if possible, among the points for which elevations are to be determined by the observations being considered, should be selected for the base station. The first observation with the field instruments should be made at this point, and the observation should be made with particular care because upon it depends the accuracies of all the differences in elevation between base station and the unknown points. It is desirable to place the altimeters at the base station and wait for approximately ten minutes before making any readings to give the instruments an opportunity to become fully adjusted to the conditions of pressure and temperature. The station and field altimeters may be set in agreement if desired. Watches must be synchronized. After the initial reading has been made and the time, temperature, and humidity noted, the field instruments are transported to any other points within approximately ten miles of the base station, where elevations are desired, and observations of indicated altitude, time, temperature, and humidity (wet and dry bulb readings) made at each point and recorded. Meanwhile the base altimeter is read every five minutes and changes in weather conditions are noted. If other points of known elevation are available so that it is convenient to make similar observations thereon, desirable checks on the work are secured. Such checks are particularly valuable if located at or near the observed points most distant from the base station. After all desired points have been observed, each instrument is returned to the base station for a final observation of altitude, time, temperature, and humidity. This final observation should be of the same accuracy as the initial observation and since it must be made at the base station, it is convenient and desirable for the work to be arranged so that a loop or circuit is formed by the unknown points. The circuits should be arranged so that not more than four hours are required for completion.

FIELD NOTES: Standard level or transit notebooks may be used for recording the field notes, or Wallace & Tiernan Form 1851. (See Fig. 11). If there is any difference in elevation between the point for which the observation is desired and



Observer | File No.
Instrument No. | Date
| Location

Time	Station	Instrument Reading	Notes

Form 1851 WALLACE & TIERNAN CO., INC. Belleville 9, N.J.

FIG. II

(This form No. 1851 may be had on request)

Wallace & Tiernan Field Note Form

the point where the instrument was actually read, this difference should be determined by direct measurement with a tape or some comparable method. This difference is not set down in the notes, but is applied with the appropriate algebraic sign as a correction to the altitude reading of the point actually observed in order to record the "field altimeter readings" of the desired point. If the observed point is lower than the desired point, the correction is plus, and vice versa.

COMPUTATIONS: A computation sheet should provide spaces in the heading for the instrument number, names of observer and recorder, general weather notes, the date, locality, county, state, and country. In the body of the form, columns may be provided for the field records and the calculations for obtaining final adjusted elevations. A suggested form is as follows.

Column 1: Record the station name and number and such brief description as may facilitate identification. Any marked change in weather such as rain or wind squall should be noted in parentheses.

Column 2: Record the time of each field observation to the nearest minute.

Column 3: "Mean Temperature" is the average, to the nearest degree, of the field temperature and the base temperature, if necessary interpolating the latter to the minute of the field observation.

Column 4: "Mean Percent Relative Humidity" is the average percent of relative humidity obtained at the field and base stations.

Column 5: Record the Field Altimeter reading.

Column 6: "Index Difference" is the algebraic difference (base station instrument reading minus field instrument reading at base station).

Column 7: "Field Index" shows field altimeter readings changed to correspond with the initial station altimeter reading by applying the index difference in turn to each of the field instrument observations. Should it be convenient to set the two instruments to the same value for the initial reading at the base station, no entries need be made in columns 6 and 7.

Column 8: "Base Station Altimeter Reading" is interpolated directly from the station record of the base station altimeter to the probable reading at the minute the field observation was made.

Column 9: "Indicated Difference" represents the apparent difference in elevation between observed base station altitude and the observed field altitude, and is obtained by algebraically subtracting the value in column 8 from the value in column 7 directly opposite.

Column 10: "Temperature and Humidity Correction Factor" is obtained from the conversion chart.

Column 11: "Difference Corrected" is obtained by multiplying columns 9 and 10.

Column 12: "Unadjusted Elevation" is obtained by algebraic addition of the successive values of Column 11 to the elevation of the initial station.

Column 13: "Closure Adjustment" provides space for the arithmetical adjustment of the difference between initial and final values obtained at the bench mark, and intermediate elevations are adjusted proportionately. If the field altimeter observations have included other points of known elevation, the series of elevations are adjusted to such known elevations.

Column 14: "Adjusted Elevations" is the algebraic sum of columns 12 and 13.

Column 15: "Known Elevations" is provided for listing the elevations of any occupied points, which have been previously determined by spirit leveling so that the "closure adjustment" may be applied between these stations.

TWO-BASE METHOD OF ALTIMETRY

In Two-Base Altimetry, it is not necessary to apply the correction factors for temperature, relative humidity, latitude and altitude, as with other methods. The effect of all these conditions is taken into consideration by calibrating the vertical column of air over the area to be surveyed with respect to density. This is done

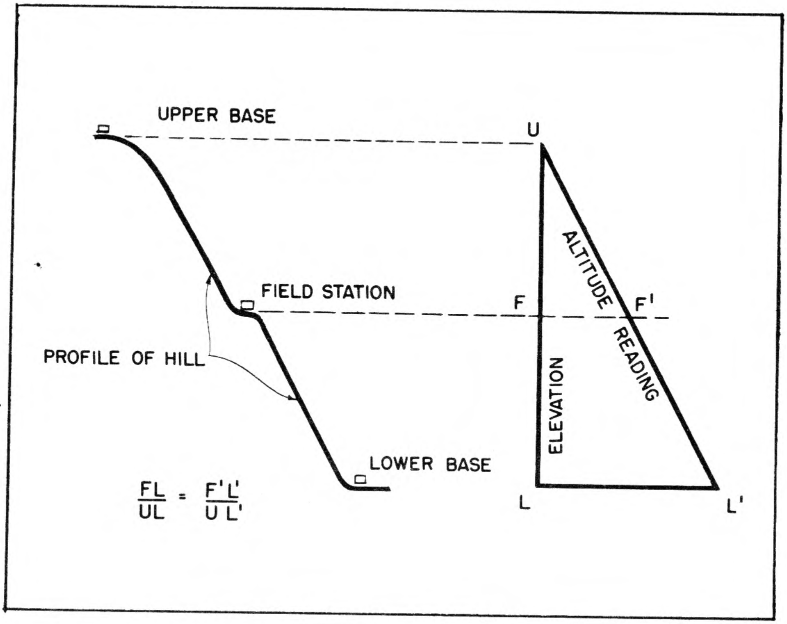


FIG. 12

Two Base Method

by reading base altimeters located at the vertical extremities of the area at the same time that the field altimeter at the unknown elevation is read. Fig. 12 illustrates the Two-Base Method.

To find the elevation of the field station, the difference in altitude readings taken simultaneously at the field station and the lower base, F'L' on Figure 12, is obtained and so is the difference in altitude readings between upper and lower bases, UL'. Since the difference in elevation between bases, UL, is known, a simple proportion yields the true difference in elevation between the field station and the lower base, FL. Recently a computer for the Two-Base Method has been made available thus eliminating calculations.

FIELD PROCEDURE: A lower and an upper base station should be selected in the area to be surveyed and the elevations of these stations established. One altimeter should be located at each station. The bases should be within ten miles of each other (the closer together the better) and should be chosen so that most points to be surveyed fall within the elevation range between bases. Best results are obtained when the difference in elevation between bases is 200 or 300 feet. In this case the average error will be less than two feet. When the vertical distance between bases is 2000 feet, the average error will be less than five feet. Any number of field altimeters can be used in conducting the survey.

In surveying with aneroid instruments, most satisfactory results are obtained when atmospheric conditions are fairly stable. Under these circumstances the atmospheric pressure is nearly uniform over a wide area. Very windy or inclement weather is an indication of rapidly and widely varying atmospheric pressure and it is inadvisable to survey with altimeters at such times. It has been found that the Two-Base Method can be used successfully when the wind speed does not exceed ten miles per hour.

Before starting the survey, the altimeters may be adjusted at one of the base stations so that they all read exactly alike. While all altimeters are at this base, they should be read simultaneously five times at two-minute intervals on the even minute. The mean of the five readings is used as the correct reading of the individual altimeters at this point. The instrument which is left at this base should be considered the comparison standard.

If the altimeters are not adjusted to correspond with each other at the base station an index difference will have to be used. The altimeters (one for the other base station and the field altimeters) which are taken from this base are compared with the comparison standard (the altimeter which is to be left at the starting point). The index difference is the algebraic difference between the comparison standard (starting point altimeter) and the other altimeter readings, at the base station.

Each altimeter reading except the comparison standard is corrected for its index difference. Should it be convenient to set the instruments to the same value for the initial reading at the base station, no entries for index difference need be made.

The base altimeters should be kept in the shade and read every five minutes. Any changes in weather conditions, especially wind speed, should be noted.

The field altimeters should be shielded from sunshine and at each observation point five readings should be taken on the even minute at two-minute intervals. The readings may start immediately on arrival at a station unless there has been an appreciable change in temperature from the preceding station, in which case it may be necessary to wait for five or ten minutes.

The instrument should be level when it is read. The pointer should be carefully aligned with its image in the mirror when taking a reading in order to avoid parallax error.

Whenever it is convenient to do so, field altimeters should be compared with each other during the course of the survey. It is also desirable to visit the same field stations with different field altimeters to check readings.

At the end of the day or after the required number of observations have been made, all altimeters should be returned to the base where the comparison standard altimeter is located. The altimeters should be read simultaneously as was done at the start of the survey in order to check the index differences.

FIELD NOTES: Standard level or transit notebooks may be used, or Wallace & Tiernan Form 1851. (See Fig. 11).

COMPUTATIONS FOR TWO-BASE METHOD

A suggested computation sheet, Wallace & Tiernan Form 1925, provides spaces in the heading for the instrument numbers, upper and lower bases, names of observer, computer and checker, the date, locality, and state. In the body of the form, spaces are provided for the field records and the calculations for obtaining final adjusted elevations. (See Fig. 13).

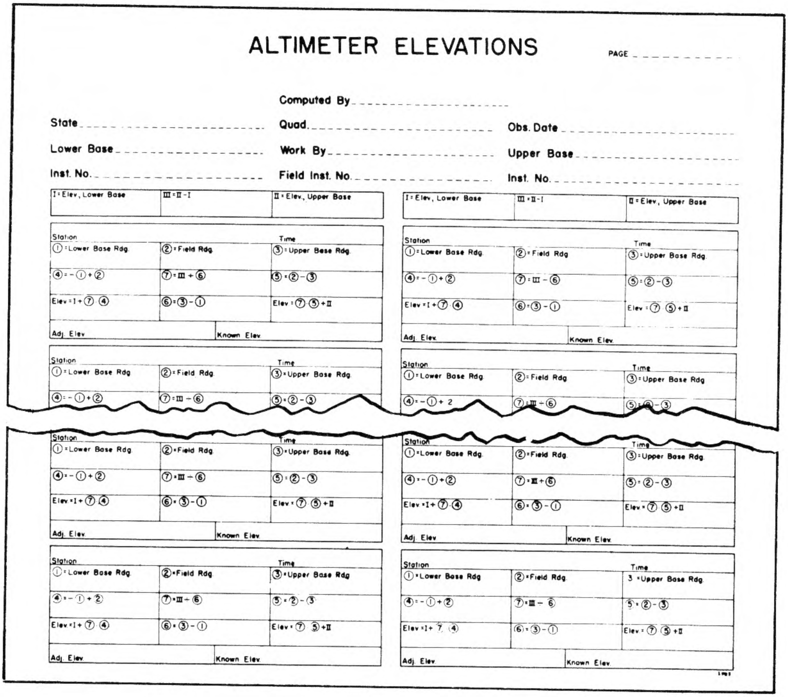
The steps in the computation procedure are as follows.

1. The lower base elevation, upper base elevation, and difference in upper base and lower base elevations shall be entered in blocks I, II, and III respectively.

2. The field station number and time of reading shall be entered in the corresponding blocks.

3. The remaining steps are self explanatory and simple providing the key to computations is followed in the order shown on the computation sheet.

4. Adjusted elevations - The adjustment of the computed altimeter elevations depends upon the


ALTIMETER ELEVATIONS PAGE

Computed By

State | Quad. | Obs. Date

Lower Base | Work By | Upper Base

Inst. No. | Field Inst. No. | Inst. No.

I = Elev., Lower Base	III = II - I	II = Elev., Upper Base
Station		Time
① = Lower Base Rdg.	② = Field Rdg.	③ = Upper Base Rdg.
④ = - ① + ②	⑦ = III + ⑥	⑤ = ② - ③
Elev = I + ⑦ ④	⑥ = ③ - ①	Elev = ⑦ ⑤ + II
Adj. Elev.	Known Elev.	

FIG. 13

(This form No. 1925 may be had on request)

Wallace & Tiernan Two-Base Computation Sheet

observations made on the roving altimeter at bench marks and other points of known elevation. The observations are called check or tie points. A minimum of two such points is desirable and more should be obtained if possible. If only two check points are used the observer can make an error in reading the altimeter at one of them, and that error will influence the final results for all other points obtained by that observer for the entire day. When more than two check points are used the computer usually can discover a faulty check point recording when an ordinary misreading is the apparent cause. Because of the many different conditions and circumstances under which a day's observations for any one altimeter are made, the computing and adjustment of new elevations require good judgment on the part of the computer for each individual problem. A knowledge of field procedure is very helpful.

Regardless of how carefully the observations and corrections are made, discrepancies will still appear when elevations by altimeters are found for bench marks or other points where elevations have been determined by higher order methods. The computer will have to adjust each series of elevations to make them agree with such tie points. Comparable corrections must then be applied to the elevations observed by the altimeter at new points which generally are found in the series between the tie points. It is assumed that such corrections are likely to be influenced by various factors, some of which are: elevation, elapsed time and horizontal distance. Between two ties that differ greatly in elevation it is probably best to prorate the adjustment through the intermediate new points according to elevation. If the ties are nearly at the same elevation, prorating according to time, distance or locality may be best. This is left to the judgment of the computer.

WALLACE & TIERNAN PALMER ALTIRULE

The Wallace & Tiernan Palmer Altirule may be used to calculate directly the elevations of field stations without resorting to computation when using the Two-Base Method.

LEAPFROG METHOD OF ALTIMETRY

A new method of altimetry is called the Leapfrog Method. (See Fig. 14). The same temperature and relative humidity corrections are required as are

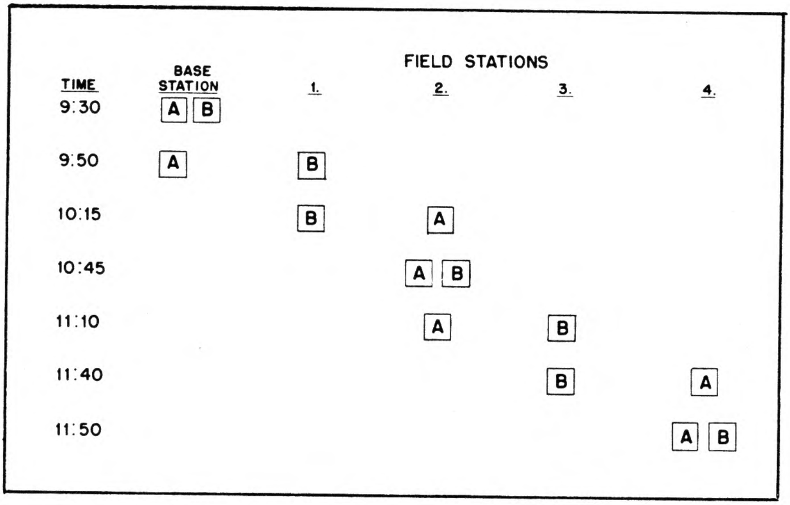


FIG. 14

Leapfrog Method

used in the Single Base Method but the observational procedure is different. In the Leapfrog Method, two altimeters are read simultaneously at a base station. Then one altimeter, "A", remains at the base station while the other, "B", advances to the first field station. The two altimeters are read simultaneously and the difference gives the elevation of the first field station after the appropriate temperature and relative humidity corrections are applied. Then altimeter "A" leaves the base station and leapfrogs the first field station and advances to the second field station. Meanwhile altimeter "B" remains at the first field station and again the altimeters are read simultaneously. The difference in altitude reading is corrected and determines the elevation of the second field station with respect to the first field station. Then the altimeters are brought together at the second field station and read. After the comparison, altimeter "B" advances to the third field station, altimeter "A" leapfrogs to the fourth field station, and the altimeters are compared at the fourth field station.

The survey may be speeded up by employing additional altimeters and by comparing altimeters at every third or fourth field station instead of at alternate stations. The advantage of the Leapfrog Method lies in the fact that the altimeters are always close together and, therefore, operate under the same atmospheric conditions. This contrasts with the fixed base methods where the roving altimeters move away from the base altimeters and perhaps encounter pressure and temperature conditions which do not affect the base altimeters.

Elevations are computed in the same way as outlined for the Single Base Method. Results are more accurate than with the Single Base Method, and may be comparable with the Two Base Method.

MAINTENANCE

These altimeters are precision instruments and each dial is individually calibrated for its particular mechanism. Each dial and mechanism is marked with a serial number and <u>they are not interchangeable</u>. Very little maintenance can be accomplished successfully in the field. Fig. 15 shows a phantom view of a typical mechanism. Complete overhaul is available at the Wallace & Tiernan factory at a nominal charge.

TO REMOVE MECHANISM FROM CASE

Removal of the mechanism from the case is not recommended except for emergency repair and should be done with extreme care.

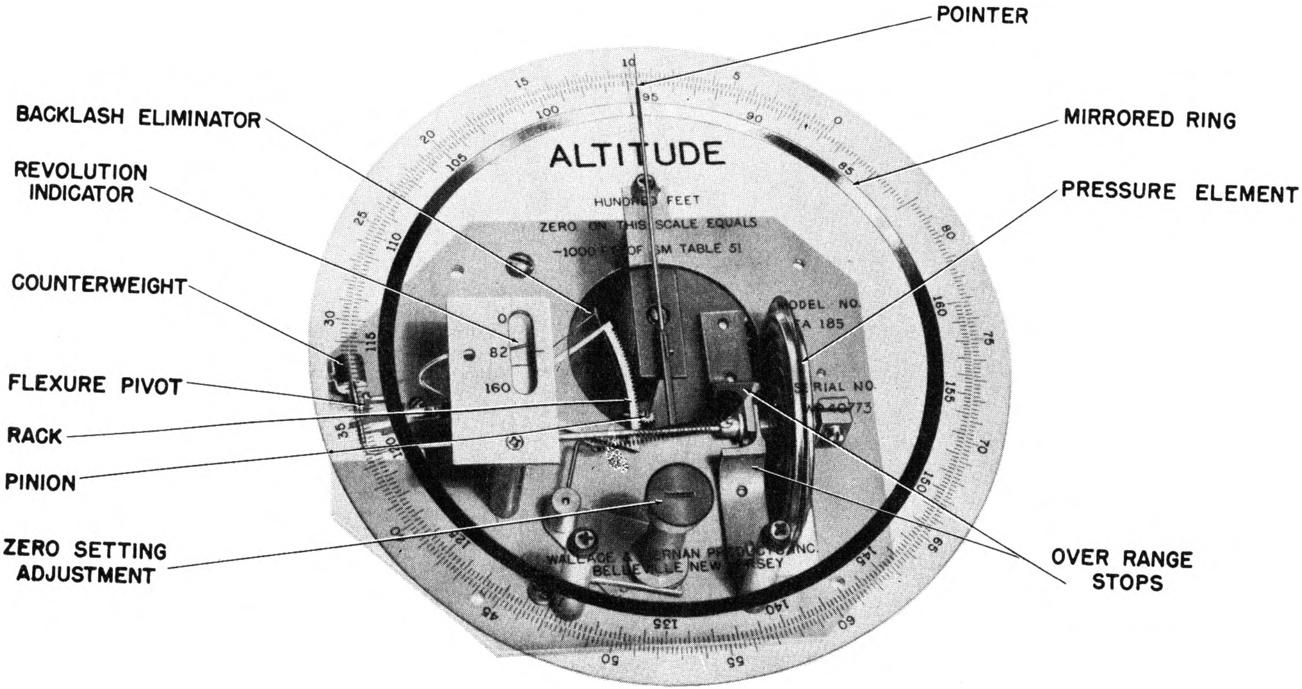


FIG. 15

FA-185 Mechanism

FA-112: Remove 4 corner screws and lift out window. Place index finger of each hand thru center hole of dial plate, taking care not to injure pointer, and lift dial plate straight up and out. The four corner rubber shock mounts will come out with the dial, on the back side of which the mechanism is mounted.

FA-176, FA-181, FA-185:

1. Remove the bezel with its window (first removing lid if provided).

2. Adjust the instrument being repaired to read the same altitude as another reference instrument by rotating the adjusting screw. This precaution is observed in order to be able to reset the instrument at its original value.

3. Using a small screw driver or the blade of a pen knife, loosen the pointer clamping screw and carefully lift the pointer from its shaft.

4. Remove 3 phillips head screws in dial; lift dial from posts.

5. Remove 4 screws (1, Fig. 16) at corners of mounting plate (2) holding it to brackets (3) of the rubber shock mounts (4).

6. With the case positioned so that the pair of posts (5 and 6) are to the right hand of the operator as in Figure 16, grasp the posts (5 and 6) between thumb and forefinger of the right hand so that the mechanism will not drop into the case. These two posts (5 and 6) are all that should be held in removing the mechanism from the case.

7. Press the near side of the mounting bracket

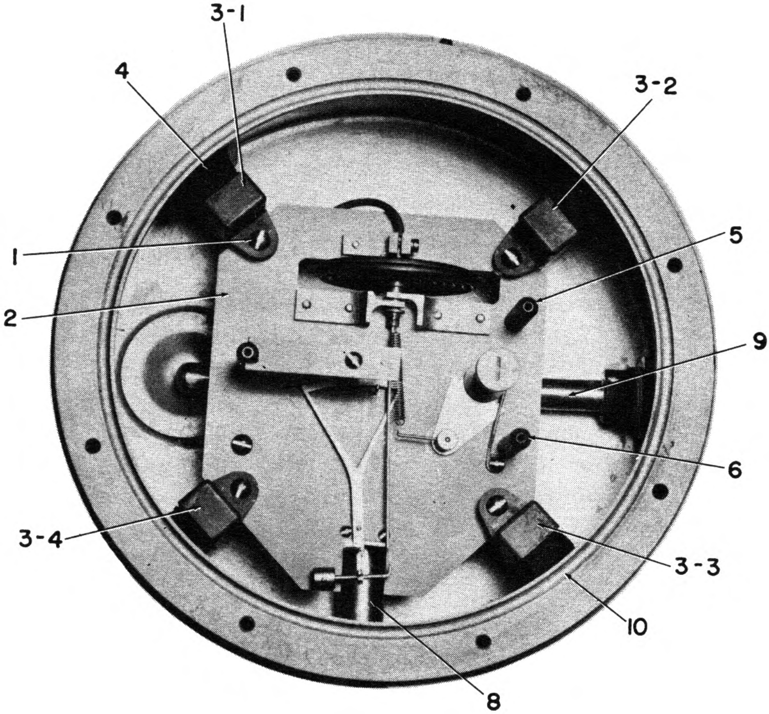


FIG. 16

Altimeter Mechanism FA-181, FA-185

(3-1) with the thumb of the left hand so the bracket (3-1) shifts to clear the mounting plate (2). Let the bracket (3-1) rest against the upper end of plate (2) so its corner is free to be lifted upward.

8. With the first two fingers of the left hand, push bracket (3-4) towards the left hand side of the case until the corner of plate (2) is free, then tilt left hand edge of plate (2) and lift it out moving towards left enough for right hand corners to slide under brackets (3-2) and (3-3). The portion which

extends under plate (2) of posts (5, 6 and 7) will thus clear desiccant container (8) and thermometer well (9) (where provided).

TO REPLACE MECHANISM IN CASE

FA-176, FA-181, FA-185:

1. Reverse the above procedure: grasp posts (5 and 6) between thumb and forefinger of right hand. (See Figure 16).

2. Hold mechanism in case so two right hand corners of mounting plate (2) are under the corresponding lugs of brackets (3-2) and (3-3). Lift plate (2) up against these lugs.

3. With thumb of left hand, push bracket (3-1) clear of corner until it rests against upper edge of plate (2).

4. With fingers of left hand, push bracket (3-4) into position. Pull plate (2) up snug against brackets with mounting holes lined up.

5. Replace 4 mounting screws (1).

6. Replace dial and the 3 phillips head screws.

7. Replace the pointer to agree <u>exactly</u> with the reference instrument to which the repaired instrument was previously adjusted. <u>Do not adjust by turning the adjusting screw</u>, but rotate the pointer on its shaft. Tighten pointer clamping screw.

8. Replace bezel with window, making sure that gasket is in place in groove (10).

9. Replace lid if provided.

TO RE-ENGAGE RACK AND PINION

Occasionally following a severe shock, the altimeter may show an error of some magnitude, which may indicate that the rack and pinion have jumped a tooth. Examination of the rack and pinion will disclose a prick punch mark located on the rack (large gear sector) between 2 teeth. There is also a similar mark on one tooth of the pinion. When in proper mesh, these two marks should be directly opposite each other. (See Fig. 17).

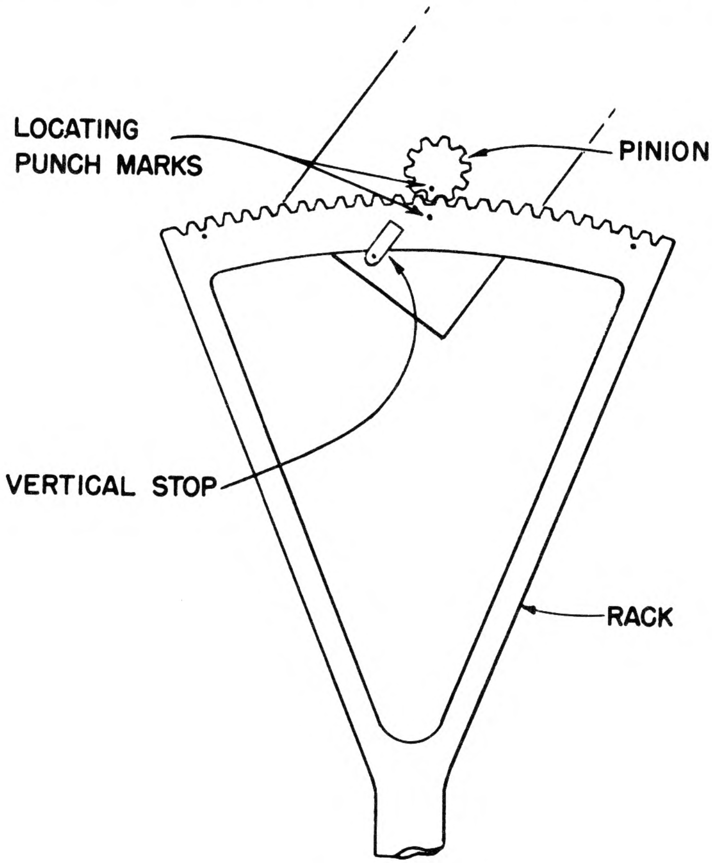


FIG. 17

Rack & Pinion

If out of mesh, swing the vertical stop away from the rack with the aid of small pliers. Gently raise the rack above the pinion and rotate the pinion until the punch marks line up. Allow the rack to return to normal position and reposition the stop.

TO RENEW DESICCANT

FA-176, FA-181:

When the desiccant condition indicator on the dial turns pink the moisture content of the air in the case is too high and the desiccant needs to be renewed. The desiccant is Silica Gel. To replace it, remove the capscrew from the desiccant tube, dump the old desiccant from the tube and dry (heat to 300°F. for 10 minutes) or refill with fresh desiccant.

TO PREPARE FOR TRANSPORT OR STORAGE

The altimeters are provided with adequate stops which limit movement of capsule and prevent damage to mechanism when instruments are subject to low pressure at high altitude. The instrument case of most models can be closed airtight as an additional precaution. This also serves to make them dust and moisture tight.

FA-176: The case is made airtight simply by closing the vent valve in the side of the case.

FA-181: The rubber vent cap is positioned to close the vent when the lid is shut and latched.

FA-185: The screwplug having the hole thru it is replaced by the blank plug which is tightened against its gasket. The blank plug is screwed in the hole provided in the bezel.

FA-112: The case is reasonably dust-tight, but cannot be made airtight. No additional precaution need be observed for protection against low pressures on instruments with serial numbers higher than WP-51500. Instruments having lower serial numbers, however, are not fully protected by their stops, and must be put inside of an auxilliary container which will be tight at about 15 psi. air pressure inside.

For storage, no special treatment is required. However, it is wise to store in a dry place, away from excessive heat or vibration.

GUARANTEE

Wallace & Tiernan warrants for a period of one year after shipment that the apparatus shipped, of its manufacture, is free from defects in workmanship and materials, but its liability is limited to the replacement f.o.b. Newark, N. J. of the defective parts thereof.

The apparatus covered by these instructions was sold under the above guarantee. We are anxious to maintain this guarantee and stand back of our apparatus absolutely. We will appreciate information regarding operating difficulties and we are prepared to give detailed advice at all times. Our guarantee, however, is contingent upon the apparatus being treated in accordance with these instructions.

NEW PARTS

We carry in stock all parts that for any reason might require renewal. In ordering new parts, please designate each desired part by the name shown on the cut shipped with the apparatus, and state the type of apparatus as specified thereon, giving type designation and serial number.

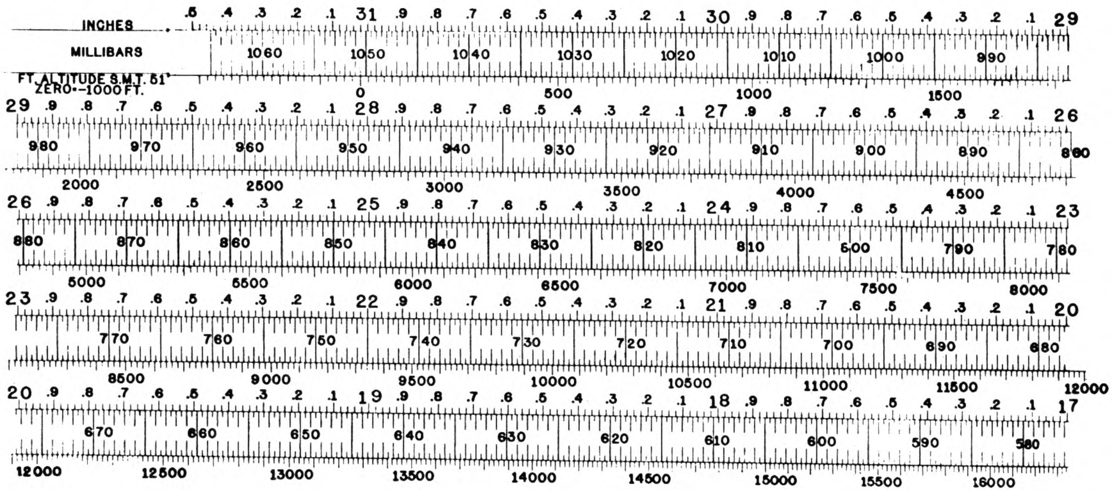


FIG. 18

CONVERSION CHART

Smithsonian Meteorological Table 51 (5th Revised Edition) with zero equal to minus 1000 ft.

SMITHSONIAN METEOROLOGICAL TABLE 51

ALTI-TUDE	INCHES HG	MILLI-BARS	ALTI-TUDE	INCHES HG	MILLI-BARS
-1000	31.0205	1050.479	2000	27.7788	940.701
- 900	30.9066	1046.621	100	27.6768	937.246
- 800	30.7931	1042.777	200	27.5751	933.804
- 700	30.6800	1038.948	300	27.4740	930.380
- 600	30.5673	1035.132	400	27.3730	926.958
- 500	30.4551	1031.330	2500	27.2724	923.554
- 400	30.3430	1027.536	600	27.1723	920.162
- 300	30.2318	1023.769	700	27.0725	916.782
- 200	30.1208	1020.010	800	26.9733	913.424
- 100	30.0102	1016.264	900	26.8740	910.061
0	29.9000	1012.532	3000	26.7753	906.719
100	29.7902	1008.814	100	26.6770	903.389
200	29.6807	1005.108	200	26.5790	900.071
300	29.5717	1001.417	300	26.4814	896.766
400	29.4632	997.740	400	26.3843	893.476
500	29.3551	994.081	3500	26.2873	890.191
600	29.2471	990.425	600	26.1907	886.922
700	29.1397	986.788	700	26.0945	883.665
800	29.0327	983.163	800	25.9987	880.420
900	28.9261	979.553	900	25.9032	877.187
1000	28.8200	975.960	4000	25.8081	873.965
100	28.7140	972.371	100	25.7133	870.755
200	28.6086	968.800	200	25.6190	867.562
300	28.5035	965.243	300	25.5250	864.379
400	28.3988	961.698	400	25.4311	861.197
1500	28.2945	958.166	4500	25.3377	858.034
600	28.1906	954.647	600	25.2446	854.883
700	28.0871	951.142	700	25.1519	851.744
800	27.9839	947.648	800	25.0595	848.616
900	27.8812	944.168	900	24.9675	845.499

FIG. 19

CONVERSION TABLE

SMITHSONIAN METEOROLOGICAL TABLE 51 (Contd.)

ALTITUDE	INCHES HG	MILLIBARS	ALTITUDE	INCHES HG	MILLIBARS
5000	24.8758	842.394	8000	22.2762	754.361
100	24.7845	839.301	100	22.1944	751.591
200	24.6934	836.218	200	22.1129	748.831
300	24.6027	833.146	300	22.0317	746.081
400	24.5124	830.088	400	21.9508	743.341
5500	24.4224	827.039	8500	21.8702	740.611
600	24.3327	824.002	600	21.7898	737.891
700	24.2433	820.976	700	21.7098	735.181
800	24.1543	817.961	800	21.6301	732.481
900	24.0656	814.957	900	21.5507	729.791
6000	23.9772	811.964	9000	21.4715	727.111
100	23.8892	808.982	100	21.3927	724.441
200	23.8014	806.011	200	21.3141	721.780
300	23.7140	803.051	300	21.2358	719.130
400	23.6269	800.102	400	21.1578	716.489
6500	23.5402	797.164	9500	21.0801	713.858
600	23.4537	794.236	600	21.0027	711.236
700	23.3676	791.319	700	20.9256	708.624
800	23.2818	788.413	800	20.8487	706.022
900	23.1962	785.518	900	20.7722	703.429
7000	23.1111	782.633	10000	20.6959	700.845
100	23.0262	779.759	200	20.5442	695.707
200	22.9417	776.898	400	20.3935	690.607
300	22.8574	774.042	600	20.2438	685.536
400	22.7734	771.199	800	20.0956	680.518
7500	22.6898	768.367	11000	19.9483	675.528
600	22.6065	765.546	200	19.8020	670.576
700	22.5230	762.720	400	19.6568	665.659
800	22.4407	759.933	600	19.5127	660.779
900	22.3583	757.142	800	19.3697	655.935

SMITHSONIAN METEOROLOGICAL TABLE 51 (Contd.)

ALTI-TUDE	INCHES HG	MILLI-BARS	ALTI-TUDE	INCHES HG	MILLI-BARS
12000	19.2277	651.126	14000	17.8636	604.934
200	19.0867	646.352	200	17.7327	600.500
400	18.9468	641.614	400	17.6023	596.084
600	18.8079	636.910	600	17.4736	591.726
800	18.6700	632.240	800	17.3455	587.388
13000	18.5331	627.605	15000	17.2183	583.081
200	18.3972	623.004	200	17.0921	578.807
400	18.2623	618.436	400	16.9668	574.563
600	18.1285	613.902	600	16.8424	570.351
800	17.9955	609.401	800	16.7189	566.169
			16000	16.5963	562.018

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