

DIVISION OF NATIONAL MAPPING
GENERAL INSTRUCTIONS FOR BAROMETRIC LEVELLING
WITH AIRCRAFT TYPE ALTIMETERS

General observations on the calculation of barometric heights as adopted by National Mapping :-

The method of reduction depends on the stations of the Meteorological network for control, and as these stations may be up to 300 miles from the observation station, it cannot be claimed that the results are precise. Experience has shown that the levels obtained will be within ± 30 feet of the correct value, but on occasions random errors of up to ± 60 feet may occur. If observations on days during which heighting would be suspected to be unreliable, i.e., storms, rain, "fronts" etc., are computed, the results may easily be in error by 100 feet or more. Since the method of reduction depends on Meteorological stations for control, the first step is to obtain original barometer pressures, attached thermometer temperatures, and dry bulb temperature readings for the days in question at the hours 0600, 0900, 1200, 1500 and 1800. These original readings, obtainable from the Meteorological Bureau, are then corrected for index error, gravity and temperature and then plotted as a time-pressure curve, from which pressures can be read for any instant of time. If the curves of any three adjacent stations are plotted, a simple analysis of the pressure gradient can be made, by the aid of which the actual pressure of a specified plane above the field observation station can be estimated. Comparison with the field station pressure reading will give a close approximation of the height of the station.

These instructions will be dealt with under the following headings and in that order :-

1. Constant setting.
2. Checks against mercury-barometers.
3. Care of instruments.
4. Reading and Recording.
5. Reading of Kollsman type altimeters.
6. Repeating observations.
7. Times for observations
8. Check readings.
9. Damaged instruments.
10. Method of reading mercury barometers.
11. Method of checking index error of altimeters.
12. Field book entries.
13. Specimen page of field book.
14. I.C.A.N. table.

1. CONSTANT SETTING

The index reading must always be set at 29.92 inches or 1013 millibars. This is the ICAN "standard atmosphere" pressure, tables of which have been prepared. Surveying aneroids are set by the maker to read pressures based on a standard index setting. These are not capable of alteration and altimeters are to be treated in a similar manner, i.e., the setting (29.92 or 1013 mbs) is NOT to be altered under any circumstances. If the standard settings are altered, reliable levels are difficult and frequently impossible to obtain. In the latter case, the value of this particular activity in field work is a total loss. The practice of re-setting altimeters to known values of bench marks is not recommended as these instruments record atmospheric pressure NOT direct levels.

2. CHECKS AGAINST MERCURY BAROMETERS

Checks against a standard mercury barometer should be made before commencing field work, during field work, and after completing field work. There is no substitute for a mercury check, and these checks should be carried out as often as possible, say at 10-14 days interval. - See Section 10.

3. CARE OF INSTRUMENTS

Altimeters must be handled with care at all times: they must not be exposed to the direct rays of the sun at any time.

When travelling, they should be firmly strapped down on to a soft surface, e.g., front seat of a vehicle, to lessen shocks, vibrations etc., which will affect their jewelled pivot mechanisms.

Dust and water are enemies of altimeters and must be excluded as much as humanly possible from the Pitot tube connection at the back of the instrument. For this reason, among others, National Mapping uses tight fitting cases housing three (3) altimeters to form a "battery".

If a battery of altimeters is accidentally dropped or knocked, even though no apparent damage is noted, this fact should be noted in the field book at that time. Such a note is very useful in the analysis of the field results and frequently verifies sudden changes in index error, disclosed by checks against mercury barometers.

4. READING AND RECORDING

When reading altimeters in the field, stop at the desired place for a few minutes. Lightly tap the glass dial cover two or three times in that period, and then read. Immediately book the readings, and then check the booked entry against the altimeters.

Then describe the point at which the height was taken as concisely as possible in the field book. The mileage from a fixed point, usually a town, is then entered in the field book in the column provided (see Section 11). This is for identification purposes and can be of great value if the point has been incorrectly described.

4. READING AND RECORDING (Contd.)

If air photos are used, the point is identified by using a stereoscope and pricked through with a fine needle. This fine hole is then circled in ink and given a number. Circle the prick-mark on the reverse side of the photo, repeat number, and give the same description as is entered in the field book. Every point must have a consecutive serial number.

A short note about the weather is also entered in the field book, particularly if there is any reason to suspect even a mild "front" in the area. Small local "fronts" or disturbances are not always obvious from a study of synoptic weather charts.

In this regard it should be noted that an analysis of the synoptic weather charts is made prior to the calculations for the reduction of levels. If this analysis shows unfavourable conditions in the area at the time, no reductions are made.

5. READING KOLLSMAN TYPE ALTIMETERS

This type of altimeter will show altitudes from 00 to 35,000 feet.

The dial is graduated to show 1000 feet in intervals of 20 feet (sometimes 10 feet).

The large hand enables readings to be estimated to 5 feet, the smaller hand gives readings in 1000 feet, whilst the smallest hand gives readings in 10,000 feet. Normally the 10,000 feet hand will not be used.

To read an altimeter, note the position of the smaller hand, which gives readings in thousands of feet. e.g., if this hand is between 1 and 2, the reading is 1000 feet plus the reading of the large hand. If this large hand was at 840 feet, then the reading would be 1840 feet.

It frequently happens that the large hand points to a reading of say 820 feet, no notice being taken of the position of the 1000 feet hand which is approximately at zero. This is to be avoided, as the correct reading in this case is -180 feet.

It is necessary to note that in this case the smaller hand would be pointing between 0 feet and 980 feet, roughly $\frac{1}{5}$ of 1000 feet. Thus, the reading is negative (-), and one counts anti-clockwise to obtain the correct reading of -180 feet.

If a battery of three altimeters gave readings of -105, -115, -95 feet the mean would be -105 feet. If the readings were -25, +10, +20 feet, the mean would be +2. In all cases the readings must be treated algebraically.

6. REPEATING OBSERVATIONS

Do not repeat readings at the same point on the same day.

Do repeat readings on different days, as this leads to increased accuracy in the results.

Work done in unsettled conditions is generally useful only for the most approximate reconnaissance purposes.

7. TIMES FOR OBSERVATIONS

Do not observe height readings outside times for which daily readings are available from Meteorological stations. Generally, this means between 0900 and 1800 hours, Zone or Standard time.

8. CHECK READINGS

Try to obtain readings on points of known heights, e.g., on bench marks, railway lines at crossings, trig. stations, road junctions etc.

The description of these points must be accurate and concise, leaving no doubt as to the position of the point so taken.

Level values derived from observations at these points serve as useful checks on the reliability of the work being undertaken.

9. DAMAGED INSTRUMENTS

If the altimeters, after being compared with a mercury barometer, read hundreds of feet or more above or below the corrected barometric pressure at that time, it can be said that they are out of adjustment, or damaged.

Experience has shown that they must be replaced or repaired, and recalibrated in any case.

If the replacement is sent by air, which is the best method, get the pilot of the plane to carry them so that they will not be damaged or out of adjustment upon arrival.

10. METHOD OF READING MERCURY BAROMETERS

To carry out a mercury check the following procedure is adopted :-

- (a) Ascertain where a mercury barometer is housed, and by whom. Generally, the Department of Civil Aviation (on aerodromes) and Post Offices have one, also the Meteorological Offices in the larger towns. Always tell the custodians of these barometers why you need to use them, and that the reading required is "as read" and NOT Station Level pressure or Mean Sea Level pressure.

All records entered on the "correction card" at field Meteorological offices are available at the Central Office of the Meteorological Bureau and copies are held at National Mapping. These are NOT collected in the field in the interests of having a uniform presentation of observations.

10. METHOD OF READING MERCURY BAROMETERS (Contd.)

- (b) Carry the altimeters up to the barometer and place them at the same height as the barometer cistern and allow the altimeters to settle for 5 to 10 minutes, tapping the glass dial covers every 2 or 3 minutes.
- (c) Keep away from the barometer until the moment of reading it, as body heat will cause the sensitive attached thermometer to give false reading, and hence a false temperature correction, e.g., a difference of 5°F at 29.00 inches at 70°F from the correct reading will give rise to an error of 0.011 inches of mercury, equivalent to a height of 11 feet even before reduction.
- (d) Always read the attached thermometer first and book, and then check. Next, read the height of the mercury column and book, and check this reading.

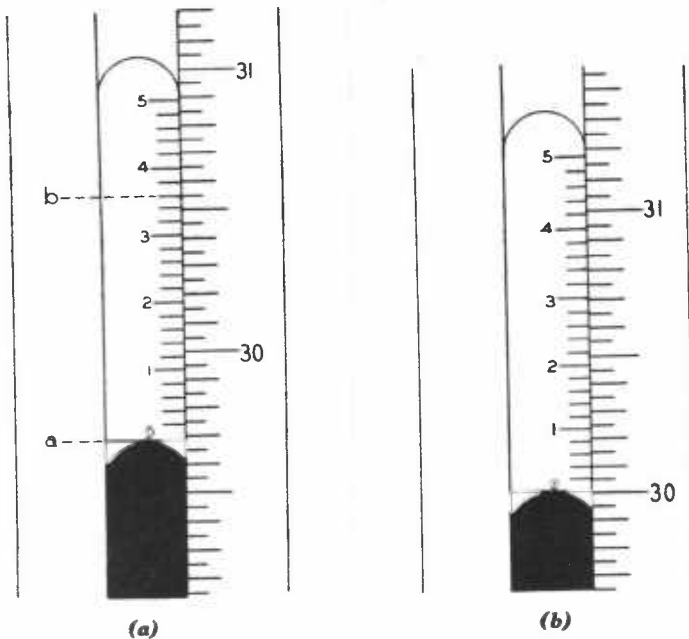
When this has been done, read the altimeters and book, and check.

It is always good practice to repeat these observations a second time to eliminate blunders.

(e) TO READ THE BAROMETER

1. Read and book attached thermometer as explained above.
2. "Set" the instrument by raising or lowering the sliding vernier scale by a milled screw until the lower edges, back and front, are in line with the extreme tip of the upper curved surface (meniscus) of the mercury column. This is for the Kew pattern barometer, which is most commonly used, but for the Fortin type, a fixed ivory index peg is provided in the cistern to which the level of the mercury must be adjusted by means of a milled screw at the bottom of the cistern.

Errors of parallax are to be avoided, i.e., the eye, the lower edges back and front of the moving piece, and the highest part of the meniscus, must all be in one line. When set correctly, light should be seen through each side of the meniscus but not above the dome. Holding a piece of white paper behind the mercury column makes the above adjustment quicker and more accurate.



3. First observe the position of the zero line of the vernier scale relative to the fixed scale and read off from the fixed scale the value of the division next below the zero line of the vernier scale. In the example above fig. (a) this value is 29.650 inches. Next, run the eye up the vernier scale until a line is found on each scale which coincide and appear as one straight line. The vernier scale is read by counting the number of divisions up to the point of coincidence and multiplying by .002. In the illustration the number of divisions is 18, which multiplied by .002 gives .036. Hence we have 29.650 inches from the fixed scale plus .036 from the vernier scale, the complete reading being 29.686 inches. If no single line of the vernier scale is found to coincide exactly with an opposite number on the fixed scale, but two lines on each scale appear to coincide, the mid value is taken. For example, in fig (b), if two such lines are the .034 and .036 divisions of the vernier scale, the intermediate or mid value .035 is taken. For reference, the "Australian Meteorological Observers Handbook" 1954 should be consulted.

11. METHOD OF CHECKING INDEX ERROR OF ALTIMETERS

If it is desired to check the index error numerically, a worked example is given below. It should be noted that this does not furnish enough information to compute heights :- see "General Observations".

13th September 1960 at Alice Springs A/D at 1506 hours.

Altimeters: No. 1. No. 2. No. 3.

1820 1790 1840 Mean = 1817 = 28,007 on I.C.A.N. tables.

Barometer: Attd. Therm. : = 79°F Barometer : = 28.232 inches.

Barometer 28,232

-0.130 Temp. Correction

-0.063 Index & Gravity Correction

Corrd. baro. 28.039 inches.

Note:- These corrections are obtainable from the O.I.C. of the barometer.

The barometer being regarded as a standard we have:-

28.039 barometer

28.007 altimeter

Error = - 0.032

∴ Corr. = + 0.032 inches

12. FIELD BOOK

This should contain all the results of mercury checks before starting field operations, during operations and after the completion of field work.

All columns should be entered, and the entries should be neat and legible.

Notes on time should include whether Eastern Standard Time, Central Standard Time etc.

The column for mileages must be entered for the reason given in Section 4.

13. SPECIMEN PAGE OF FIELD BOOK

Date	Time	No. 1.	No. 2.	No. 3.	Mean	Run	Photo	Station Description	Miles
15 July 1960	1230	855	845	880	860			Charleville A/D	
			Attd. therm = 65°F.						
			Barometer = 29.160						00.0
15 July	1315	1460	1445	1480	1462	9	5071	Road Junction	12.0
15 July	1700	1830	1800	1850	1827	4	5061	Bridge	28.0
16 July	0910	1155	1145	1160	1153			Rlwy. Crossing	32.0
- -	- -	- -	etc -	- -	- -	- etc -	- -	- - - - - etc	
22 July 1960	1025	1030	1025	1055	1037			Tambo P.O.	
			Attd. therm = 65°F.						
			Barometer = 28.048						124.0

If this work is done with National Mapping equipment, National Mapping field books will be supplied on request.

I. C. A. N. TABLES

PRESSURE	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
26.0	3834	3824	3814	3803	3793	3782	3772	3762	3751	3741
26.1	3731	3720	3710	3700	3689	3679	3669	3659	3648	3638
26.2	3628	3617	3607	3597	3586	3576	3566	3556	3545	3535
26.3	3525	3515	3504	3494	3484	3474	3463	3453	3443	3433
26.4	3422	3412	3402	3392	3382	3371	3361	3351	3341	3331
26.5	3320	3310	3300	3290	3279	3269	3259	3249	3239	3229
26.6	3218	3208	3198	3188	3178	3168	3157	3147	3137	3127
26.7	3117	3107	3097	3086	3076	3066	3056	3046	3036	3026
26.8	3016	3005	2995	2985	2975	2965	2955	2945	2935	2925
26.9	2915	2905	2895	2884	2874	2864	2854	2844	2834	2824
27.0	2814	2804	2794	2784	2774	2764	2754	2744	2734	2724
27.1	2714	2704	2694	2684	2674	2664	2654	2644	2634	2624
27.2	2614	2604	2594	2584	2574	2564	2554	2544	2534	2524
27.3	2514	2504	2494	2484	2474	2464	2454	2444	2434	2425
27.4	2415	2405	2395	2385	2375	2365	2355	2345	2335	2325
27.5	2315	2306	2296	2286	2276	2266	2256	2246	2236	2226
27.6	2217	2207	2197	2187	2177	2167	2158	2148	2138	2128
27.7	2118	2108	2098	2089	2079	2069	2059	2049	2040	2030
27.8	2020	2010	2000	1990	1981	1971	1961	1951	1942	1932
27.9	1922	1912	1902	1893	1883	1873	1863	1854	1844	1834
28.0	1824	1814	1805	1795	1785	1776	1766	1756	1746	1737
28.1	1727	1717	1707	1698	1688	1678	1668	1659	1649	1639
28.2	1630	1620	1610	1601	1591	1581	1572	1562	1552	1542
28.3	1533	1523	1513	1504	1494	1484	1475	1465	1456	1446
28.4	1436	1427	1417	1407	1398	1388	1378	1369	1359	1350
28.5	1340	1330	1321	1311	1302	1292	1282	1273	1263	1254
28.6	1244	1234	1225	1215	1206	1196	1186	1177	1167	1158
28.7	1148	1139	1129	1120	1110	1100	1091	1081	1072	1062
28.8	1053	1043	1034	1024	1015	1005	995	986	976	967
28.9	957	948	938	929	919	910	900	891	881	872
29.0	863	853	844	834	825	815	806	796	787	777
29.1	768	758	749	739	730	721	711	702	692	683
29.2	673	664	655	645	636	626	617	607	598	589
29.3	579	570	560	551	542	532	523	514	504	495
29.4	485	476	467	457	448	439	429	420	410	401
29.5	392	382	373	364	354	345	335	326	317	307
29.6	298	289	280	270	261	252	242	233	224	215
29.7	205	196	187	177	168	159	149	140	131	122
29.8	112	103	94	85	75	66	57	47	38	29
29.9	20	10	1	- 8	-17	-26	-36	-45	-54	-63
30.0	-73	-82	-91	-100	-110	-119	-128	-137	-146	-156
30.1	-165	-174	-183	-192	-202	-211	-220	-229	-238	-248
30.2	-257	-266	-275	-284	-293	-303	-312	-321	-330	-339
30.3	-348	-358	-367	-376	-385	-394	-403	-412	-421	-431
30.4	-440	-449	-458	-467	-476	-485	-494	-504	-513	-522
30.5	-531	-540	-549	-558	-567	-576	-585	-594	-604	-613
30.6	-622	-631	-640	-649	-658	-667	-676	-685	-694	-703
30.7	-712	-721	-730	-740	-749	-758	-767	-776	-785	-794
30.8	-803	-812	-821	-830	-839	-848	-857	-866	-875	-884
30.9	-893	-902	-911	-920	-929	-938	-947	-956	-965	-974

Calculated for a Standard Atmosphere, temperature at Sea Level 288 de-
grees.
Absolute = 59 degrees Fahrenheit.