ICAO CIRCULAR

CIRCULAR 26-AN/23
Second Edition - 1956

1956

TERRAIN CLEARANCE AND VERTICAL SEPARATION OF AIRCRAFT
(ALTIMETER SETTING)

Prepared by the Secretariat and published by authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION
MONTREAL • CANADA

This Publication is issued in English, French and Spanish.

Published in Montreal, Canada, by the
International Civil Aviation Organization.
Correspondence concerning publications
should be addressed to the Secretary General
of ICAO, International Aviation Building,
1080 University Street, Montreal, Canada.

Orders for ICAO publications should be sent, on payment:

In Canadian currency ($), to

Secretary General, ICAO,
International Aviation Building,
1080 University Street,
Montreal, Canada.
(Cable address: ICAO MONTREAL)

In French currency (fr), to

ICAO Representative,
European and African Office,
60bis, avenue d'Iéna,
Paris (16e), France.
(Cable address: ICAOREP PARIS)

In Peruvian currency (soles), to

ICAO Representative,
South American Office,
Apartado 680,
Lima, Perú.
(Cable address: ICAOREP LIMA)

In Australian currency (s/d), to

Robertson and Mullens,
107 Elizabeth Street,
Melbourne, C.1, Australia.

In Sterling or Irish currency (s/d), to

Her Majesty's Stationery Office,
P.O. Box 569,
London, S.E. 1,
England.
(Cable address:
WHOLECORN, SEDIST, LONDON)

In Egyptian currency (L.E.), to

ICAO Representative,
Middle East Office,
Wadie Saad Building,
Sharia Salah el Dine,
Zamalek, Cairo, Egypt.
(Cable address: ICAOREP CAIRO)

In Thai currency (bahts), to

ICAO Representative,
Far East and Pacific Office,
Sala Santitham, Rajadamnoen Ave.,
Bangkok, Thailand.
(Cable address: ICAOREP BANGKOK)

In Indian currency (Rs.), to

Oxford Book and Stationery Company,
Scindia House,
New Delhi, India.

In Argentine currency: from

Editorial Sudamericana S.A.,
Calle Alsina 500,
Buenos Aires, Argentina.
(Cable address: LIBRECOL)

TERRAIN CLEARANCE AND VERTICAL SEPARATION OF AIRCRAFT

Second Edition - 1956

This edition of Circular 26-AN/23, which supersedes the 1953 edition, contains several editorial amendments and amendments to paragraphs 20 to 26 inclusive resulting from the work of the Second Air Navigation Conference (September 1955).

TABLE OF CONTENTS

APPENDICES

TERRAIN CLEARANCE AND VERTICAL SEPARATION OF AIRCRAFT

INTRODUCTION

1. This circular describes a method for assessing the height of an aircraft above the terrain during all stages of a flight and for ensuring adequate vertical separation of aircraft during flight while en route. This method, which was developed for world-wide application and is now in use in most areas of the world, is the product of several years study by three technical divisions of the Air Navigation Commission of ICAO and various regional air navigation meetings. It was developed with a view to eliminating the hazards created by the use of several different methods in various parts of the world and to facilitate international aircraft operations in general by introducing standard procedures.

2. The basic purpose of this circular is to assist national administrations, its various departments and operators in applying the relevant procedures which have been published in Part I of ICAO document 7030. It contains a somewhat detailed discussion of the principles on which this method is based but in the interest of brevity it does not attempt to cover the various other methods which were discussed at length during the development of the method described.

3. Bearing in mind that this circular may be found useful as a general reference on the subject of "altimeter setting" by readers ranging from those having little knowledge of the subject to those quite familiar with the method described, the material has been arranged in such a way as to facilitate reference to discussion of any one of the several aspects of this rather involved subject. The principal part of the circular is only concerned with a description of the method; detailed discussions of the several associated subjects will be found in appendices. Examples illustrating one or more of the subjects discussed will be found in attachments to this circular.

TERMINOLOGY

4. Early discussions in ICAO of altimeters and their various uses indicated that several terms commonly used in such discussions were being assigned quite different meanings and that the meaning of such terms varied from one country to another. Accordingly, prior to undertaking an examination of existing methods or to developing a world-wide method, it became evident that standard definitions of such basic terms as "height" "altitude" and "elevation" would be required. The following definitions were adopted for use in all ICAO documents and are found in the ICAO Lexicon of Terms (Doc 7200).

<u>Height</u> - The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.

<u>Altitude</u> - The vertical distance of a level, a point or an object considered as a point, measured from mean sea level.

<u>Elevation</u> - The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.

5. Mention should also be made of those signals found in the Q Code which are related to the various altimeter settings now in use. The Q signals of the Aeronautical Code, which have now been in use for many years, were developed for use in air-ground radio-telegraphy. While three-letter groups such as "QFE" for example are used in messages relating to a particular type of altimeter setting, familiarity with this code gradually led to the use of such terms as "a QFE altimeter setting" when referring to an altimeter sub-scale pressure setting corresponding to barometric pressure at a particular place and time. Likewise the term "QNH altimeter setting" has been adopted as a term meaning another type of sub-scale setting and both terms have now been adopted as common terminology.*

6. The three different types of altimeter settings used in the method under consideration are QNH, QFE and 1013.2 mbs. As indicated in the following table, each setting will result in an altimeter indication which provides a measure of the vertical distance above the particular reference datum shown. In every instance the term "altimeter indication" means the reading obtained from an instrument, bearing in mind that this indication is seldom if ever the true vertical distance.

Altimeter Setting	Reference Datum	Altimeter Indication
QNH	mean sea level	altitude
QFE	QFE reference point	height above QFE reference point
1013.2 mbs.	1013.2 mbs. (29.92 ins.)	vertical position relative to flight levels, height above pressure level of 1013.2 mbs. or height in standard atmosphere

* The origin and meaning of these and other Q Code signals relating to altimeter setting is discussed in further detail in Appendix D.

7. It will be seen that if the terms "altitude" and "height" are always used in their defined sense, there is little possibility of confusion as to their meaning in view of the following simple relationship.

Setting		Indication
QNH	-	Altitude
QFE	-	Height
1013, 2 mbs.	-	Flight Levels

DEVELOPMENT AND USE OF THE ALTIMETER

8. The functions performed by an early-type altimeter were comparatively simple and the accuracy required of such an instrument was not great. It indicated height in the standard atmosphere and the difference between the reading obtained prior to take off and that obtained while in flight provided a useful indication of the height above terrain. With the advent of instrument flight the need for more accurate indications of the vertical position of an aircraft, both relative to the terrain and to other aircraft, became an important consideration. These new operational requirements were met by developing an altimeter which could be adjusted to select any of several pressure reference data other than that of sea level in the standard atmosphere (1013.2 mbs.) and by the introduction of ground services which provided the altimeter settings during flight. Whereas formerly a pilot was required to estimate heights above the terrain using altimeter indications associated with a reference datum, the vertical position of which was unknown, he now was able to select a reference datum on the surface of the earth by obtaining either a QNH or a QFE setting while in flight. Additional refinements were also incorporated into the design of altimeters which resulted in greater sensitivity and readability.

9. In view of the large variation from one region of the world to another in the operating conditions encountered and ground facilities and airborne equipment available, it was not surprising to find that over a period of time several different methods for determining terrain clearance and for ensuring vertical separation of aircraft were developed, each designed to satisfy the requirements of a particular region.

10. In areas where the necessary air-ground communications were lacking or did not provide adequate coverage, and where air traffic was comparatively light, the use of a QFF setting for terrain clearance and vertical separation purposes was adopted. A QFE setting was normally used for landing and due to limitations of the altimeter in use, a QNE setting was used for landings at high aerodromes.*

*See Appendix D for meaning of QFF and QNE altimeter settings

11. In areas of high traffic density it was found that closely co-ordinated communications, meteorological and air traffic services were required to satisfy the operational requirements associated with such areas. Given such services, it was found that a QNH altimeter setting provided the most useful altimeter indications for both terrain clearance and vertical separation purposes.

12. The use of several different methods in various parts of the world presented serious difficulties to international operations, evidenced by the fact that in certain instances airline operations manuals were required to specify as many as three different procedures to be followed on a single flight. Since such lack of standardization could well result in serious errors on the part of both ground personnel and flight crews, ICAO undertook to review all the methods currently in use, plus several proposed new methods, with a view to arriving at the one method most suitable for world-wide application. This study led to the development of procedures for the following distinct purposes,

a) determination of terrain clearance during take-off and landing,

b) determination of the vertical position of one aircraft relative to another during en-route flight, for vertical separation purposes,

c) determination of terrain clearance during en-route flight.

BASIC PRINCIPLES OF THE ICAO METHOD

13. The principles on which the ICAO method is based may be summarized as follows:

a) For take-off and landing, a QNH altimeter setting is always made available to a pilot for terrain clearance purposes.

b) For landing, a QFE altimeter setting is made available to a pilot on request, for terrain clearance purposes.

c) During en-route flight, in areas where QNH reports are available, QNH altimeter settings for the route flown are made available to a pilot for terrain clearance purposes.

d) During en-route flight, in areas where suitable QNH settings cannot be made available, the information required to ensure adequate terrain clearance, using an altimeter setting of 1013.2 mbs., is provided prior to take-off and where possible during flight.

e) During en-route flight, vertical separation of aircraft is based on altimeter indications obtained from an altimeter set on 1013.2 mbs., and aircraft are flown at specific pressure levels which are defined by a system of "flight levels".

f) The instrument used to indicate the vertical position of an aircraft relative to a flight level or to the terrain may be either a sensitive altimeter, a flight level indicator, or any suitable combination of the two so long as it provides the required indications.

Prior to discussing the application of the method a brief explanation of the specific uses of each of the three different types of altimeter setting namely QNH, QFE and 1013.2 mbs. is in order.

USE OF A QNH ALTIMETER SETTING

14. Prior to take-off a pilot will set the pressure sub-scale of his altimeter to the QNH setting for the aerodrome in order that it will indicate altitude, and when on the aerodrome the altimeter will quite naturally indicate the elevation of that aerodrome. In flight he will compare the altitude of his aeroplane with the elevation of obstacles on the ground as shown on charts and will thus be able to determine his terrain clearance. Since a QNH setting is based on the atmospheric pressure at a particular point, generally speaking, the reliability of the altimeter indication will decrease as the distance from this point increases. For this reason additional QNH settings should be obtainable along a route in order that the altimeter may be reset and the reliability of its indication maintained within safe limits. Prior to landing, a final QNH setting will be obtained from the aerodrome. This will enable a pilot to obtain a reliable indication of the altitude of his aeroplane which he will compare with the elevation of obstacles in the vicinity of the aerodrome. Thus the same type of altimeter setting can be used for terrain clearance purposes throughout all stages of a flight, take-off and climb, en route, and approach and landing*

USE OF A QFE ALTIMETER SETTING

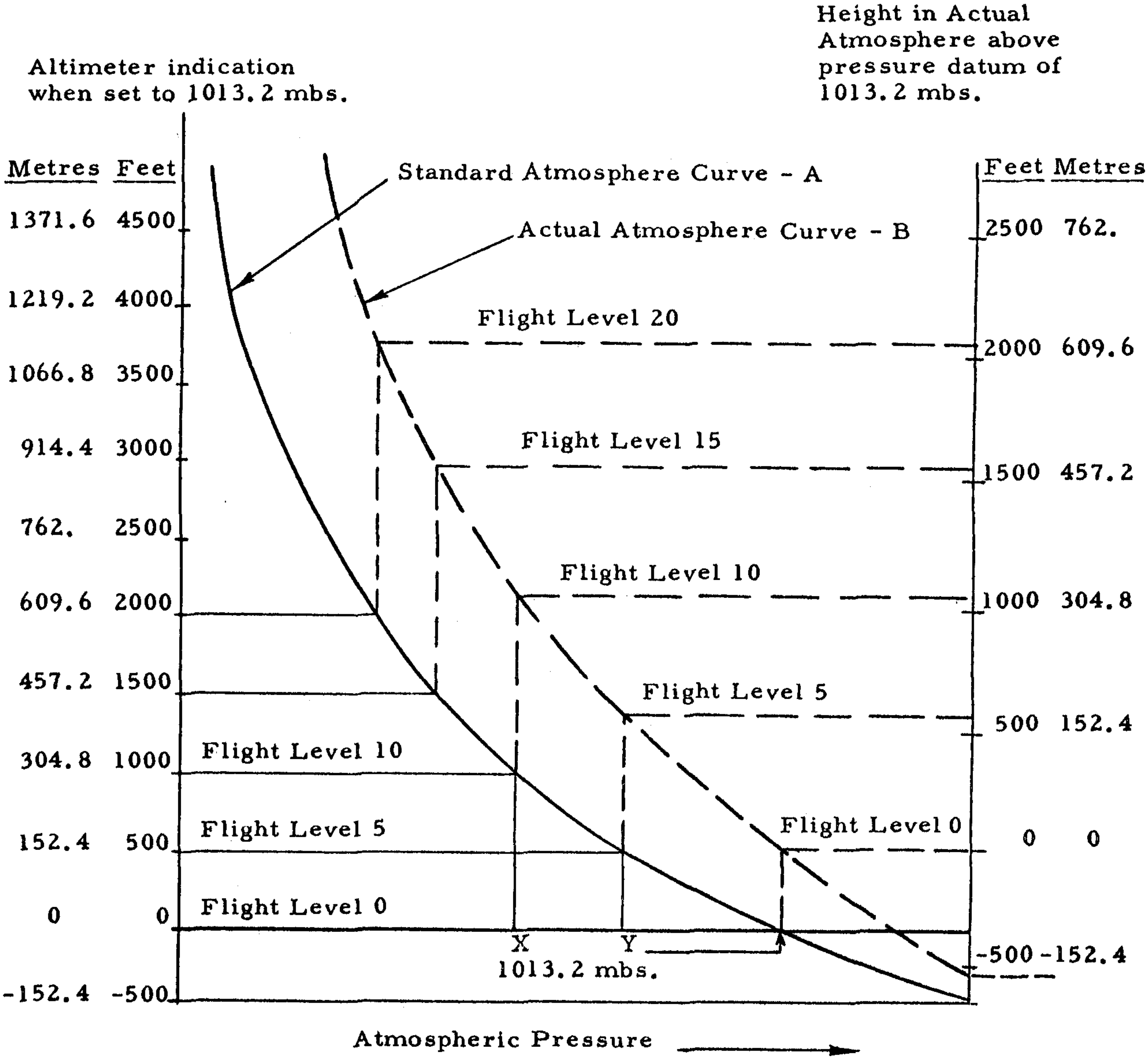
15. In the event that a pilot prefers that his altimeter indicate the actual height of his aeroplane above the runway during the final approach for a landing, he will use a QFE altimeter setting. This setting is obtainable on request from the aerodrome and is intended to be used only when he has been cleared to commence his final approach. Having set his altimeter to a QFE setting, it will, for all practical purposes, indicate the height above the runway. This height can be compared with the heights of obstacles in the immediate vicinity of the aerodrome which are shown on instrument approach

---

*The derivation of a QNH and a QFE altimeter setting is discussed in Appendix A.

charts. On landing his altimeter will indicate zero height. The use of a QFE setting is restricted to final approach and landing because whereas instrument approach charts indicate both the elevations and heights of obstacles, charts covering areas not in the immediate vicinity of aerodromes indicate only the elevations of obstacles.

FIGURE 1



FLIGHT LEVELS

16. The system of flight levels referred to in paragraph 13 e) consists of a series of essentially parallel, constant atmospheric pressure levels separated by specific pressure intervals, with flight level zero located at the datum pressure level of 1013.2 millibars. Accordingly the term "flight levels" has been defined as follows:

> "surfaces of constant atmospheric pressure which are related to a specific pressure datum and are separated by specific pressure intervals".

Once on a flight level, one needs only to maintain a constant altimeter indication in order to stay on this level. Since it is intended that the system of flight levels should be so arranged as to permit the use of a sensitive altimeter as a flight level indicator, the separation of consecutive flight levels has been based on a specific distance interval as indicated on the dial of an altimeter. For example, flight level zero corresponds to an altimeter indication of zero and flight level 5 corresponds to an altimeter indication of 500 feet or 152.4 metres.

17. The derivation of this system of flight levels is illustrated in Figure 1. Curve A represents the pressure-height curve of the Standard Atmosphere, the curve used in calibrating an altimeter*. When exposed to a pressure Y the altimeter indicates a height of 500 feet (152.4 metres) above the pressure datum 1013.2 millibars. When exposed to a pressure X the altimeter indicates a height of 1000 feet (304.8 metres) above the same datum. Thus it may be stated that consecutive flight levels (5 and 10 for example) are separated by an indicated distance of 500 feet (152.4 metres) or more precisely are separated by a specific pressure interval (Y-X) which corresponds to a vertical distance of 500 feet (152.4 metres) in the Standard Atmosphere. This part of Figure 1 indicates the situation found in a Standard Atmosphere only.

18. Since the system of flight levels is found not in a hypothetical standard atmosphere but in an actual atmosphere, the position of flight levels in the latter is of more practical significance. This is represented by the second part of Figure 1. Due to variations in atmospheric temperature from standard conditions the pressure-height relationship found in an actual atmosphere is normally not that found in the Standard Atmosphere (Curve A) and may be something similar to Curve B. Since the pressure interval between consecutive flight levels is fixed (Y-X for example) and since an altimeter is actuated by changes in pressure and not changes in height, the position of flight levels 5 and 10 in an actual atmosphere will be found by extending the pressure lines Y and X to intersect Curve B. It will be seen that in this instance the distance between flight levels 10 and 5 is not 500 feet (152.4 metres) as it was in the Standard Atmosphere but is considerably greater, even though the pressure interval between these two levels is still Y-X.

---

* See Appendix A for discussion on the calibration of an altimeter.
See Appendix B for discussion on the Standard Atmosphere.

Figure 1 also indicates that regardless of the atmospheric conditions involved, an altimeter, when exposed to a pressure Y will always indicate a height of 500 feet (152.4 metres) above the pressure datum 1013.2 millibars even though the actual height above this datum may be more or less than this value. It is important that this relationship between an altimeter indication, the corresponding pressure and the actual height be well understood.

19. Figure 1 indicates that variations in atmospheric conditions result in an increase or decrease in the vertical distance between flight levels, but makes no mention of the position of flight level 0 (pressure level of 1013.2 mbs.) relative to the surface of the earth. The position of flight level 0 relative to any point on the earth's surface at a particular time is dependent upon the elevation of this point and the atmospheric pressure. As indicated in Figure 2, flight level 0 is above point A, which is located at sea level, due to the fact that the atmospheric pressure is above standard. Although point B is in an area of even higher general atmospheric pressure, flight level 0 is below it due to its elevation. It will also be seen that the spacing between consecutive pressure levels is greater at B than at A. This subject is discussed at some length in Appendix C with the aid of examples taken from meteorological records.

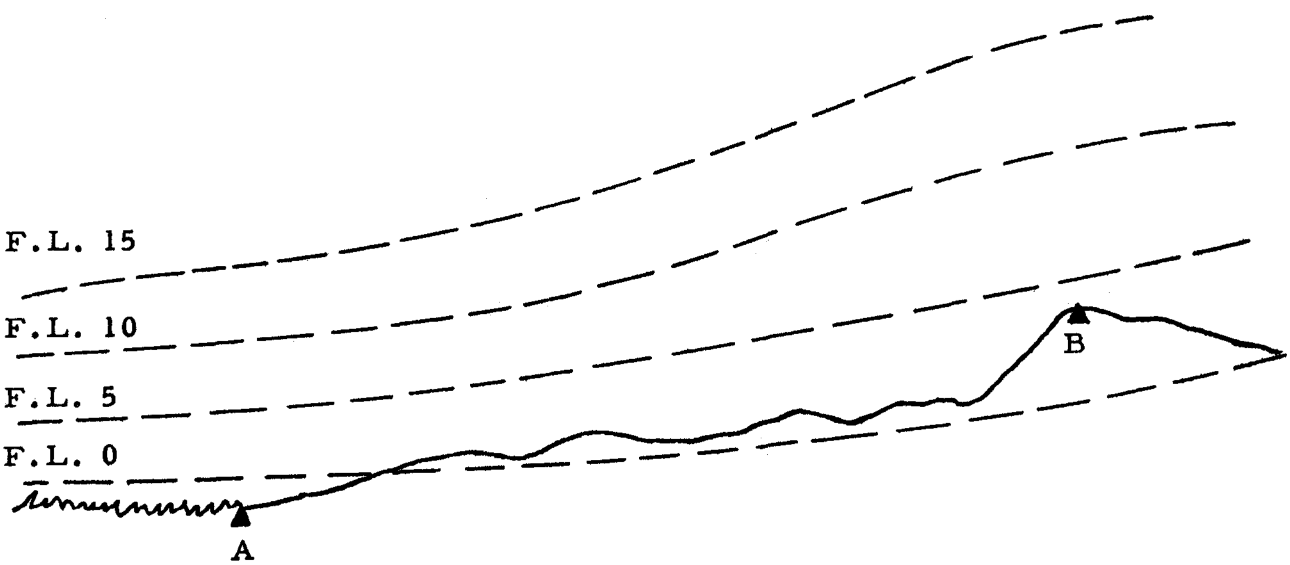


FIGURE 2

20. Flight level 0 is located at the atmospheric pressure level of 1013.2 millibars and consecutive flight levels are numbered 5, 10, 15, etc. The corresponding altimeter indications (using a pressure setting of 1013.2 mbs.) are as shown in the following table:

Flight Level Number	Altimeter Indication Feet	Altimeter Indication Metres
15	1500	457
10	1000	305
5	500	152
0	0	0
-95	-500	-152
-90	-1000	-305

Figure 3 illustrates the use of flight levels for vertical separation purposes while en route and the use of QNH and QFE settings for take-off and landing . In this example, flight level 0 happens to be 200 feet above aerodrome elevation or 200 + 100 = 300 ft (30.5 + 61 = 91.5 m) above mean sea level due to the fact that the atmospheric pressure is greater than standard.

21. The aircraft at flight level 45 is overflying the aerodrome and continues on this level with no change in altimeter setting. Another aircraft is approaching the aerodrome from flight level 35 and intends to land. Since the exact height above aerodrome of this and other flight levels is not self-evident, a more accurate height indication must be used for landing. The aircraft descends to flight level 25 (the transition level) and on leaving this level the pilot changes his reference from an altimeter set to 1013.2 mbs. to one set on a QNH setting. He now reads "altitude". The aircraft continues its descent to the "transition altitude" (1600 feet in this case) from which it will commence its final approach to land. During the final approach a QFE setting may be used instead of a QNH setting, should the pilot prefer to read "height above aerodrome" instead of "altitude".

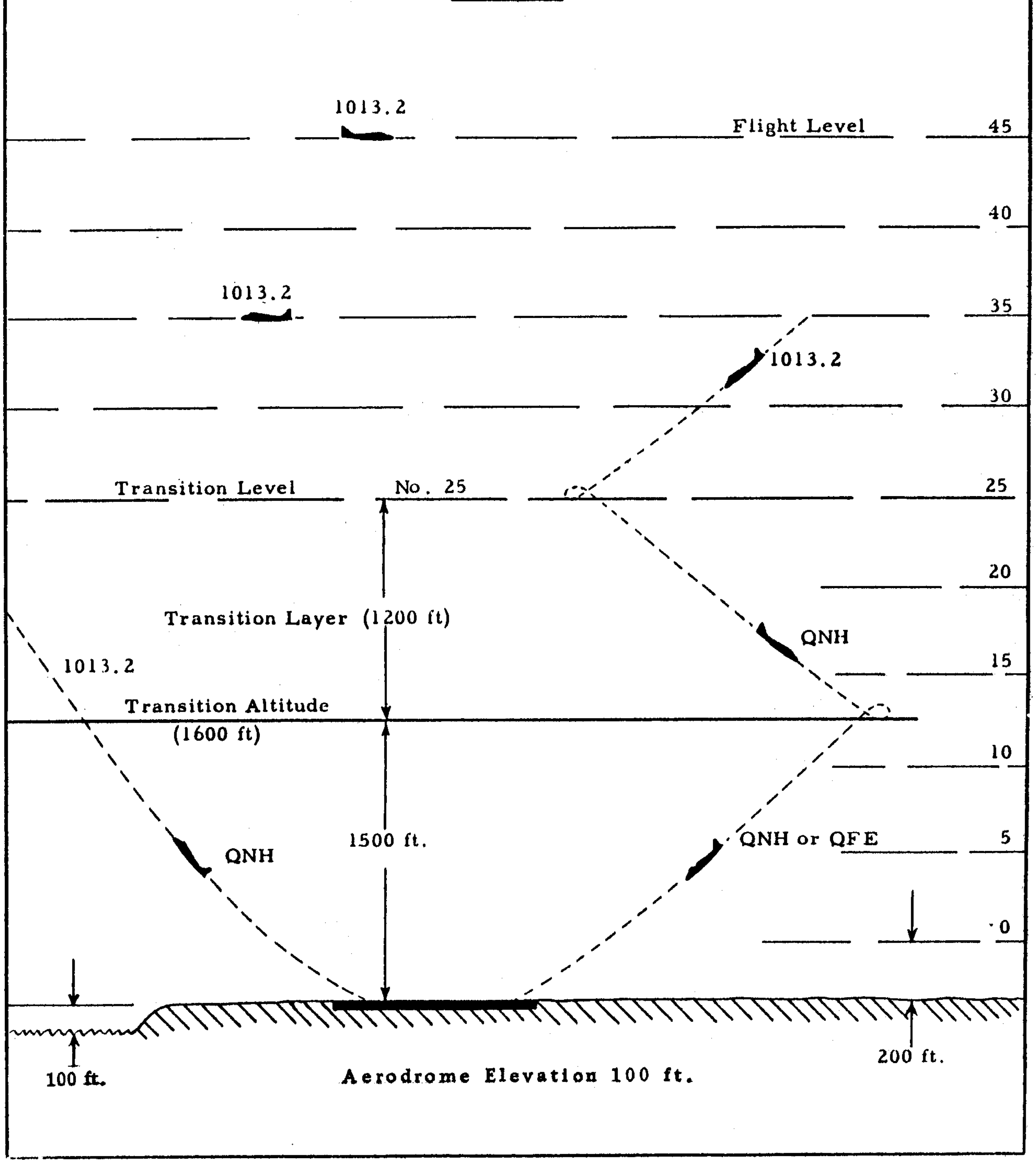
22. The aircraft taking off completes the same procedure in reverse. A QNH setting is used until the aircraft passes through the transition altitude when the pilot's reference is changed to an altimeter set on 1013.2 mbs. and thereafter the aircraft is flown on flight levels.

Transition Altitude

23. The transition altitude which is located at a fixed height above an aerodrome is defined as follows:

> "The altitude in the vicinity of an aerodrome at or below which the vertical position of an aircraft is controlled by reference to altitudes."

FIGURE 3


1013.2
Flight Level
45
40
1013.2
35
1013.2
30
Transition Level
No. 25
25
20
Transition Layer (1200 ft)
QNH
1013.2
15
Transition Altitude
(1600 ft)
10
1500 ft.
QNH
QNH or QFE
5
0
100 ft.
Aerodrome Elevation 100 ft.
200 ft.

To reduce the possibility of aircraft approaching the aerodrome below this transition altitude, it should be kept as low as possible. On the other hand it should not be lower than the altitude at which the final approach procedure is commenced and 1500 feet (457 m) appears to satisfy this requirement at most aerodromes. In some instances, however, local conditions may necessitate the use of a higher transition altitude.

Transition Level

24. The transition level, which is defined as "the lowest flight level available for use above the transition altitude", is usually not fixed in view of the fact that the whole system of flight levels can move up or down with changes in atmospheric pressure. In practice "the lowest level available for use" is determined by aerodrome control taking into account local requirements. In Figure 3 a case is illustrated wherein a separation interval is incorporated in the airspace lying between the transition altitude and the transition level and the transition level is therefore level 25. In this case aircraft can be positioned or held at the transition altitude (1600 ft) and simultaneously at flight levels 25, 35, etc. as well, but are forbidden to approach on flight levels 15 and 20. However, in the event that the aerodrome control authority does not wish to include a separation interval between the transition altitude and the transition level aerodrome control can select flight level 15 as the transition level (200 feet above transition altitude). If this is done, it is obvious that aircraft can then be held at either the transition altitude (1600 ft) or the transition level (No. 15) but not simultaneously at both. Experience has shown that in areas of high traffic density, the use of the lower transition level permits the use of all airspace, eliminates the possibility of aircraft (en route or intending to land) approaching the aerodrome below the transition level and can simplify air traffic control procedures. Thus, in practice any flight level located between 1 foot and 1500 feet above the transition altitude can be selected as the transition level.

25. In certain areas of the world variations in atmospheric pressure are relatively small and, provided traffic and other considerations permit, a fixed transition level may be used. For example, if meteorological records indicate that flight level 15 is likely to be above the transition altitude on 95% of occasions, then this level can be adopted as a fixed transition level and will be usable except on those infrequent occasions when exceptional meteorological conditions are encountered.

Transition Procedure

26. The "transition" illustrated in Figure 3 is basically a change in the pilot's reference from "flight levels" to "altitudes" and vice versa and may or may not involve a resetting of an altimeter at a particular time. If two altimeters are available, one may be set to the aerodrome QNH long before reaching the transition level. If only one altimeter is available the

FIGURE 4 - AERODROME SURROUNDED BY LOW TERRAIN

- Atmospheric pressure above standard
- QNH for aerodrome 1043.8 mbs.
- Transition Layer 1250 ft. (381 m) thick
- Transition Level - No. 20
- Transition Altitude 1575 ft. (479 m)
- Holding at flight levels only

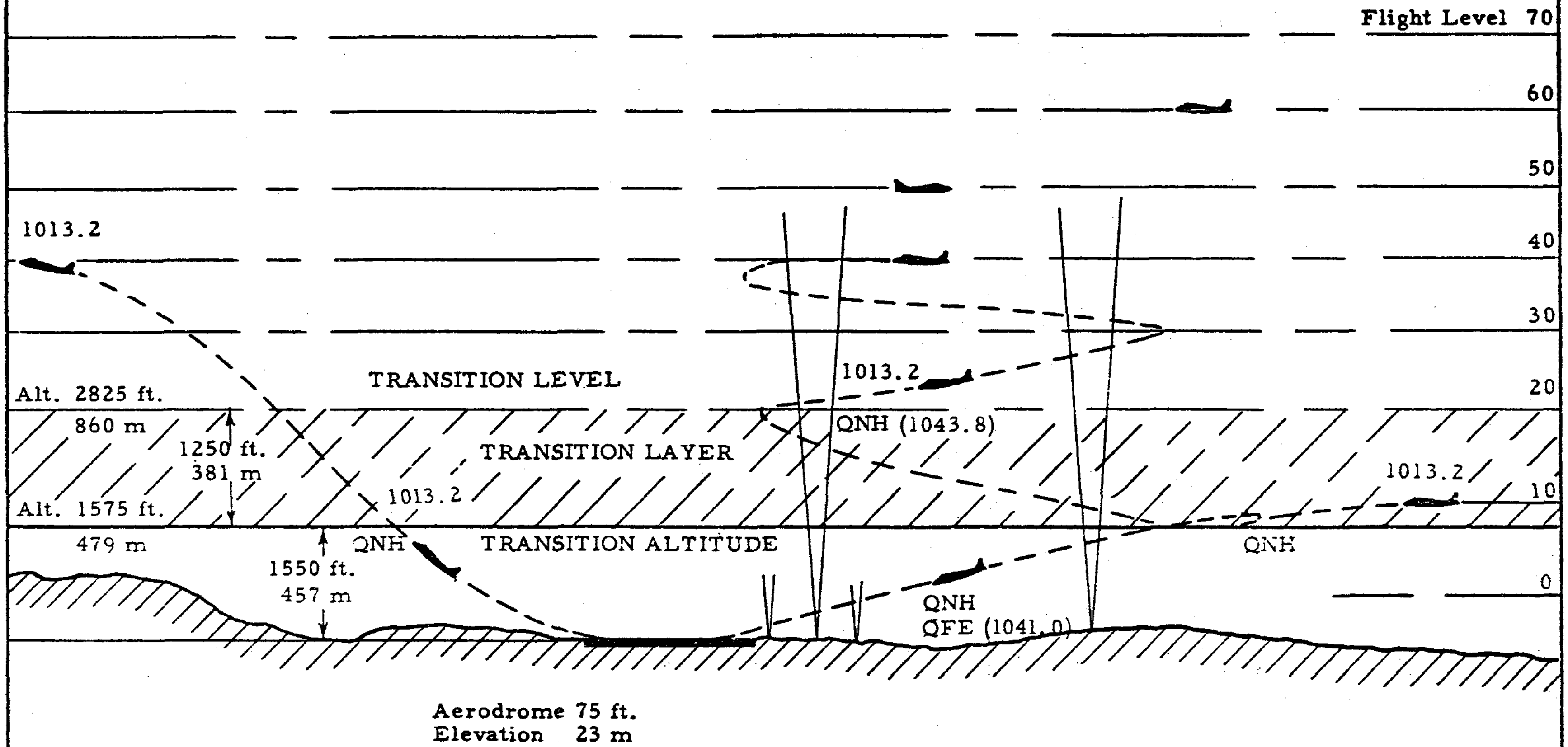
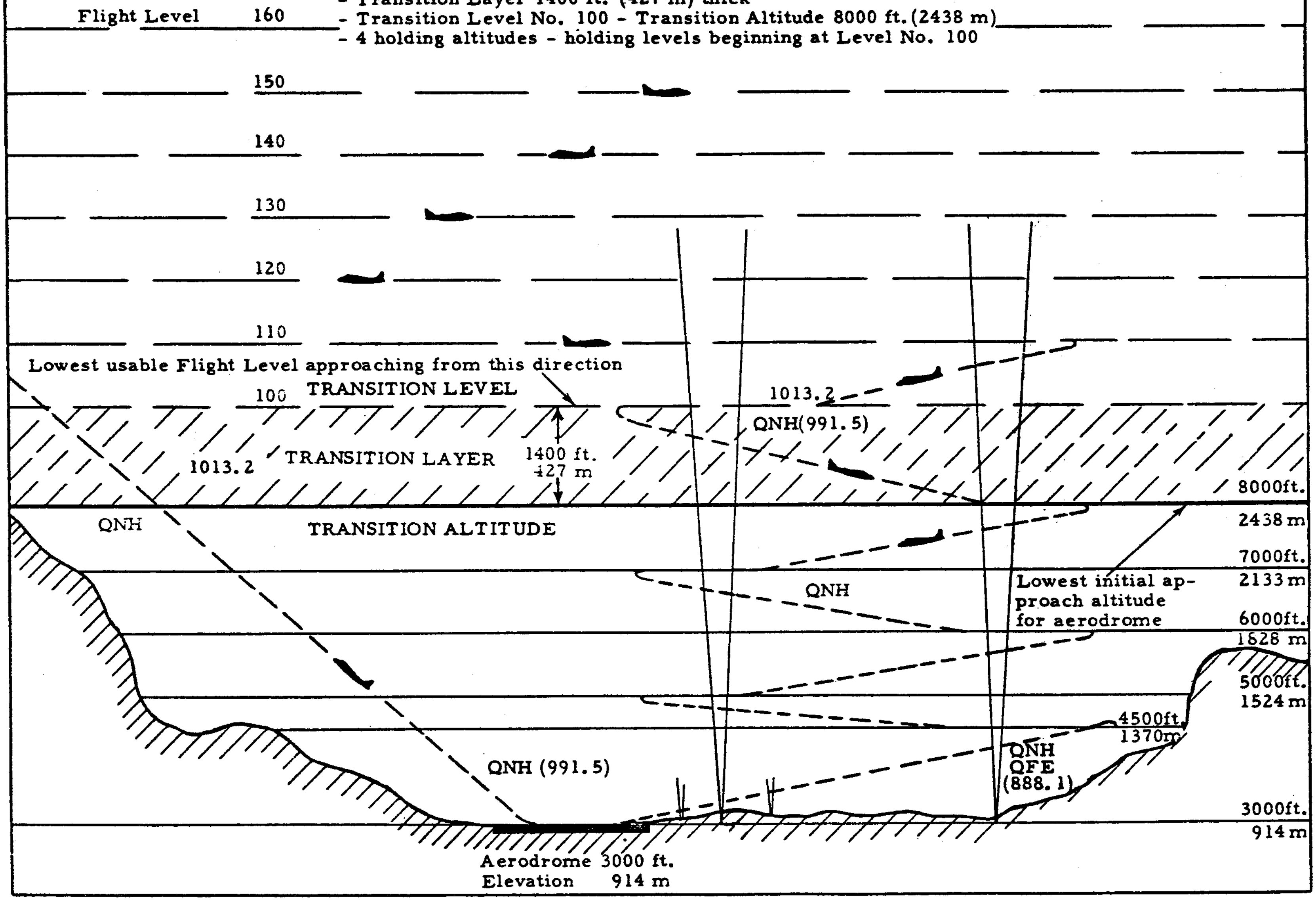


FIGURE 5 - AERODROME SURROUNDED BY HIGH TERRAIN

- Atmospheric pressure below standard
- QNH for aerodrome = 991.5
- Transition Layer 1400 ft. (427 m) thick
- Transition Level No. 100 - Transition Altitude 8000 ft. (2438 m)
- 4 holding altitudes - holding levels beginning at Level No. 100



change in reference must be accompanied by a change in altimeter setting or alternatively either the transition level or transition altitude can be set on a simple adjustable index on the face of the altimeter. The same applies to the use of a QFE setting; on descending from the transition level one altimeter can be set on QNH and one on QFE. Figures 4 and 5, further illustrate the application of the basic principles to differing situations.

27. The advantages of a transition at a horizontal boundary over a transition at some vertical boundary are evident. Whereas a pilot may have some difficulty in determining his position relative to a vertical boundary, he will always know his position relative to the transition level. Furthermore, no special procedures are required in the case of aircraft flying over but not landing at an aerodrome.

APPLICATION OF THE METHOD

28. As indicated in paragraph 13 the method under consideration makes use of three different types of altimeter settings:

1) a QNH setting for terrain clearance purposes and approach and landing;

2) a QFE setting as an alternative to a QNH setting for approach and landing only;

3) a setting of 1013.2 mbs. as the pressure datum of the system of flight levels.

In applying the method, the use of these three settings is co-ordinated in such a way as to ensure that a pilot will be able to maintain adequate terrain clearance and vertical separation at all times even though the operating conditions and ground services available may vary greatly from one area to another. The method is flexible in that it permits a pilot to make use of the most accurate and most suitable information available to him on any route. It also allows variations in the detailed procedures which may be developed by air traffic and meteorological services to account for conditions peculiar to a locality. For this reason the following description of the application of the method does not attempt to describe all of the alternative methods of applying the basic procedures. Instead examples of such detailed procedures taken from national regulations and airline operating manuals have been attached to this circular.

29. The basic procedures on which the method is based, as contained in Part 1 of ICAO Doc 7030, have been reproduced as Attachment 1 to this circular. These procedures have been adopted by the majority of ICAO Air Navigation Regions. The following description of the application of the method consists of a simpl e explanation of these procedures indicating the interrelation of the operational, meteorological and air traffic aspects of this subject.

Pre-flight

30. The cruising levels at which a pilot intends to conduct his flight will be listed in a flight plan in terms of flight levels and not altitudes. or heights. The flight levels listed will depend upon such considerations as air traffic density, topography, and the amount and type of altimeter setting information available prior to take-off and while en route. Since a pilot is responsible for insuring that he has adequate terrain clearance at all times, he will be primarily concerned with the vertical position of the flight levels he will use, relative to obstructions along the route. The air traffic service is concerned with the number of the lowest flight level which will provide adequate terrain clearance and therefore can be assigned to a flight. The number of this level is determined with the aid of information obtained from the meteorological service.

31. When adequate QNH reports are available en route a pilot will be able to check the vertical position of the flight level which he is using. When no QNH reports are available it may be necessary to fly at a higher flight level in order to provide an adequate margin of safety. On most high altitude flights the position of the lowest usable flight level is of little importance. The examples found in the attachments to this circular will indicate how this method may be applied to the many different types of operating conditions which are likely to be encountered.

32. Prior to take-off a pilot will acquaint himself with the height of the transition altitude above aerodrome elevation (expressed as an altitude) and the number of the transition level (expressed as a number).

Take-off and Climb

33. The number of the transition level will be made available to a pilot in the routine take-off instructions. Prior to commencing the take-off, the altimeter will be set to the current QNH altimeter setting for the aerodrome.

34. During take-off and during climb up to the transition altitude, the vertical position of the aircraft will be referred to in terms of "altitude" in all air-ground communications initiated by either the pilot or by an air traffic services unit. Aircraft approaching to land also use a QNH altimeter setting. Thus the vertical position of all aircraft at or below the transition altitude will be expressed in terms of altitude.

35. Flights in the vicinity of an aerodrome may be conducted entirely at or below the transition altitude, in which case only a QNH altimeter setting need be used. However, for flights above the transition altitude the altimeter setting will be changed to 1013.2 mbs. on passing through this altitude.

En Route

36. Having passed through the transition altitude an aircraft will continue to climb to the first cruising flight level listed in the clearance, reporting its vertical position as required by air traffic control service in terms of "flight levels", e.g. flight level 5, 10, 15, or 20. During en-route flight the aircraft will be flown at the flight levels listed in the air traffic clearance, until descending to the transition level at the aerodrome of intended landing.

37. The height of the aircraft above the earth's surface will be determined by means of an altimeter set on a QNH altimeter setting or, in areas where suitable QNH reports are not available, by flying at flight levels, the vertical position of which has been determined prior to take-off. In certain areas it may be decided that some combination of the two should be used, i.e. such QNH altimeter setting reports, or other meteorological reports as are available, may be used to check the position of the predetermined flight levels in flight. The information on which predetermined flight levels may be based can vary from MET forecasts for a particular flight to climatological date covering a period of 50 years. As stated previously a pilot will make the best use of the pre-flight and in-flight information available to him.

Approach and Landing

38. During the initial approach to an aerodrome and prior to reaching the transition level, the number of the transition level and the current QNH altimeter setting for the aerodrome will be made available to a pilot by the appropriate air traffic services unit.

39. Depending upon the height of the transition altitude above an aerodrome, an aircraft may be required to hold at specified flight levels and/or altitudes. During descent and upon passing through the transition level the altimeter setting will be changed from 1013.2 mbs. to the current QNH setting for the aerodrome. Thereafter the vertical position of the aircraft will always be referred to in terms of "altitude" even though a QFE altimeter setting may be used during the final approach to the runway. The use of only one unit of vertical distance in all air-ground communications initiated by either a pilot or an air traffic controller is essential in view of the fact that in certain instances a controller may be in communication with aircraft at or below the transition altitude and an aircraft completing a missed approach procedure at the same time. All vertical distances contained in such communications must be expressed in terms of altitudes since a controller cannot be expected to remember which aircraft are using a QNH setting and which are using a QFE. A QFE setting is intended to be used only during the final approach to land and at no time will vertical distances in air-ground communications be expressed in heights.

Missed Approach

40. In the event of a missed approach, a QNH altimeter setting will continue to be used provided the missed approach procedure is to be executed at or below the transition altitude. Otherwise the procedures applicable to take-off and climb will apply.

APPENDIX A

DEVELOPMENT AND USE OF AN ALTIMETER

1. Since an altimeter has always been one of the most important basic flight instruments and since its purpose and method of operation are rather apparent, little consideration is usually given to its capabilities and limitations. The following remarks regarding the development of the instrument, the functions which it is capable of performing, and its limitations are quite relevant to the subject of this circular.

2. In view of the well-known variation in atmospheric pressure with altitude, it was quite logical that the instrument adopted for indicating the height of an aircraft above the ground should have been one actuated by atmospheric pressure. Although such an instrument could have developed as a simple absolute pressure gauge calibrated in either millibars, pounds per square inch or kilograms per square metre, the user would have had to learn to associate units of pressure with vertical distances. To eliminate the need for such mental conversions on the part of the pilot, the pressure actuated instrument was calibrated to provide an indication of vertical distance.

Calibration of an Altimeter

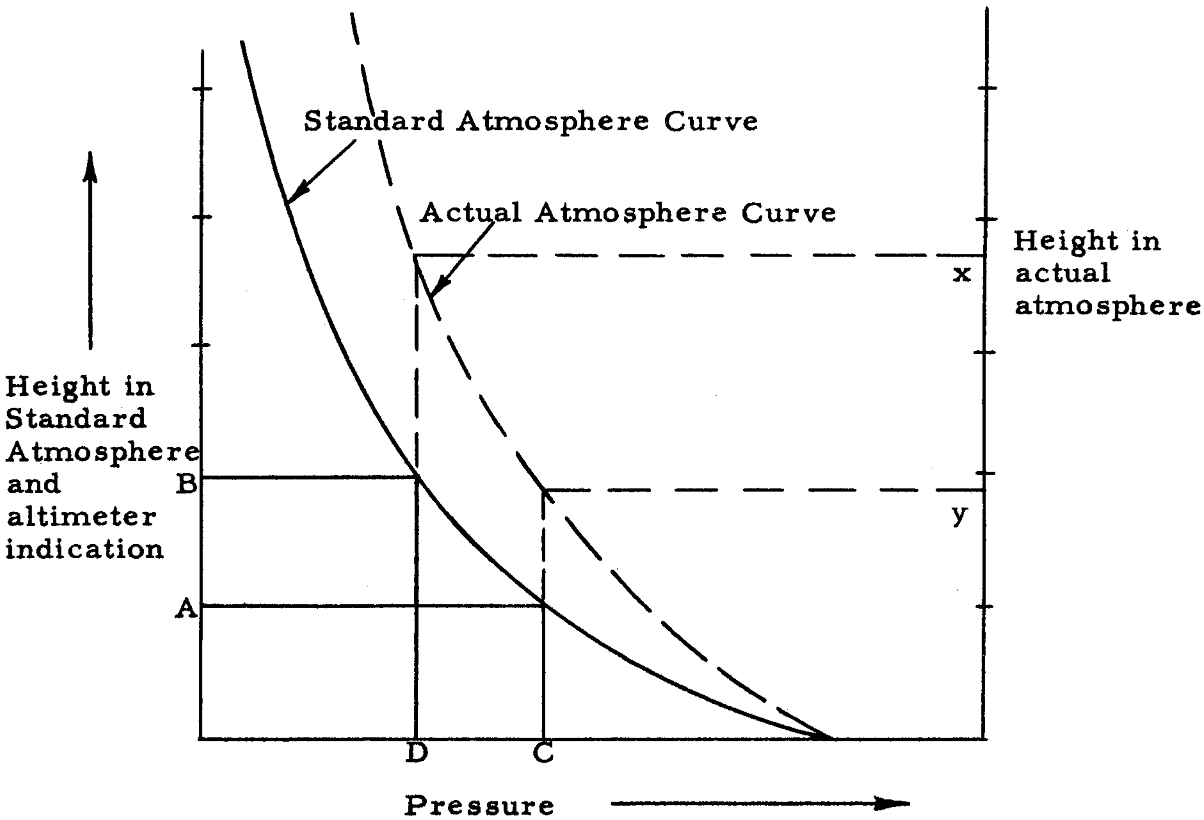
3. Since the change in atmospheric pressure for any given vertical distance in the atmosphere is not constant, the calibration of such an instrument presented a problem. In order to establish a fixed pressure-vertical-distance relationship on which the calibration of instrument could be based, a "Standard Atmosphere" was developed. *This Standard Atmosphere is representative of the many different atmospheric conditions found in various parts of the world. Due to the fact that the pressure-height relationship represented by this atmosphere will seldom correspond to conditions actually encountered, the indication provided by an altimeter calibrated in accordance with this atmosphere will usually be in error. Since nothing can be done about variations in atmospheric pressure and since the Standard Atmosphere was designed to be representative of a mean of many different atmospheres, its use provided the most logical approach to the problem.

Errors in Indication

4. The errors resulting from variations in atmospheric pressure from standard conditions are illustrated in the figure below, which contains curves representing the pressure-height relationship found in the standard atmosphere and in an actual atmosphere. In order to simplify the discussion

* See discussion on Standard Atmosphere in Appendix B.

the atmospheric pressure at zero height in both atmospheres is assumed to be same. In calibrating a simple altimeter the instrument is adjusted so that for any pressure value it will always indicate the corresponding height on the standard-atmosphere curve. For example, whenever the instrument is exposed to a pressure C it will always indicate a height A. Likewise, a change in pressure of C-D will always result in a change in height indication of A-B. One often loses sight of the fact that an altimeter is only capable of measuring pressure; that it functions as though it were always in a standard atmosphere and therefore indicates only height in such an atmosphere.



5. An altimeter once having been calibrated to follow the standard-atmosphere curve shown may, when in service, be exposed to an atmosphere such as that shown by the second curve. When an aeroplane ascends until the atmospheric pressure falls to a value C, the aeroplane will be at a height Y. Since the altimeter functions as though it were in a standard atmosphere and has been calibrated to indicate a height A when exposed to a pressure C it will in fact indicate a height A. Likewise for an actual change in height of X-Y the altimeter will show a change of height A-B. the difference between the actual height X and the indicated height B is usually referred

to as one of the several "altimeter errors" but it is useful to note that such an error is not due to inability of the instrument to measure atmospheric pressure accurately but is due to the fact that it was calibrated in a standard atmosphere but is generally used in one which is non-standard.* While mechanical and installation errors of the instrument may be equally important they are not mentioned here due to the fact that they are not relevant to the particular subject under discussion.

Selection of Reference Datum

6. The pressure datum adopted for the Standard Atmosphere, 1013.2 mbs., corresponds to zero height. Since the atmospheric pressure at any given point on the earth's surface is continually increasing or decreasing, the position of this pressure datum is likewise rising or falling and it may be either above or below the earth's surface. Since a pilot often wishes to know his height above the terrain rather than above such an arbitrary pressure datum, a method for selecting a more useful datum was developed. The dial of modern altimeters contains a window displaying a pressure sub-scale which can be adjusted to obtain a desired atmospheric-pressure setting, e.g. a QNH or a QFE altimeter setting. (See illustrations at pages 23 and 24.)

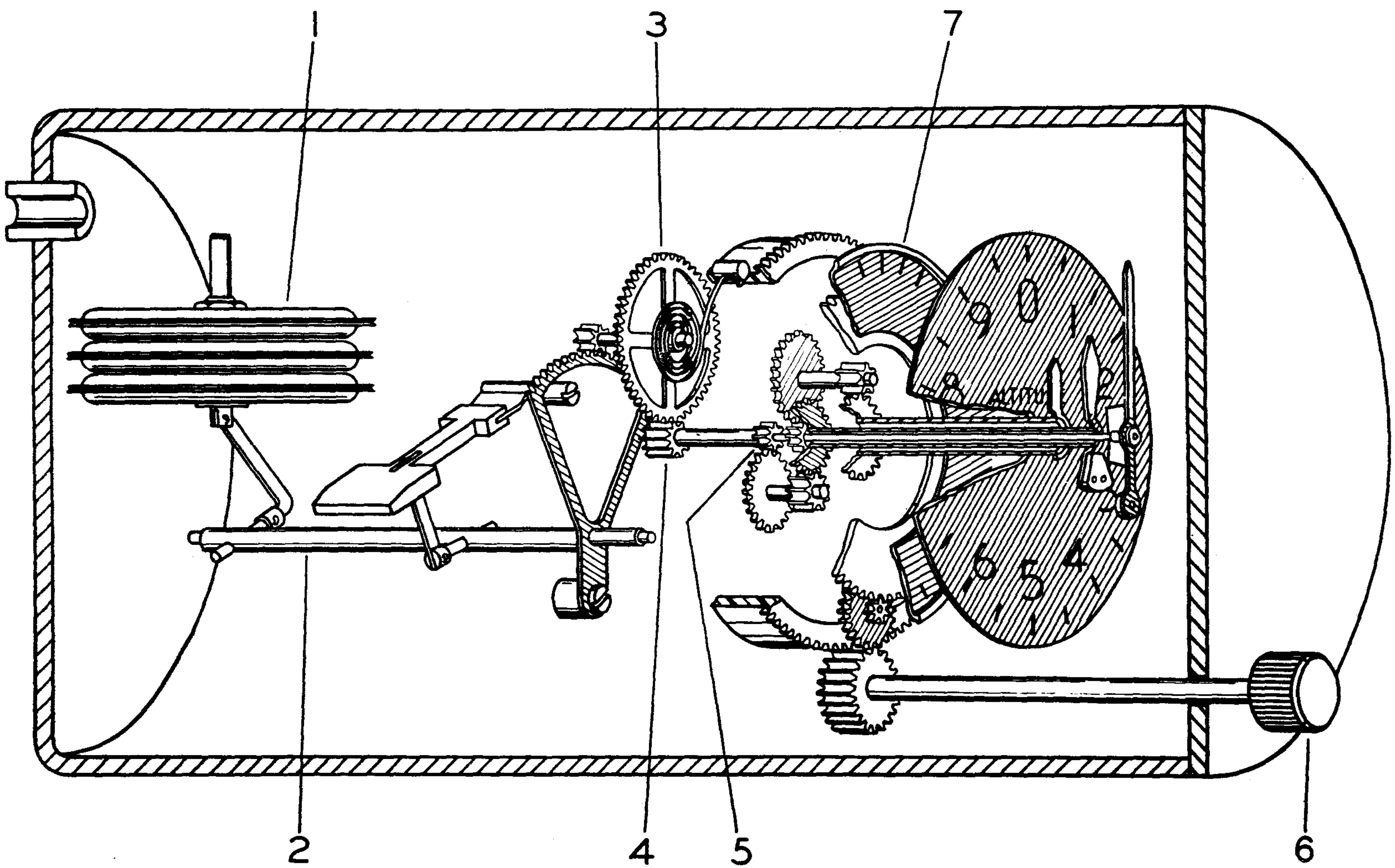
Functions of the Pressure sub-Scale

7. The pressure sub-scale is mechanically connected in such a way that adjustments in the position of the sub-scale are converted into corrections to the height indication in accordance with the pressure-height relationship in the Standard Atmosphere. The amount of adjustment of the pressure sub-scale required to make the height indication accurate depends on the datum selected (e.g., the surface or mean sea level) and/or on the magnitude of the deviation of pressure at the selected reference level from the corresponding pressure in the Standard Atmosphere.

Methods of Computing QFE Values

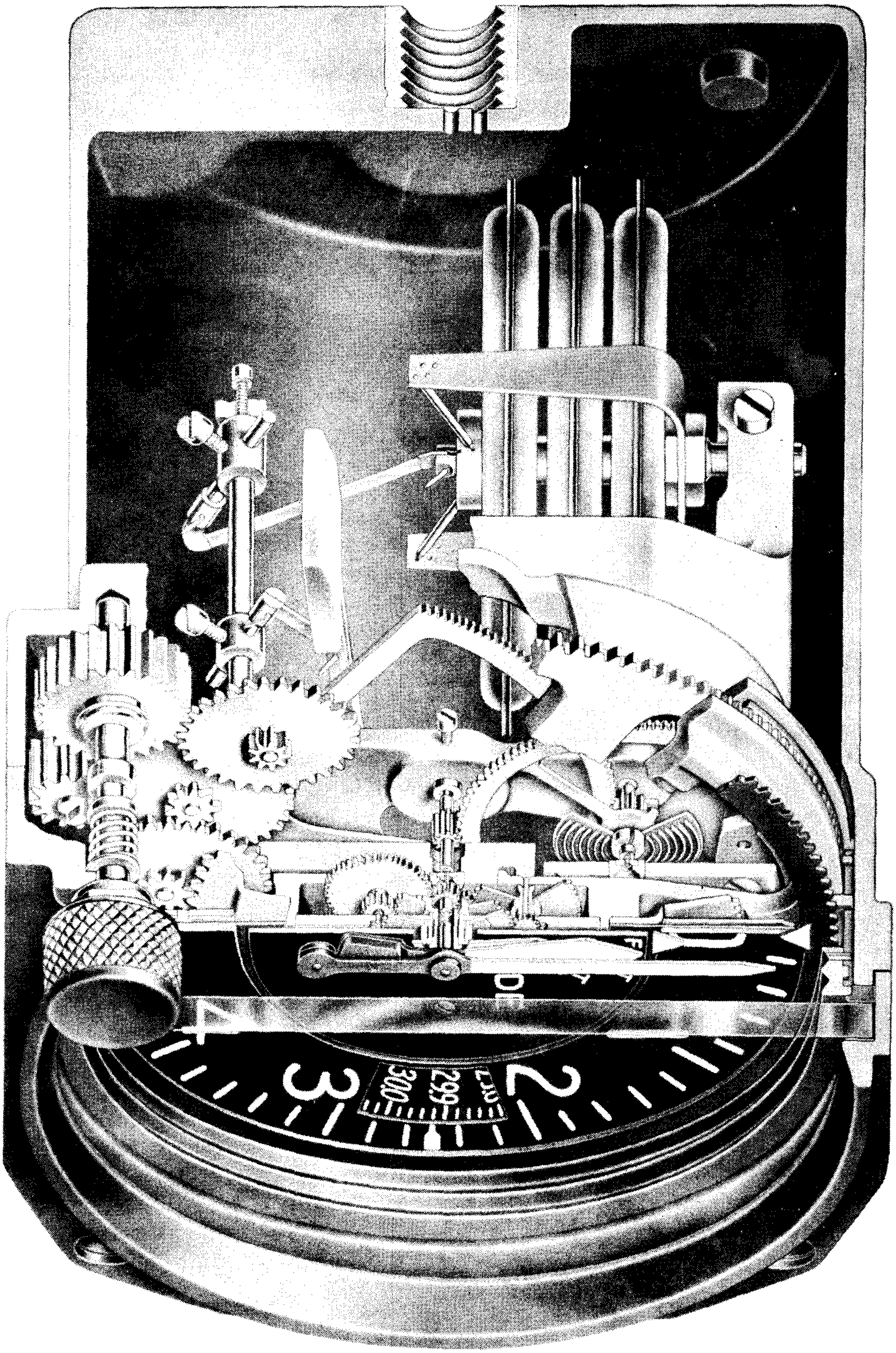
8. The QFE setting of the pressure sub-scale of the altimeter is derived directly from the atmospheric pressure at the location where the setting is to be applied. Since the observations of pressure are normally made in the Meteorological Office, it is usually necessary to reduce the observed pressures to the elevation of the aerodrome. In most circumstances, the differences in elevation between the point where the observations are to be taken and the elevation of the aerodrome is sufficiently small that the reduction can be accomplished by the addition of a constant correction. Where this difference in elevation is greater than about 20 feet (7 metres) and where temperature variations are large, it is necessary to develop a simple correction table using temperature and the observed pressure as the two arguments. It should be noted that the pressure value used should be the reading of the mercurial barometer, corrected for temperature, index error and gravity.

* This is discussed in greater detail in Appendix C.



1. DIAPHRAGM ASSEMBLY
2. ROCKING SHAFT
3. INTERMEDIATE PINION WHEEL
4. HANDSTAFF PINION
5. PINION
6. SETTING KNOB
7. BAROMETRIC SCALE

Kollsman Instrument Corporation



Kollsman Instrument Corporation

9. QFE values may also be derived directly from a sensitive altimeter located on the aerodrome by setting the height scale to zero height and reading the QFE values from the pressure sub-scale. If this practice is used, care should be taken to take into account any differences in elevation between the altimeter used and the elevation of the aerodrome to which the QFE values are referred. An example of the determination of QFE values will illustrate the description of the method as outlined above.

Elevation of aerodrome	500 m
Elevation of cistern of mercurial barometer	513 m
Actual reading of the mercurial barometer	989.0 mb
Sum of corrections for temperature, index errors, gravity, etc.	- 0.2 mb
Reduction to elevation of aerodrome plus 3 metres* . .	1.1 mb
QFE value for aerodrome	989.9 mb

Methods for Computing QNH Values

10. The most direct way to obtain QNH values for a given time and place is to adjust the pressure sub-scale of a sensitive altimeter located at the aerodrome until the altitude indication is equal to the elevation of the instrument.* The QNH value can then be read directly from the pressure sub-scale. This method has the advantage of simplicity. However, where more accurate pressure measuring instruments are available, such as the mercurial barometer, these should be used in determining the basic information from which QNH can be derived. It may be noted that special instruments have been designed for indicating QNH values directly. These are simply precision aneroid barometers which can be pre-set for the field elevation to indicate QNH directly on the scale.

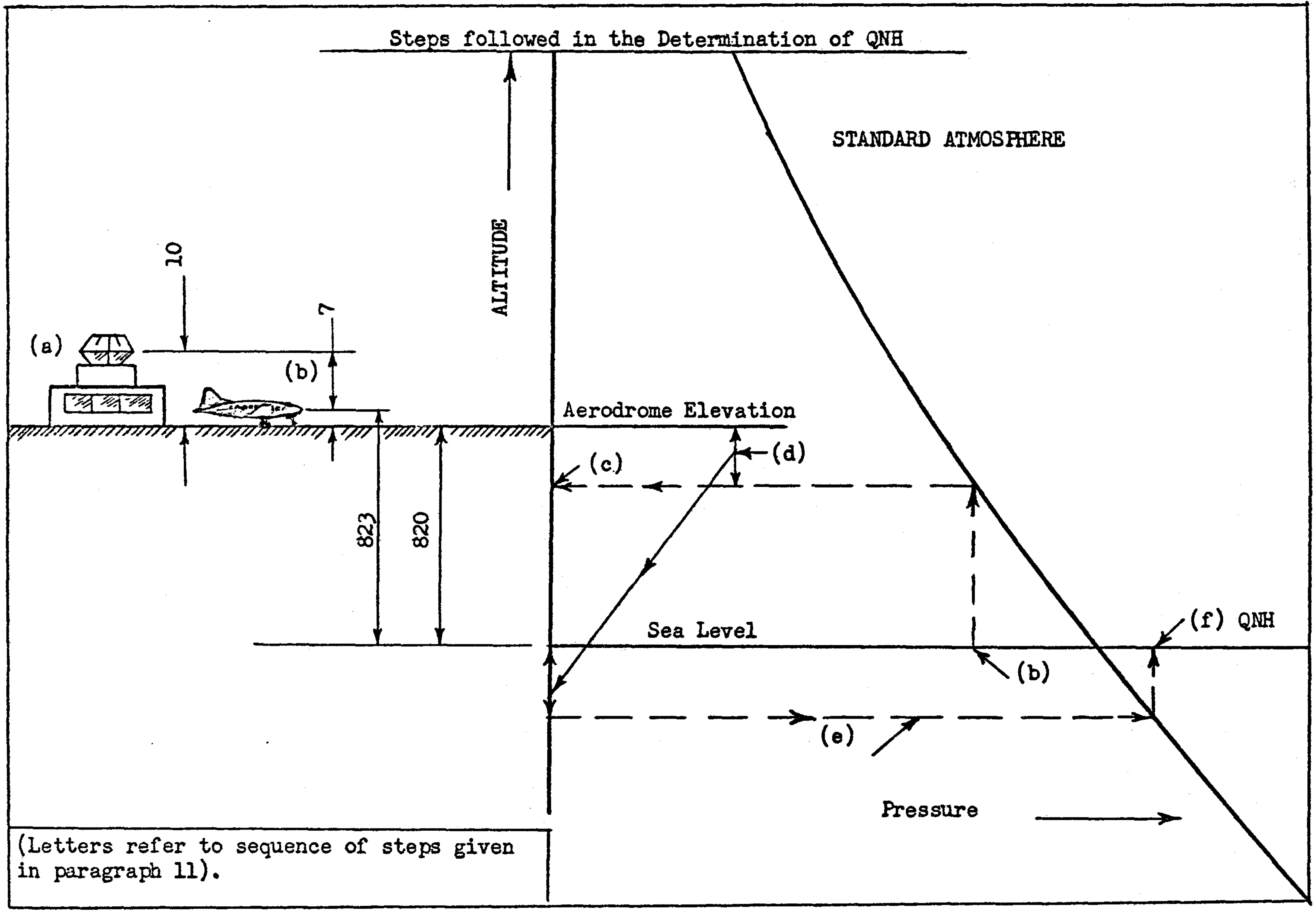
11. The method for determining the QNH values from the observed atmospheric pressure is described in the following steps:

a) measure atmospheric pressure;

b) determine QFE value as described above;

---

* It has become a common practice when computing QNH (and QFE) values to make allowance for the height of the altimeter above the runway when the aircraft is on the ground. While no standard allowance has been agreed, a compromise between large and small aircraft of 3 metres is generally used. It is important to note that the observed pressure is reduced to official aerodrome elevation plus 3 metres, but this additional 3 metres is not considered in the subsequent steps for determining QNH.


Steps followed in the Determination of QNH
STANDARD ATMOSPHERE
ALTITUDE
10
7
(a)
(b)
Aerodrome Elevation
(d)
(c)
823
820
Sea Level
(f) QNH
(b)
(e)
Pressure
(Letters refer to sequence of steps given in paragraph 11).

c) find the altitude in the standard-atmosphere table corresponding to the pressure in b);

d) from the altitude found in c) subtract algebraically the aerodrome elevation;

e) find the pressure in the standard-atmosphere table corresponding to the altitude found in d);

f) the pressure determined in e) is the QNH value for the aerodrome.

Example

Official aerodrome elevation	820 m
Height of barometer above aerodrome elevation	10 m
Assumed standard height above aerodrome elevation of altimeter in aircraft when on aerodrome*	3 m
Height of barometer above altimeter in aircraft on the aerodrome (10-3)	7 m
a) Measured atmosphere pressure	932.3 mb
b) QFE value	933.0 mb
c) Altitude in the Standard Atmosphere equivalent to 933.0 mb	690 m
d) Altitude c) less aerodrome elevation (690-820)	- 130 m
e) Pressure in Standard Atmosphere equivalent to -130 m	1029.3 mb
f) QNH	1029.3 mb

This procedure is illustrated in the diagram, which is schematic in character and is not intended for actual use in determining other QNH values.

* It has become a common practice when computing QNH (and QFE) values to make allowance for the height of the altimeter above the runway when the aircraft is on the ground. While no standard allowance has been agreed, a compromise between large and small aircraft of 3 metres is generally used. It is important to note that the observed pressure is reduced to official aerodrome elevation plus 3 metres, but this additional 3 metres is not considered in the subsequent steps for determining QNH.

Preparation of QNH Tables

12. The procedures described above can be simplified by use of a table of QNH values. Such a table can be prepared by determining the QNH value for each value of pressure likely to be encountered at the aerodrome for which the table is to be used. These values, arranged in convenient tabular form, then eliminate any further computation. As QNH depends only on the observed pressure at aerodrome level (and not on temperature as does QFF) only one factor need be shown in the table. A sample table for an aerodrome at 914.4 metres (3,000 feet) is given in Table 1.

The Standard Atmosphere

13. Because of the necessity for using standard-atmosphere values in the preparation of the QNH table, a limited portion of the standard-atmosphere specifications is given in the Table at Appendix B.

TABLE 1

SAMPLE QNH TABLE

(Elevation of Aerodrome = 914.4 metres)

Pressure at Aerodrome	0	1	2	3	4	5	6	7	8	9
850	950	951	952	953	954	955	956	957	958	960
860	961	962	963	964	965	966	967	968	969	970
870	972	973	974	975	976	977	978	979	980	981
910	1015	1016	1018	1019	1020	1021	1022	1023	1024	1025
920	1026	1027	1028	1029	1031	1032	1033	1034	1035	1036
930	1037	1038	1039	1040	1042	1043	1044	1045	1046	1047

APPENDIX B

THE STANDARD ATMOSPHERE

1. Since pressure-type altimeters are used throughout the world for determining terrain clearance and for vertical separation purposes, it is essential that the calibration of all instruments be based on one and the same pressure-vertical distance relationship. Likewise one fixed set of atmospheric conditions must be used in expressing the performance of an aircraft in order that performance figures of different types of aircraft may be comparable. These considerations led to the development of an empirical atmosphere which is representative of the atmospheric conditions found in various parts of the world. Several such atmospheres, referred to as "Standard Atmospheres", were developed for the same purpose in Germany, by ICAN and in the United States, each differing only slightly from the others.

2. In 1949 ICAO developed the following definition of a Standard Atmosphere which was adopted for use by all States:

"Standard Atmosphere: An atmosphere defined as follows:

a) the air is a perfect dry gas;

b) the temperature at sea level is 15° C (59° F);

c) the pressure at sea level is 760 millimetres (29.92 inches) of mercury (1013.3 millibars);

d) the temperature gradient from sea level to the altitude at which the temperature becomes -56.5° C (-69.7°F) is -0.0065°C per metre (-0.003566°F per foot), and zero thereabove."

A detailed specification of this ICAO Standard Atmosphere complete with tables and diagrams will soon be published in Metric and English units.

3. In addition to these basic assumptions, it is also necessary to establish the values of certain physical constants and the relationship between the various dimensional units in which these constants can be expressed. A complete list of the constants used is given in a detailed report on the *ICAO Standard Atmosphere*, Doc 7041.

Standard Atmosphere Tables

4. The Standard Atmosphere is represented primarily by a table listing the pressures and temperatures corresponding to various heights. Additional tables list derived values, such as pressure and temperature ratio between sea level and various levels above, the mean temperature of the air column between sea level and various levels and the density ratio. The specific weight the co-efficient of viscosity and the kinematic viscosity, the speed of sound, etc., are also used for various aeronautical engineering purposes. A portion of the temperature, pressure, and height table which is based on the NACA Standard Atmosphere has been included for purposes of illustration.

STANDARD ATMOSPHERE

(Based on NACA Standard)

Symbols

zp	(m)	Height in metres above datum level (1013.2 mbs.)
zp	(f)	Height in feet above datum level (1013.2 mbs.)
Tp		Standard temperature (degrees centigrade)

			0	1	2	3	4	5	6	7	8	9
500	zp	(m)	5572	5557	5543	5528	5513	5499	5484	5469	5455	5440
	zp	(f)	18281	18233	18185	18136	18088	18041	17993	17944	17897	17849
	Tp		-21.2	-21.1	-21.0	-20.9	-20.8	-20.7	-20.6	-20.5	-20.5	-20.4
510	zp	(m)	5425	5411	5397	5382	5368	5354	5339	5325	5311	5296
	zp	(f)	17800	17754	17706	17659	17612	17564	17517	17470	17423	17376
	Tp		-20.3	-20.2	-20.1	-20.0	-19.9	-19.8	-19.7	-19.6	-19.5	-19.4
520	zp	(m)	5282	5268	5254	5239	5225	5211	5197	5183	5168	5154
	zp	(f)	17329	17282	17236	17189	17142	17096	17050	17003	16956	16910
	Tp		-19.3	-19.2	-19.1	-19.1	-19.0	-18.9	-18.8	-18.7	-18.6	-18.5
530	zp	(m)	5140	5126	5112	5098	5084	5070	5056	5042	5028	5015
	zp	(f)	16865	16818	16772	16726	16681	16634	16589	16543	16497	16452
	Tp		-18.4	-18.3	-18.2	-18.1	-18.0	-18.0	-17.9	-17.8	-17.7	-17.6
540	zp	(m)	5001	4987	4973	4959	4945	4932	4918	4904	4891	4877
	zp	(f)	16406	16361	16316	16270	16225	16180	16135	16090	16045	16000
	Tp		-17.5	-17.4	-17.3	-17.2	-17.1	-17.1	-17.0	-16.9	-16.8	-16.7
550	zp	(m)	4863	4850	4836	4823	4809	4795	4782	4768	4755	4741
	zp	(f)	15956	15911	15866	15822	15777	15732	15688	15644	15599,	15555
	Tp		-16.6	-16.5	-16.4	-16.3	-16.2	-16.2	-16.1	-16.0	-15.9	-15.8
560	zp	(m)	4728	4714	4701	4688	4674	4661	4647	4634	4621	4607
	zp	(f)	15511	15467	15422	15379	15335	15291	15247	15204	15160	15116
	Tp		-15.7	-15.6	-15.5	-15.5	-15.4	-15.3	-15.2	-15.1	-15.0	-14.9
			0	1	2	3	4	5	6	7	8	9

		0	1	2	3	4	5	6	7	8	9
570	z_p (m)	4594	4581	4568	4555	4542	4528	4515	4502	4489	4476
	z_p (f)	15073	15030	14986	14943	14900	14856	14813	14770	14727	14684
	T_p	-14.9	-14.8	-14.7	-14.6	-14.5	-14.4	-14.3	-14.3	-14.2	-14.1
580	z_p (m)	4463	4449	4436	4424	4410	4397	4385	4371	4359	4346
	z_p (f)	14641	14598	14555	14513	14470	14427	14385	14342	14300	14257
	T_p	-14.0	-13.9	-13.8	-13.8	-13.7	-13.6	-13.5	-13.4	-13.3	-13.2
590	z_p (m)	4333	4320	4307	4294	4281	4269	4256	4243	4230	4217
	z_p (f)	14215	14173	14131	14088	14046	14005	13962	13920	13879	13836
	T_p	-13.2	-13.1	-13.0	-12.9	-12.8	-12.7	-12.7	-12.6	-12.5	-12.4
600	z_p (m)	4205	4192	4179	4167	4154	4141	4129	4116	4104	4091
	z_p (f)	13795	13753	13711	13670	13628	13587	13546	13504	13463	13422
	T_p	-12.3	-12.2	-12.2	-12.1	-12.0	-11.9	-11.8	-11.8	-11.7	-11.6
610	z_p (m)	4078	4066	4053	4041	4028	4016	4003	3991	3979	3966
	z_p (f)	13380	13339	13298	13257	13216	13175	13134	13094	13053	13012
	T_p	-11.5	-11.4	-11.3	-11.3	-11.2	-11.1	-11.0	-10.9	-10.9	-10.8
620	z_p (m)	3954	3941	3929	3917	3904	3892	3880	3867	3855	3843
	z_p (f)	12972	12931	12890	12850	12810	12769	12729	12688	12648	12608
	T_p	-10.7	-10.6	-10.5	-10.5	-10.4	-10.3	-10.2	-10.1	-10.1	-10.0
630	z_p (m)	3831	3819	3806	3794	3782	3770	3758	3745	3733	3721
	z_p (f)	12568	12528	12488	12448	12407	12368	12328	12288	12249	12209
	T_p	-9.9	-9.8	-9.7	-9.7	-9.6	-9.5	-9.4	-9.3	-9.3	-9.2
640	z_p (m)	3709	3697	3685	3673	3661	3649	3637	3625	3613	3601
	z_p (f)	12169	12128	12090	12051	12012	11972	11933	11893	11854	11815
	T_p	-9.1	-9.0	-9.0	-8.9	-8.8	-8.7	-8.6	-8.6	-8.5	-8.4
650	z_p (m)	3589	3577	3565	3554	3542	3530	3518	3506	3494	3483
	z_p (f)	11775	11737	11697	11659	11620	11581	11542	11503	11464	11426
	T_p	-8.3	-8.2	-8.2	-8.1	-8.0	-7.9	-7.9	-7.8	-7.7	-7.6
660	z_p (m)	3471	3459	3447	3435	3424	3412	3400	3389	3377	3365
	z_p (f)	11387	11348	11310	11271	11233	11194	11156	11118	11079	11041
	T_p	-7.6	-7.5	-7.4	-7.3	-7.2	-7.2	-7.1	-7.0	-6.9	-6.9
670	z_p (m)	3354	3342	3331	3319	3307	3296	3284	3273	3261	3249
	z_p (f)	11003	10965	10927	10889	10851	10813	10775	10737	10699	10661
	T_p	-6.8	-6.7	-6.6	-6.6	-6.5	-6.4	-6.3	-6.3	-6.2	-6.1
680	z_p (m)	3238	3227	3215	3203	3192	3181	3170	3158	3146	3135
	z_p (f)	10624	10586	10549	10510	10473	10436	10399	10361	10323	10286
	T_p	-6.0	-6.0	-5.9	-5.8	-5.8	-5.7	-5.6	-5.5	-5.4	-5.4
		0	1	2	3	4	5	6	7	8	9

			0	1	2	3	4	5	6	7	8	9
690	z_p	(m)	3124	3113	3101	3090	3078	3067	3056	3045	3034	3022
	z_p	(f)	10249	10212	10174	10137	10100	10063	10026	9989	9953	9919
	T_p		-5.3	-5.2	-5.1	-5.1	-5.0	-4.9	-4.9	-4.8	-4.7	-4.6
700	z_p	(m)	3011	3000	2989	2977	2966	2955	2944	2933	2922	2911
	z_p	(f)	9879	9842	9805	9768	9731	9695	9658	9622	9585	9549
	T_p		-4.6	-4.5	-4.4	-4.3	-4.3	-4.2	-4.1	-4.1	-4.0	-3.9
710	z_p	(m)	2900	2888	2877	2866	2855	2844	2833	2822	2811	2800
	z_p	(f)	9513	9476	9440	9403	9367	9331	9295	9258	9222	9186
	T_p		-3.8	-3.8	-3.7	-3.6	-3.6	-3.5	-3.4	-3.3	-3.3	-3.2
720	z_p	(m)	2789	2778	2767	2756	2745	2734	2723	2712	2702	2691
	z_p	(f)	9150	9115	9078	9043	9006	8971	8935	8899	8864	8828
	T_p		-3.1	-3.0	-3.0	-2.9	-2.8	-2.8	-2.7	-2.6	-2.6	-2.5
730	z_p	(m)	2680	2669	2658	2647	2637	2626	2615	2604	2593	2583
	z_p	(f)	8793	8756	8721	8685	8650	8615	8579	8544	8508	8474
	T_p		-2.4	-2.4	-2.3	-2.2	-2.1	-2.1	-2.0	-1.9	-1.9	-1.8
740	z_p	(m)	2572	2561	2551	2540	2529	2518	2508	2497	2487	2476
	z_p	(f)	8438	8403	8368	8333	8298	8262	8228	8192	8158	8123
	T_p		-1.7	-1.7	-1.6	-1.5	-1.4	-1.4	-1.3	-1.2	-1.2	-1.1
750	z_p	(m)	2465	2455	2444	2434	2423	2412	2402	2391	2381	2370
	z_p	(f)	8088	8053	8018	7984	7949	7914	7879	7845	7811	7776
	T_p		-1.0	-0.9	-0.9	-0.8	-0.8	-0.7	-0.6	-0.5	-0.5	-0.4
760	z_p	(m)	2360	2349	2339	2328	2318	2307	2297	2286	2276	2266
	z_p	(f)	7742	7707	7673	7638	7604	7570	7535	7500	7467	7433
	T_p		-0.3	-0.3	-0.2	-0.1	-0.1	-0.0	0.1	0.1	0.2	0.3
770	z_p	(m)	2255	2245	2234	2224	2214	2203	2193	2183	2172	2162
	z_p	(f)	7399	7365	7330	7297	7263	7229	7195	7161	7127	7093
	T_p		00.3	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.9	1.0
780	z_p	(m)	2152	2142	2131	2121	2111	2101	2090	2080	2070	2060
	z_p	(f)	7060	7026	6992	6959	6925	6892	6857	6824	6790	6757
	T_p		1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.5	1.6
790	z_p	(m)	2049	2039	2029	2019	2009	1999	1989	1978	1968	1958
	z_p	(f)	6724	6690	6658	6624	6591	6557	6524	6491	6458	6425
	T_p		1.7	1.7	1.8	1.9	1.9	2.0	2.1	2.1	2.2	2.3
800	z_p	(m)	1948	1938	1828	1918	1908	1898	1888	1878	1868	1858
	z_p	(f)	6392	6359	6326	6293	6260	6227	6194	6161	6129	6095
	T_p		2.3	2.4	2.5	2.5	2.6	2.7	2.7	2.8	2.9	2.9
			0	1	2	3	4	5	6	7	8	9

		0	1	2	3	4	5	6	7	8	9
810	z_p (m)	1848	1838	1828	1818	1808	1798	1788	1778	1768	1758
	z_p (f)	6063	6030	5998	5965	5932	5899	5867	5834	5802	5769
	T_p	3.0	3.1	3.1	3.2	3.2	3.3	3.4	3.4	3.5	3.6
820	z_p (m)	1749	1739	1729	1719	1709	1700	1690	1680	1670	1660
	z_p (f)	5737	5705	5672	5641	5608	5576	5543	5512	5479	5447
	T_p	3.6	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.1	4.2
830	z_p (m)	1650	1641	1631	1621	1611	1602	1592	1582	1572	1563
	z_p (f)	5415	5383	5351	5319	5287	5255	5223	5191	5159	5127
	T_p	4.3	4.3	4.4	4.5	4.5	4.6	4.7	4.7	4.8	4.8
840	z_p (m)	1553	1544	1534	1524	1514	1505	1495	1486	1476	1466
	z_p (f)	5095	5064	5032	5000	4968	4937	4905	4874	4842	4811
	T_p	4.9	5.0	5.0	5.1	5.2	5.2	5.3	5.3	5.4	5.5
850	z_p (m)	1457	1447	1438	1428	1419	1409	1399	1390	1380	1371
	z_p (f)	4780	4748	4717	4685	4654	4622	4591	4560	4529	4497
	T_p	5.5	5.6	5.7	5.7	5.8	5.8	5.9	6.0	6.0	6.1
860	z_p (m)	1361	1352	1342	1333	1323	1314	1305	1295	1286	1276
	z_p (f)	4466	4435	4404	4373	4342	4311	4280	4249	4218	4186
	T_p	6.2	6.2	6.3	6.3	6.4	6.5	6.5	6.6	6.6	6.7
870	z_p (m)	1267	1257	1248	1238	1229	1220	1210	1201	1192	1182
	z_p (f)	4156	4124	4094	4063	4033	4001	3971	3940	3910	3879
	T_p	6.8	6.8	6.9	7.0	7.0	7.1	7.1	7.2	7.3	7.3
880	z_p (m)	1173	1164	1154	1145	1136	1127	1117	1108	1098	1089
	z_p (f)	3849	3818	3787	3757	3726	3696	3665	3635	3604	3574
	T_p	7.4	7.4	7.5	7.6	7.6	7.7	7.7	7.8	7.9	7.9
890	z_p (m)	1080	1071	1062	1052	1043	1034	1025	1016	1006	997
	z_p (f)	3543	3514	3483	3453	3422	3393	3362	3333	3302	3271
	T_p	8.0	8.0	8.1	8.2	8.2	8.3	8.3	8.4	8.5	8.5
900	z_p (m)	988	979	970	960	952	942	933	924	915	906
	z_p (f)	3242	3212	3182	3151	3122	3092	3062	3032	3002	2972
	T_p	8.6	8.6	8.7	8.8	8.8	8.9	8.9	9.0	9.0	9.1
910	z_p (m)	897	888	879	870	861	852	843	834	825	816
	z_p (f)	2943	2913	2883	2853	2824	2794	2765	2735	2706	2676
	T_p	9.2	9.2	9.3	9.3	9.4	9.5	9.5	9.6	9.6	9.7
920	z_p (m)	807	798	789	780	771	762	753	744	735	726
	z_p (f)	2646	2617	2587	2558	2528	2499	2469	2440	2411	2382
	T_p	9.8	9.8	9.9	9.9	10.0	10.0	10.1	10.2	10.2	10.3
		0	1	2	3	4	5	6	7	8	9

			0	1	2	3	4	5	6	7	8	9
930	z_p	(m)	717	708	699	690	681	673	664	655	646	637
	z_p	(f)	2352	2323	2294	2265	2235	2207	2177	2148	2119	2090
	T_p		10.3	10.4	10.4	10.5	10.6	10.6	10.7	10.7	10.8	10.9
940	z_p	(m)	628	619	611	602	593	584	575	567	558	549
	z_p	(f)	2061	2032	2003	1974	1945	1916	1888	1859	1830	1801
	T_p		10.9	11.0	11.0	11.1	11.1	11.2	11.3	11.3	11.4	11.4
950	z_p	(m)	540	531	523	514	505	497	488	479	470	461
	z_p	(f)	1773	1743	1715	1686	1657	1629	1600	1572	1542	1514
	T_p		11.5	11.5	11.6	11.7	11.7	11.8	11.8	11.9	11.9	12.0
960	z_p	(m)	453	444	436	427	418	410	401	392	384	375
	z_p	(f)	1485	1458	1429	1400	1372	1344	1315	1287	1259	1230
	T_p		12.1	12.1	12.2	12.2	12.3	12.3	12.4	12.4	12.5	12.6
970	z_p	(m)	366	358	349	340	332	323	315	306	297	289
	z_p	(f)	1202	1173	1145	1116	1089	1060	1033	1004	976	948
	T_p		12.6	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.1	13.1
980	z_p	(m)	280	272	263	255	246	238	229	221	212	204
	z_p	(f)	920	892	864	836	808	780	752	725	696	668
	T_p		13.2	13.2	13.3	13.3	13.4	13.5	13.5	13.6	13.6	13.7
990	z_p	(m)	195	187	178	170	162	153	144	136	128	119
	z_p	(f)	641	613	585	557	530	502	474	447	419	392
	T_p		13.7	13.8	13.8	13.9	14.0	14.0	14.1	14.1	14.2	14.2
1000	z_p	(m)	111	103	94	86	77	69	61	52	44	35
	z_p	(f)	364	337	308	281	253	226	199	171	143	116
	T_p		14.3	14.3	14.4	14.4	14.5	14.6	14.6	14.7	14.7	14.8
1010	z_p	(m)	27	19	10	2	-6	-15	-23	-31	-39	-48
	z_p	(f)	89	62	34	7	-20	-48	-75	-102	-129	-157
	T_p		14.8	14.9	14.9	15.0	15.0	15.1	15.1	15.2	15.3	15.3
1020	z_p	(m)	-56	-64	-73	-81	-89	-97	-105	-114	-122	-130
	z_p	(f)	-183	-211	-238	-265	-292	-319	-346	-373	-400	-427
	T_p		15.4	15.4	15.5	15.5	15.6	15.6	15.7	15.7	15.8	15.9
1030	z_p	(m)	-138	-147	-155	-163	-171	-179	-188	-196	-204	-212
	z_p	(f)	-454	-481	-508	-535	-562	-588	-616	-642	-669	-695
	T_p		15.9	16.0	16.0	16.1	16.1	16.2	16.2	16.3	16.3	16.4
1040	z_p	(m)	-220	-229	-237	-245	-253	-261	-269	-277	-285	-293
	z_p	(f)	-722	-750	-776	-803	-829	-856	-882	-909	-936	-962
	T_p		16.4	16.5	16.5	16.6	16.6	16.7	16.8	16.8	16.9	16.9
			0	1	2	3	4	5	6	7	8	9

			0	1	2	3	4	5	6	7	8	9
1050	z_p	(m)	-301	-309	-318	-326	-333	-342	-350	-358	-366	-374
	z_p	(f)	-989	-1015	-1042	-1068	-1094	-1121	-1147	-1173	-1200	-1226
	T_p		17.0	17.0	17.1	17.1	17.2	17.2	17.3	17.3	17.4	17.4
1060	z_p	(m)	-382	-390	-398	-406	-414	-422	-430	-438	-446	-454
	z_p	(f)	-1253	-1279	-1306	-1332	-1358	-1384	-1411	-1437	-1463	-1489
	T_p		17.5	17.5	17.6	17.6	17.7	17.7	17.8	17.8	17.9	18.0
1070	z_p	(m)	-462	-470	-478	-486	-494	502	-510	-518	-525	-533
	z_p	(f)	-1515	-1541	-1567	-1594	-1620	-1646	-1672	-1698	-1724	-1750
	T_p		18.0	18.1	18.1	18.2	18.2	18.3	18.3	18.4	18.4	18.5
1080	z_p	(m)	-541	-549	-557	-565	-573	-581	-589	-596	-604	-612
	z_p	(f)	-1776	-1801	-1827	-1853	-1879	-1905	-1931	-1957	-1982	-2008
	T_p		18.5	18.6	18.6	18.7	18.7	18.8	18.8	18.9	18.9	19.0
1090	z_p	(m)	-620	-628	-636	-643	-651	-659	-667	-675	-682	-690
	z_p	(f)	-2034	-2060	-2085	-2111	-2137	-2162	-2188	-2213	-2239	-2265
	T_p		19.0	19.1	19.1	19.2	19.2	19.3	19.3	19.4	19.4	19.5
1100	z_p		-698									
	z_p		-2290									
	T_p		19.5									
			0	1	2	3	4	5	6	7	8	9

APPENDIX C

NON-STANDARD PRESSURE - HEIGHT RELATIONSHIPS AND THEIR EFFECT ON THE INDICATIONS OF PRESSURE ALTIMETERS

Errors in Height and Altitude Indications

1. The pressure at a point in the free atmosphere is due mainly to the weight of air above. In pressure altimetry, however, its relation to the pressure near the earth's surface is used.

2. On this basis errors in altimeter indications result from

a) deviations of the pressure at the datum level* from the datum pressure in the standard atmosphere (1013.2 mbs);

b) deviations from standard of the pressure difference between the datum level and the altimeter.

Deviations of the second kind result from differences of density from standard which in turn result almost entirely from differences of temperature from standard (assuming a given altimeter reading, i.e. a given pressure interval in the atmosphere). Humidity also affects density, but to a negligible extent as far as ICAO altimeter setting procedures are concerned. The pressure difference between the datum level and the altimeter may also be affected significantly by vertical motion in the atmosphere when this is intense, as in thunderstorms or in the vicinity of mountains. This matter is under study but, as no practical method of applying any necessary corrections has yet been devised, it is not considered further here.

3. The general relationship of deviations of pressure at the datum level and temperature to the indications of height or altitude provided by an altimeter may be expressed as follows:

a) When the pressure at the datum level or the mean temperature of the air column between the aircraft and the datum level (the other element assumed to be standard) is lower than standard, the aircraft is lower than indicated by the altimeter (the dangerous case);

b) When the pressure at the datum level or the mean temperature of the air column between the aircraft and the datum level (the other element assumed to be standard) is higher than standard, the aircraft is higher than indicated by the altimeter.

---

* The datum level is the level above which it is desired to measure height by means of the altimeter (e.g. MSL when altitude is to be measured; aerodrome level when height above aerodrome is to be measured).

4. A deviation in the pressure at the datum level will introduce an error which is reflected equally at all levels of the atmosphere. The magnitude of the error is approximately 8 metres per 1 millibar deviation from standard. Thus if the actual pressure at the datum level is 30 mbs from standard the error in the altimeter's indication of height above the datum level due to this cause will be approximately 240 m. regardless of the actual height of the altimeter.

5. The error due to deviations from the standard vertical distribution of temperature is a function of both the amount of temperature deviation and the vertical distance over which it is effective. When the altimeter is at the datum level this factor does not cause an error. The magnitude of the error is approximately 4 m per degree centigrade temperature deviation per 1000 m of height. Thus, if the mean temperature of the vertical column of air between the altimeter and the datum level differed by 10 degrees centigrade from standard, the height indication error for various heights would be approximately 4 m at 100 m; 12 m at 300 m; 120 m at 3000 m and 320 m at 8000 m.

6. The first of the deviations mentioned in paragraph 2 may be compensated for by adjusting the pressure sub-scale of the altimeter. When adjustment is made to cause the altimeter to read altitude, it is necessary to determine the hypothetical pressure at sea level (QNH) on the basis of the observed pressure at the surface of the earth. Strictly this procedure will, in general, eliminate the error in height indication only when the altimeter is at the point for which the hypothetical sea level pressure has been computed, and, of course, only if the pressure at that point has not changed. It is particularly important to note that, if the altimeter is higher or lower than that point, there will generally be some error in its indication.

7. The second of the deviations mentioned in paragraph 2 can be satisfactorily allowed for if the necessary information on the temperature between the datum level and the altimeter is available. The computation of this correction is usually accomplished by means of the appropriate scale on a navigator's computer.

8. The ICAO altimeter setting procedures for vertical separation of aircraft disregard temperature errors in altimeter indications since even large temperature deviations from standard introduce errors in the difference of altitude between two consecutive flight levels which are acceptably small. (Compare paragraph 18.)

Determination of the vertical position of flight levels

9. The effects of temperature deviations are most significant when it becomes necessary to determine from pressure measurement made at the earth's surface, heights of flight levels above the ground. In these circumstances it is necessary either:

a) to have actual or estimated temperature values at various levels aloft, or

b) to know the surface temperature and to assume a lapse rate of temperature with height.

From this information the mean temperature of the air column can be determined and the heights of particular flight levels computed.

10. A simple procedure for determining the height above station, and the altitude, of a flight level is as follows:

a) The standard atmosphere height of the station

= the height in standard atmosphere tables corresponding to the QFE value.

b) The standard atmosphere thickness of the layer between station and flight level

= the standard atmosphere height of the flight level minus the standard atmosphere height of the station.

c) The height above station of the flight level

= standard atmosphere thickness of the layer multiplied by the actual mean absolute temperature of the layer divided by the standard atmosphere mean absolute temperature of the layer.

d) The altitude of the flight level

= the height above station of the flight level plus the elevation of the station.

Example

Problem: Find the height above station and the altitude of flight level 40.

Given: Station elevation = 1800 ft.;

QFE = 963.0 mbs

Mean temperature of the layer = 22°C (295°K).

Procedure

a) The standard atmosphere height of the station = 1400 ft. (height corresponding to a pressure of 963.0 mbs. in the standard atmosphere)

b) The standard atmosphere thickness of the layer between station and flight level 40 = 4000 - 1400 = 2600 ft.

c) The height above station of flight level 40

$$= 2600 \times \frac{295}{283} = 2710 \text{ ft.}$$

(Standard atmosphere mean temperature of the layer

$$= \frac{(12.2 + 7.1)}{2}{}^{\circ}C$$

$$= 10^{\circ}C = 283^{\circ} K)$$

d) The altitude of flight level 40

$$= 2710 + 1800 = 4510 \text{ ft.}$$

Variations in the heights of transition levels and flight levels

11. In establishing the transition levels at aerodromes and lowest usable flight levels en route, the variability of the height or altitude of such levels is an important factor. In some areas the range of variation is so small that, with the aid of statistical data, fixed transition levels and lowest usable flight levels en route can be chosen, to give the necessary clearances when these levels fall to their lowest altitude, without causing a serious waste of flight levels on the occasions when these are near the upper limit of their range of variation. In other areas the rate and magnitude of variation are such that in order to avoid serious waste of flight levels it is necessary to determine transition levels and lowest usable flight levels from hourly meteorological data or even from forecast data. Given adequate statistical data it should be possible for individual States to decide on procedures suited to their needs. The choice of method will be influenced by traffic density, number of flight levels required and other operational considerations. Some States may, for example, find it convenient to choose transition levels and lowest usable flight levels which can be used without change for, say, 90% of the time and to transfer to other levels for the remaining 10% of the time.

12. The procedure for the use of climatological data as a basis for fixing flight levels depends to some degree on the character of the data available at a given location. If only surface temperature and pressure data are at hand, maps with QNE correction values* or any equivalent correction values, to cover the corresponding area, may be used.

Where detailed climatological data for the upper air are available the standard deviations of the altitude of selected constant pressure surfaces from the heights of those surfaces in the standard atmosphere should be the most satisfactory basis for deciding on the flight levels to be used.

---

* QNE correction is defined as the difference between the standard height of a given flight level, over a given station, and the lowest altitude of that flight level, according to climatological records.

13. The table below, which contains data on flight levels and temperatures for two points on air route, namely Misawa (Japan) and Massacre Bay (Aleutians), has been prepared to illustrate the variations which can occur in:

a) the position of flight levels relative to mean sea level (altitude of flight levels), and

b) the vertical distance between flight levels.

The examples shown are typical of the extremes which may occur in the storm belt of middle latitudes. In the tropics variations of this magnitude would be associated only with intense tropical storms and would be rare.

Flight Level(s)	WINTER: Route change (1730 miles)				WINTER: Time change (28 days)		SUMMER: Route change (1730 miles)				SUMMER: Time change (6 days)	
	(1) Misawa 30 Dec'49		(2) Mass. Bay 30 Dec'49		(3) Mass. Bay 2 Dec'49		(4) Mass. Bay 13 July'49		(5) Misawa 13 July'49		(6) Misawa 7 July'49	
	Altitude of, and Temperature at, Flight Level (Ft. and °C.)											
170	16,920	-36	16,920	-34	16,850	-39	17,960	-12	19,090	- 6	18,230	-6
100	10,130	-21	9,210	-14	9,400	-23	9,770	10	10,550	13	9,870	4
50	6,090	-15	4,160	- 4	4,780	-12	4,650	9	5,230	18	4,670	9
0	420	-	-1,030	-	50	- 4	-240	7	70	18	-550	-

Flight Level(s)	(1)	(2)	(3)	(4)	(5)	(6)
	Vertical Separation of Flight Levels (Ft)					
170-160	930	940	920	1030	1050	1050
100- 90	940	970	930	1050	1070	1030
50- 40	930	970	940	1010	1050	1010

14. The figures in columns 1 and 2 indicate that on December 30 flight level 170 was located at an altitude of 16, 920 feet both at Misawa and Massacre Bay, which are 1730 miles apart. However, on the same day the altitude of flight level 50 at these two points differed by 10, 130 - 9, 210 = 920 feet. Figures applicable to the same route in Summer are found in columns 4 and 5.

15. The figures in columns 3 and 4 and again in 5 and 6 indicate the variation in the altitude of flight levels over a period of time. For example on July 13 at Misawa flight level 170 was at 19, 090 feet and six days later it was at 18, 230 feet, 860 feet lower.

16. The table also indicates the variation in the vertical positions of flight level 0 due to changes in sea level pressure. For example columns 2 and 3 indicate that at Massacre Bay on December 2 flight level 0 was 50 feet above sea level, while on December 30 it was 1080 feet lower, at an altitude of -1030 feet (i.e. below sea level).

17. The temperature figures illustrate the effect of temperature on the vertical distance between flight levels. For example, at Misawa the vertical distance between levels 170 and 100 on December 30 was 16, 920 - 10, 130 = 6, 790 feet when the mean temperature of the layer was about -29°C; on 13 July it was 19, 090 - 10, 550 = 8, 540 feet when the mean temperature of the layer was about + 4°C.

18. The lower section of the table gives examples of the variation in the vertical distance between flight levels normally 1000 feet apart. It will be noticed that variations in separation are relatively small. (Compare paragraph 8.)

APPENDIX D

THE Q-SIGNALS ASSOCIATED WITH ALTIMETER SETTINGS

1. In developing the Q code, it was only natural that signals should be introduced to facilitate the transmission of data used in the setting of altimeters. Since the first signals were introduced, a number of amendments have been made to specify more exactly the various types of settings. The signals have now reached a point of development where the concept of each particular setting is succinctly defined by these Q code significations and the associated signal is often used as a convenient term for referring to each type of setting.

2. The atmospheric pressures which were used initially for adjusting the pressure sub-scale were:

a) the observed pressure at the aerodrome, which caused the altimeter to read zero on the aerodrome, and

b) the meteorological sea level pressure, which caused the altimeter to read approximate heights above sea level.

As a result of practices adopted largely in North America, where an altimeter located on the aerodrome was commonly used to determine the pressure setting for aircraft in flight, there developed a special setting first described as the "Kollsman Reading" later as the "altimeter setting", and which has now been given the Q-signal QNH. It was also found that the use of observed atmospheric pressures (QFE) at high altitude aerodromes resulted in a setting beyond the limits of the pressure sub-scale. This difficulty was overcome by the development of a new signal to indicate the height reading of an altimeter on the aerodrome when the pressure sub-scale was set to the datum pressure in the standard atmosphere, i.e., 1013.2 mbs. This setting is now identified by the signal QNE.

3. The present texts of the four Q-signals related to altimeter setting data are quoted below.

Signal	SIGNIFICATION	
	Question or Interrogatory Form	Answer, Information or Advice Form
QFE	[At ... (place)] what is the present atmospheric pressure at official aerodrome elevation?	At ... (place) the atmospheric pressure at official aerodrome elevation is (or was observed at ... hours to be) ... tenths of millibars. (Example QFE KLGA 9737) [i.e. 973.7 millibars]
QFF	[At ... (place)] what is the present atmospheric pressure converted to mean sea level in accordance with meteorological practice?	At ... (place) the atmospheric pressure converted to mean sea level in accordance with meteorological practice is (or was determined at ... hours to be) ... tenths of millibars.
QNE	What indication will my altimeter give on landing at ... (place) at ... hours, my sub-scale being set to 1013.2 millibars (29.92 inches)?	On landing at ... (place) at ... hours, with your sub-scale being set to 1013.2 millibars (29.92 inches) your altimeter will indicate ... (figures and units)
QNH	What should I set on the sub-scale of my altimeter so that the instrument would indicate my elevation if I were on the ground at your station?	If you set the sub-scale of your altimeter to read ... tenths of millibars (or hundredths of an inch*), the instrument would indicate your elevation if you were on the ground at my station at ... hours. * Note. - When the setting is given in hundredths of an inch the abbreviation "INS" is used to identify the units.

ATTACHMENTS

THIS PAGE INTENTIONALLY LEFT BLANK

ATTACHMENT 1

(Extract from Part 1 of Doc 7030)

1. - ALTIMETER SETTING

The following procedures for ensuring adequate terrain clearance and vertical separation of aircraft were designed to take account of the many different operating conditions encountered in various parts of the world, and the meteorological and communications services available. In brief the method used is based on the following basic principles:

a) for terrain clearance purposes a QNH altimeter setting is used whenever possible;

b) for vertical separation en route a system of flight levels is used. These flight levels are related to a pressure datum of 1013.2 mbs. (29.92 ins.) and are separated by a nominal distance of 500 feet (152.4 metres);

c) the transition from flight levels to altitudes in the vicinity of an aerodrome is effected by means of a horizontal transition layer above which aircraft are flown at flight levels and below which aircraft are flown at altitudes;

d) an altimeter set to 1013.2 mbs. (29.92 ins.), or any other suitable instrument is used to indicate flight levels and an altimeter set to a QNH setting is used to indicate altitudes.

The method is flexible in that it permits considerable variation in the detailed procedures which may be required to account for local conditions, without deviating from the basic principles

The chart on page 1-1-11 of Doc 7030 indicates those areas of the world in which these procedures apply.

1.1. - DEFINITIONS AND BASIC PROCEDURES

DEFINITIONS

Altitude - The vertical distance of a level, a point or an object considered as a point, measured from mean sea level.

Height - The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.

Elevation - The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.

Flight Levels - Surfaces of constant atmospheric pressure which are related to a specific pressure datum, 1013.2 mbs. (29.92 ins.), and are separated by specific pressure intervals (equivalent to 500 feet in the Standard Atmosphere).

Note.- A pressure type altimeter calibrated in accordance with the Standard Atmosphere:

a) when set to QNH altimeter setting, will indicate altitude;

b) when set to QFE altimeter setting, will indicate height above the QFE reference datum;

c) when set to a pressure of 1013.2 mbs. (29.92 ins.) may be used to indicate flight levels.

Transition Altitude - The altitude in the vicinity of an aerodrome at or below which the vertical position of an aircraft is controlled by reference to altitudes.

Transition Level - The lowest flight level available for use above the transition altitude.

Transition Layer - The airspace between the transition altitude and the transition level.

BASIC PROCEDURES

1.1.1 General

1.1.1.1 A transition altitude shall be specified for each aerodrome by the State in which the aerodrome is located and shall be published in NOTAMS and be depicted on ICAO Instrument Approach Charts.

1.1.1.2 The transition altitude shall coincide with the higher of:

a) the lowest initial approach altitude associated with the aerodrome, if established, or

b) a height of 450 metres (1500 feet) above aerodrome elevation,

unless operational considerations require that the transition altitude be located at some altitude other than specified in a) or b).

1.1.1.3 Where two or more closely spaced aerodromes are so located as to require co-ordinated procedures, a common transition altitude shall be established. This common transition altitude shall be the highest of the transition altitudes for the aerodromes considered.

1.1.1.4 Vertical displacement of aircraft when at or below the transition altitude shall be expressed in terms of altitude whereas such displacement at or above the transition level shall be expressed in terms of flight levels. While passing through the transition layer, vertical displacement shall be expressed in terms of altitude when descending, and in terms of flight levels when ascending.

1.1.1.5 Flight level zero shall be located at the atmospheric pressure level of 1013.2 mbs. (29.92 ins.). Consecutive flight levels shall be separated by a pressure interval corresponding to 500 feet (152.4 metres.) in the Standards Atmosphere.

Note. - Examples of the relationship between flight levels and altimeter indications are given in the following table:

Flight Level Number	Altimeter Indication Feet	Metres
-90	-1000	-300
-95	- 500	-150
0	0	0
5	500	150
10	1000	300
15	1500	450
20	2000	600
50	5000	1500
100	10000	3050
150	15000	4550
200	20000	6100

1.1.2 Take-off and Climb

1.1.2.1 A QNH altimeter setting shall be made available to aircraft in the routine take-off and climb instructions.

1.1.2.2 Vertical displacement of aircraft during climb shall be controlled by reference to altitudes until reaching the transition altitude above which vertical displacement shall be controlled by reference to flight levels.

1.1.3 En Route

1.1.3.1 Vertical Separation - En Route

1.1.3.1.1 Aircraft shall be flown en route at flight levels at all times during an IFR flight.

1.1.3.1.2 When complying with the quadrantal rule of Annex 2 an aircraft shall be flown at flight levels corresponding to the magnetic tracks shown in the following table:

	MAGNETIC TRACK			
	0-89°	90-179°	180-269°	270-359°
Flight Level Number	10	15	20	25
	30	35	40	45
	50	55	60	65
	etc.	etc.	etc.	etc.

1.1.3.2 Terrain Clearance - En Route

1.1.3.2.1 QNH altimeter setting reports should be provided from sufficient locations to permit determination of terrain clearance with an acceptable degree of accuracy.

1.1.3.2.2 For those areas in which adequate QNH altimeter setting reports cannot be provided, the appropriate authorities shall make available in the most usable form the information required to determine the lowest flight level which will ensure adequate terrain clearance.

Note. - This information may consist of current meteorological information or information based on climatological data and consequently the lowest flight level so derived may pertain to an area or a particular route or segments of routes and may be applicable to an indefinite period of time or to one particular flight.

1.1.3.2.3 Flight information centres, area control centres, approach control offices and aerodrome control towers shall at all times have available for flight planning purposes and for transmission to aircraft in flight, on request, the information required to determine the lowest flight level which will ensure adequate terrain clearance for routes or segments of routes on which this information is required.

1.1.4 Approach and Landing

1.1.4.1 A QNH altimeter setting shall be made available in the routine approach and landing instructions.

1.1.4.2 A QFE altimeter setting shall be made available in the landing instructions on request from the aircraft.

1.1.4.3 Vertical displacement of aircraft during approach shall be controlled by reference to flight levels until reaching the transition level below which vertical displacement shall be controlled by reference to altitudes.

1.1.5 Missed Approach

The relevant portions of 1.1.1.4, 1.1.2 and 1.1.4 shall be applied to the case of a missed approach.

1.2. - PROCEDURES APPLICABLE TO OPERATORS (INCLUDING PILOTS)

1.2.1 Flight Planning

1.2.1.1 The levels at which a flight is to be conducted shall be specified in a flight plan:

a) in terms of flight levels if the flight is to be conducted at or above the transition level, and

b) in terms of altitudes if the flight is to be conducted in the vicinity of an aerodrome and at or below the transition altitude.

Note 1. - Short flights in the vicinity of an aerodrome may often be conducted only at altitudes below the transition altitude.

Note 2. - Flight levels are specified in a plan by number, e.g., 50, 60, 70 and not in terms of feet or metres as is the case with altitudes.

1.2.1.2 The flight level or levels selected for a flight:

a) should ensure adequate terrain clearance at all points along the route to be flown;

b) should satisfy air traffic services requirements, and

c) should be compatible with the application of the quadrantal rule of Annex 2, if relevant.

Note 1. - The information required to determine the lowest flight level which will ensure adequate terrain clearance may be obtained from the appropriate air traffic services unit and/or meteorological office.

Note 2. - The flight level or levels chosen will depend upon the accuracy with which the vertical position of such levels relative to the terrain can be estimated, which in turn is dependent upon the type of meteorological information available. A lower flight level may be used with confidence when its position is based on current information closely associated with the particular route to be flown and when it is known that amendments to this information will be available in flight. A higher flight level will be used when based on information less relevant to the particular route to be flown and the time at which the flight is to be conducted. The latter type of information may be provided in chart or table form and may be made applicable to a large area and any period of time.

Note 3. - Flights over level terrain may often be conducted at one flight level whereas flights over mountainous terrain may require several changes in flight levels to account for changes in the elevation of the terrain. The use of several flight levels may also be required in order to comply with air traffic services requirements.

1.2.2 Take-off and Climb

1.2.2.1 Prior to taking off one altimeter shall be set on the latest QNH altimeter setting for the aerodrome.

1.2.2.2 During climb to and while at the transition altitude, references to the vertical position of the aircraft as contained in air/ground communications shall be expressed in terms of altitudes.

Note 1. - Instructions received from air traffic services units will also be expressed in terms of altitudes.

Note 2. - The transition altitude for an aerodrome is listed on instrument approach charts for that aerodrome.

1.2.2.3 On penetrating the transition altitude the altimeter setting shall be changed to 1013.2 mbs. (29.92 ins.) and thereafter the vertical position of the aircraft should be determined with reference to flight levels.

1.2.3 En Route

1.2.3.1 Vertical Separation

At or above the transition level of an aerodrome and during en-route flight conducted in accordance with IFR an aircraft shall be flown at flight levels.

1.2.3.2 Terrain Clearance

1.2.3.2.1 Where adequate QNH altimeter setting reports are available the latest and most appropriate reports shall be used for assessing terrain clearance.

1.2.3.2.2 Where terrain clearance cannot be assessed with an acceptable degree of accuracy solely by means of the QNH reports available, then adequate terrain clearance should be based on the flight levels listed in the flight plan. The position of these flight levels relative to the terrain should be checked in flight by means of such QNH reports or other information as are available.

1.2.4 Approach and Landing

1.2.4.1 Prior to commencing the initial approach to an aerodrome the number of the transition level shall be obtained from the appropriate air traffic unit.

Note. - In areas where the variation in sea-level atmospheric pressure is relatively small, a fixed transition level, based on the lowest pressure likely to be encountered, may be established and published in NOTAMS and on instrument approach charts.

1.2.4.2 Prior to descending below the transition level the latest QNH altimeter setting for the aerodrome shall be obtained from air traffic control.

1.2.4.3 On descending below the transition level the altimeter setting shall be changed to the QNH of the aerodrome and thereafter the vertical position of the aircraft shall be controlled with reference to altitude.

1.2.5 Missed Approach

The altimeter settings used while completing a missed approach procedure will be dependent upon whether or not procedure can be carried out below the transition altitude and in any event they should be consistent with the relevant procedures contained in 1.2.2, 1.2.3 and 1.2.4.

1.3. - PROCEDURES APPLICABLE TO AIR TRAFFIC SERVICES

1.3.1 Flight information centres, area control centres, approach offices and aerodrome control towers shall at all times have available the information required to determine the lowest flight level which will ensure adequate terrain clearance for routes or segments of routes on which this information is required.

1.3.2 Flight Plans

1.3.2.1 For flights in the vicinity of aerodromes the vertical position of aircraft shall be expressed in terms of altitudes if clearance is requested for at or below the transition altitude and in terms of flight levels if clearance is requested at or above the transition level.

1.3.2.2 For flights in control areas the vertical position of aircraft shall be expressed in terms of flight levels if clearance is requested.

Note. - In all air traffic control instructions, clearances, etc., flight levels are referred to by number only e.g., "flight level 50, 60, 75, etc...".

1.3.3 Flight Information Service

1.3.3.1 Flight information centres shall have available for transmission to aircraft on request an appropriate number of QNH reports or forecast pressures for the flight information regions for which they are responsible.

1.3.3.2 Where the information required by 1.3.3.1 cannot be provided, flight information centres shall have available for transmission to aircraft in flight the information required to determine the lowest flight level or levels which will ensure adequate terrain clearance for the routes or segments of routes on which this information is required.

1.3.4 Area Control Service

1.3.4.1 Area control centres shall have available for transmission to aircraft on request an appropriate number of QNH reports or forecast pressures for the control areas for which they are responsible.

1.3.4.2 Area control centres shall determine the lowest usable flight level or levels for the whole or parts of the control area for which they are responsible, and use it when assigning flight levels and pass it to the pilots on request.

Note 1. - The lowest usable flight level will provide a terrain clearance of at least 1000 feet (300 metres).

Note 2. - Additionally, air traffic services requirements will determine the distance along a route for which a particular lowest usable flight level extends.

Note 3. - *See* Note 2,para. 1, Part II of the PANS-RAC (Doc 4444-RAC/501/5).

1.3.4.3 For vertical separation all IFR flights shall be controlled by reference to flight levels, except when otherwise necessary in the vicinity of aerodromes (*see* paragraph 1.3.5).

1.3.5 Approach and Aerodrome Control Services

1.3.5.1 In the vicinity of aerodromes, approach control offices or aerodrome control towers shall establish the transition level for the appropriate period of time on the basis of QNH reports. The transition level shall be the lowest flight level available for use above the transition altitude for the aerodromes concerned. Where two or more aerodromes are in close proximity a single transition level shall be used for both aerodromes.

1.3.5.2 In setting the transition level the air traffic control plan and procedures in use shall preserve the separation Standards contained in the PANS-RAC (Doc 4444-RAC/501/5).

1.3.5.3 The transition level shall be passed to aircraft in routine take-off and approach and landing instructions.

1.3.5.4 A QNH altimeter setting shall be passed to aircraft in routine take-off instructions.

1.3.5.5 A QNH (and QFE on request) altimeter setting shall be passed to aircraft in routine landing instructions.

1.3.5.6 For vertical separation of aircraft in the vicinity of aerodromes the vertical position of aircraft shall be expressed in terms of altitudes when at or below the transition altitude and in terms of flight levels when at or above the transition level. While passing through the transitional layer, vertical displacement should be expressed in terms of altitudes while descending and in terms of flight levels when ascending.

1.4.- PROCEDURES APPLICABLE TO METEOROLOGICAL SERVICES

1.4.1 Responsibility of Meteorological Offices

1.4.1.1 Meteorological offices shall have available for use by air traffic services, operator's local representatives and air crews, as necessary, pressure and temperature information required:

a) to determine the lowest flight level which will ensure adequate terrain clearance for routes or portions of routes on which this information is required;

b) to establish the transition level for the aerodrome; and

c) to meet other local requirements.

1.4.1.2 Meteorological Offices shall have available at all times the current QNH and QFE values for the local aerodromes.

1.4.2 Data required

1.4.2.1 The information referred to in paragraph 1.4.1.1 shall invariably include the current QNH and QFE values for the relevant local aerodrome(s) and QNH reports from stations associated with the routes or areas(1) concerned. Where an adequate network of QNH reporting stations is not available, forecast values of minimum mean sea level pressure and of temperature for selected (3) points along the routes or over the area (1) shall be made available in addition (2). When the operational requirements can be met by providing this data for the duration of only one particular flight, the data to be provided may be limited to that particular flight.

Note 1.- For guidance as to the extent of the areas to be embraced, see Paras. 1.2 and 1.3 of these altimeter setting procedures.

Note 2.- In certain areas, for example, where the pressure and/or temperature variations are small, or where the resulting loss of airspace is acceptable, it may be practicable to use seasonal or fixed values. When this is done, it is necessary that some local procedure be established which will draw attention to the occasions when actual values of the elements entering into the computations are less than the fixed or seasonal values assumed.

Note 3.- These points are selected on the basis of the topography of the routes or area and prevailing meteorological situation.

1.4.2.2 The particular type of information made available in accordance with paragraph 1.4.2.1 shall be as determined by the Meteorological Offices concerned in consultation with Air Traffic Service Units and operators.

1.4.3 Dissemination of QNH values

1.4.3.1 QNH values shall be added to the meteorological reports of a network of stations within the FIRs or control areas under the jurisdiction of the State concerned. Such network shall be specially designated by the Meteorological Service of that State in consultation with its appropriate aeronautical authorities, with due consideration of the requirements stated in paragraph 1.4.2.1.

1.4.3.2 QNH values shall be added to meteorological reports included in ground/air hourly and half-hourly broadcasts.

1.4.3.3 QNH values and QFE values if required shall be made available by Meteorological Offices at all international aerodromes to the local Air Traffic Service unit on an hourly basis for transmission on request to aircraft in flight. When QNH values are made available for meteorological broadcast purposes at hourly and half-hourly intervals, they shall also be made available to the local Air Traffic Service Unit.

1.4.3.4 Meteorological Offices serving Flight Information Centres or Area Control Centres shall provide these centres with QNH values from the reporting stations of the network referred to in paragraph 1.4.3.1.

1.4.4 Pre-flight briefing

1.4.4.1 Pre-flight briefing by meteorological offices shall include information required to determine the lowest safe flight level.

ATTACHMENT 2

DETERMINATION OF LOWEST FLIGHT LEVEL PROVIDING ADEQUATE TERRAIN CLEARANCE EN ROUTE

The following extract from the Operations Manual of an airline has been reproduced to illustrate the type of detailed procedures which may be required for the use and guidance of flight crews and operations personnel, to amplify the procedures found in Attachment 1.

"OVERSEAS OPERATIONS BULLETIN

To: International Pilots, Navigators and Flight Radio Officers

Use of 'Flight Levels' (29.92"/1013.2 mbs.) in Cairo, Karachi and Bombay FIRs

1. This represents the first instance where flight levels are being used for vertical separation over land areas, thus creating a necessity for procedures which will assure adequate terrain clearance. The following discussion outlines the general principles involved in maintaining adequate terrain clearance and the procedures to be used for this purpose.

2. Use of Term FLIGHT LEVEL

In order to eliminate confusion arising from the use of 'altitudes' based on different settings, IATA has recommended the term FLIGHT LEVEL be used, corresponding to the reading on an altimeter set to 29.92" (1013.2 mbs.). The FLIGHT LEVELS will be indicated as 10 for 1000 ft., 15 for 1500 ft., and 20 for 2000 ft., 25 for 2500 ft., 30 for 3000 ft., etc.

When the pressure setting on the altimeter remains unchanged while the aircraft flies over stations with different pressure values or altimeter settings, the aircraft is in fact flying along a constant pressure level. When the QNH increases (indicating a rise in pressure at the station), the altitude of this pressure level also rises. Similarly, when the QNH decreases, the altitude of the pressure level also decreases. It is this constant pressure level which will be referred to as a FLIGHT LEVEL.

3. Terrain Clearance

Adequate terrain clearance en route will be provided by assuring that FLIGHT LEVELS selected do not violate existing minimum en-route altitudes. This will be accomplished by checking the QNH value from the appropriate en-route station. The altitude of FLIGHT LEVELS over a QNH reporting station can be determined from the difference between 29.92" and the actual QNH value at the time, using the relationship of 10 ft. for .01". For example, a QNH of 29.97" represents an increase over 29.92" of .05" or 50 ft. Since an increase of QNH means an increase of the altitude of the FLIGHT LEVEL, we find that for a QNH of 29.97", FLIGHT LEVEL 30 is 3050 ft. above mean sea level. Conversely, with a QNH of 29.42" the altitude of FLIGHT LEVEL 30 would be 2500 ft. (.50" decrease = 500 ft. decrease).

The above discussion is summarized graphically in Figure 1. The QNH reporting stations are shown along the surface of the ground (which, for simplification, has been placed at mean sea level) with the QNH value beside the point indicating the station. Levels of constant pressure corresponding to the QNH values are shown as dotted lines. A single FLIGHT LEVEL (FLIGHT LEVEL 30) is shown by a dashed line. The minimum en-route altitude is shown as a solid line and a scale of altitudes above sea level is shown in the right-hand margin. It will be readily seen that an aircraft cruising a FLIGHT LEVEL 30 is in effect flying a pressure contour line which is 3000 ft. above the pressure contour line corresponding to a QNH value of 29.92". For discussion purposes, certain of the QNH reporting stations have been numbered. The numbers below correspond to the station numbers in Figure 1:

1) QNH = 29.92"; therefore, since the isobar corresponding to 29.92" is at mean sea level at this station, FLIGHT LEVEL 30 is 3000 ft. MSL. The lowest usable FLIGHT LEVEL is 20, corresponding to the minimum en-route altitude of 2000 ft.

2) QNH = 31.92", which is 2.00" higher than 29.92" corresponding to an increase of 2000 ft. Thus, the altitude of FLIGHT LEVEL 30 is 3000 ft. plus 2000 ft. = 5000 ft. MSL. The lowest usable FLIGHT LEVEL in the vicinity of this station is still FLIGHT LEVEL 20.

3) QNH = 28.29", a decrease of 1.00" below 29.92". This is equivalent to a decrease of 1000 ft. Therefore, the altitude of FLIGHT LEVEL 30 is 3000 ft. minus 1000 ft. = 2000 ft. MSL. The MSL altitude of FLIGHT LEVEL 20 is below the minimum en-route altitude, and consequently, a new lowest usable FLIGHT LEVEL must be chosen. The MSL altitude of FLIGHT LEVEL 30 equals the minimum en-route altitude, thus making FLIGHT LEVEL 30 the lowest usable FLIGHT LEVEL in the vicinity of this station.

FIGURE 1

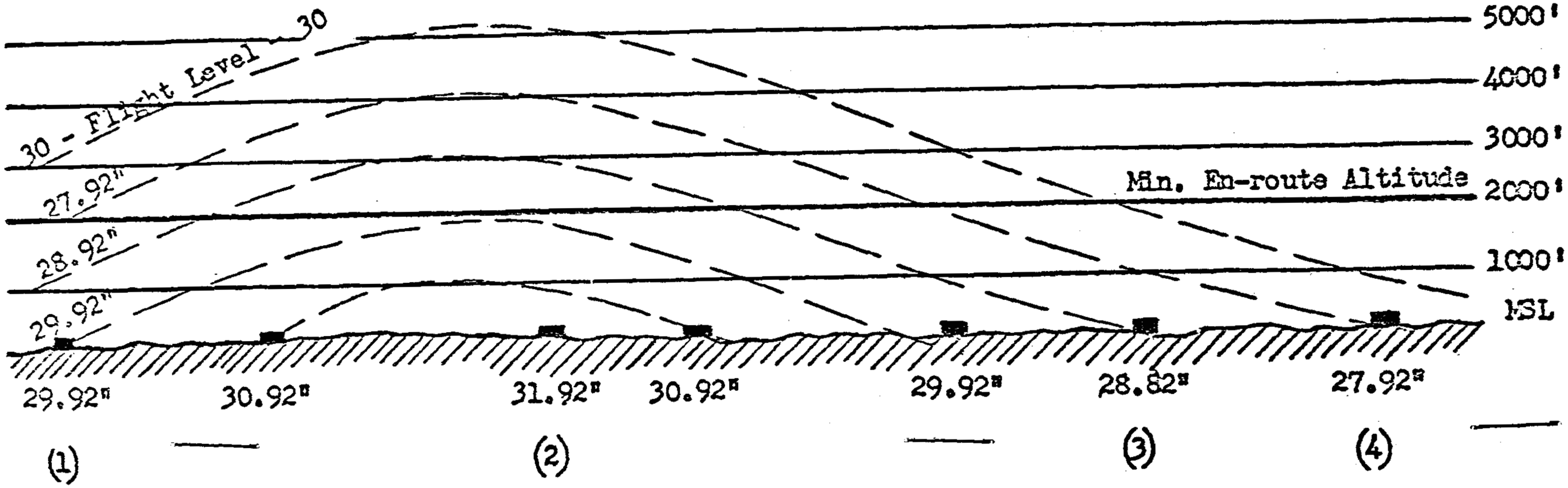
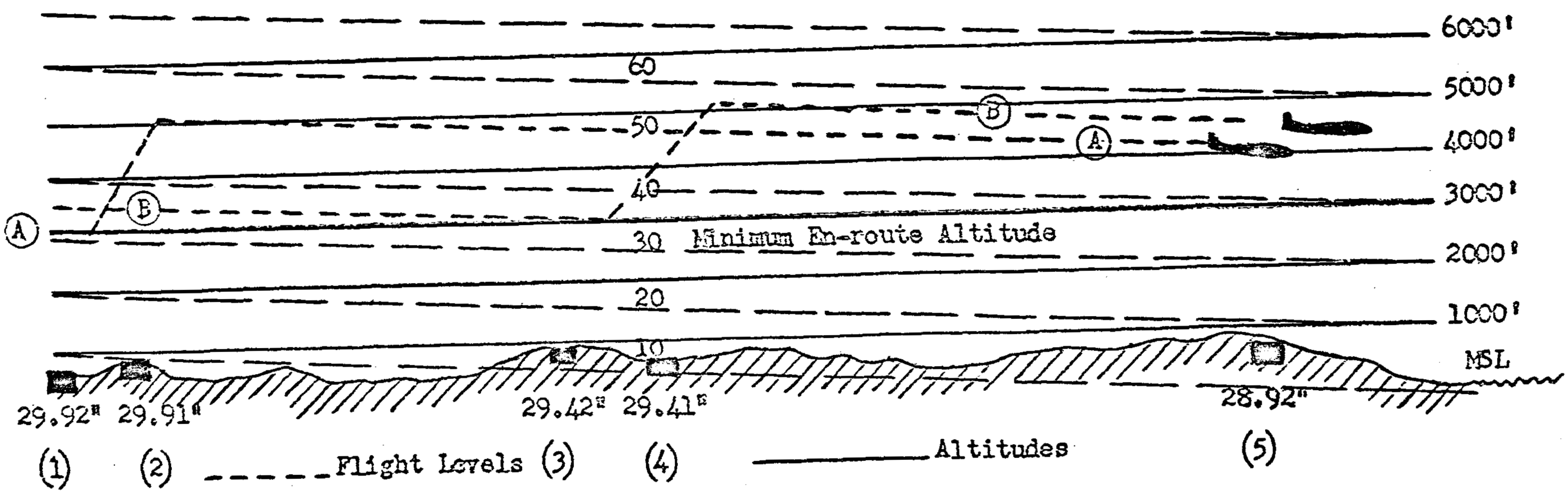


FIGURE 2



4) QNH = 27.92", a decrease of 2.00" or 2000 ft. The MSL altitude of FLIGHT LEVEL 30 of this station is 3000 ft. minus 2000 ft. = 1000 ft. Since the QNH has continued to lower the lowest usable FLIGHT LEVEL must be raised. In the vicinity of this station, the lowest usable FLIGHT LEVEL would be 40.

4. Procedures for Insuring Adequate Terrain Clearance

A. Preflight

1) Determine minimum en-route altitude for each stage of the route.

2) Determine latest actual QNH from en-route QNH reporting stations. If the intended flight will be of long duration, it is desirable to consider the forecast change in QNH as well as the actual QNH.

3) Wherever the QNH is equal to or higher than 29.92" or 1013.2 mbs., FLIGHT LEVELS down to and including that FLIGHT LEVEL which corresponds to the minimum en-route altitude may be used. For example, if the minimum en-route altitude is 3000 ft., FLIGHT LEVELS down to and including 30 may be used with QNH of 29.92" or higher.

4) Whenever the QNH is below 29.92" or 1013.2 mbs., determine the lowest usable FLIGHT LEVEL in accordance with the method outlined under Terrain Clearance, above. The lowest usable FLIGHT LEVEL is the lowest FLIGHT LEVEL having an altitude which equals the minimum en-route altitude.

5) The selection of FLIGHT LEVEL to be used en route must not be lower than the lowest usable FLIGHT LEVEL and, in addition, must conform to quadrantal separation rules or other air traffic control instructions.

B. En route

1) Obtain QNH values regularly from en-route QNH reporting stations.

2) Whenever the QNH of your nearest station is above 29.92" or 1013.2 mbs, no change in FLIGHT LEVEL is required.

3) Whenever the QNH of the nearest station is below 29.92" or 1013.2 mbs., the general rule is to climb to the next FLIGHT LEVEL consistent with the quadrantal rule.

a) If you are flying at a FLIGHT LEVEL corresponding to the minimum en-route altitude and QNH goes below 29.92", you will be below the minimum en-route altitude if you continue at that FLIGHT LEVEL. Therefore, when flying at a FLIGHT LEVEL corresponding to the minimum en-route altitude and the QNH goes below 29.92", the rule is always climb to the next appropriate FLIGHT LEVEL.

b) If you are flying at a FLIGHT LEVEL above the FLIGHT LEVEL corresponding to the minimum en-route altitude and the QNH goes below 29.92", check to determine if the decrease in pressure has lowered the MSL altitude of your FLIGHT LEVEL sufficiently to place it at or below the minimum en-route altitude. If so, then a) above applies; if not, no change in FLIGHT LEVEL is required.

4) The change of FLIGHT LEVEL should be made, as nearly as possible, at the mid-point between two QNH reporting stations.

C. Example

An example of the application of these principles to aircraft in flight is portrayed in Figure 2. In the example shown, the minimum en-route altitude is 3000 ft. MSL. The terrain profile is shown and QNH reporting stations are shown by dots on the terrain profile with the QNH values shown under the station. Aircraft "A" flying in a northeasterly direction starts out over station 1 at FLIGHT LEVEL 30. Aircraft "B" flying in a southeasterly direction starts out over station 1 at FLIGHT LEVEL 35. Since QNH at station 1 is 29.92", all aircraft have adequate terrain clearance over station 1.

While flying from station 1 to station 2, both aircraft receive routine reports of the QNH at 1 and the QNH at 2. The mid-point between stations 1 and 2 is the point where the aircraft should begin any change of altitude dictated by changes in QNH of station 2. Since the QNH at station 2 is reported as 29.91", a decrease of .01" or 10 ft., FLIGHT LEVEL 30 is 10 ft. below the minimum en-route altitude and, consequently, no longer constitutes the lowest usable FLIGHT LEVEL. Aircraft "A" must therefore leave FLIGHT LEVEL 30 and climb to the next FLIGHT LEVEL appropriate to its heading -- FLIGHT LEVEL 50 in this example. Aircraft "B" at FLIGHT LEVEL 35 over station 2 is still above the minimum en-route altitude.

While the aircraft are en route between stations 2 and 3, the QNH of station 3 reveals that FLIGHT LEVEL 35 constitutes the lowest usable FLIGHT LEVEL over station 3. A QNH of 29.42" equals a decrease of .50" or 500 ft., thus, placing FLIGHT LEVEL 35 at 3500 ft. minus 500 ft. = 3000 ft. MSL. Aircraft "A" at FLIGHT LEVEL 50 is still well above the lowest usable FLIGHT LEVEL 35.

When the QNH of station 4 is checked, it becomes evident that FLIGHT LEVEL 35 is at 2990 ft. MSL over that station. Thus, it is below the minimum en-route altitude. (29.92" - 29.41" = .51" or 510 ft.; 3500-510 ft. = 2990 ft.) FLIGHT LEVEL 35 is no longer the lowest usable FLIGHT LEVEL over station 4. Accordingly, aircraft "B" must climb to the next FLIGHT LEVEL appropriate to its heading (FLIGHT LEVEL 55) in order to avoid flying below the minimum en-route altitude."

- END -

ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the ICAO Aeronautical Chart Catalogue *or the* Combined Meteorological Tables for International Air Navigation.

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications comprised in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

PROCEDURES FOR AIR NAVIGATION SERVICES (PANS) are approved by the Council for world-wide application. They comprise, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome. As in the case of Recommended Practices, the Council has invited Contracting States to notify any differences between their national practices and the PANS when the knowledge of such differences is important for the safety of air navigation.

REGIONAL SUPPLEMENTARY PROCEDURES (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

ICAO FIELD MANUALS have no status in themselves but derive their status from the International Standards, Recommended Practices and PANS from which they are compiled. They are prepared primarily for the use of personnel engaged in operations in the field, as a service to those Contracting States who do not find it practicable, for various reasons, to prepare them for their own use.

TECHNICAL MANUALS provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

ICAO CIRCULARS make available specialized information of interest to Contracting States.

EXTRACT FROM THE CATALOGUE
ICAO SALABLE PUBLICATIONS

ANNEXES

Annex 2 — Rules of the air. 2nd edition (incorporating amendment 1). April 1952. 42 pp.	$0.40
Annex 6 — Operation of aircraft - International commercial air transport. 4th edition (incorporating amendments 1 to 135). May 1953. 26 pp.	$0.25
Annex 11 — Air Traffic Services. 2nd edition (incorporating amendments 1 to 6). May 1952. 62 pp.	$0.60
Annex 14 — Aerodromes. 2nd edition (incorporating amendments 1 to 6). September 1953. 66 pp.	$1.25

PROCEDURES FOR AIR NAVIGATION SERVICES

OPS - Holding and approach-to-land. (Doc 7458-OPS/610). 1st edition, 1954. 40 pp.	$0.50
RAC - Rules of the air and Air Traffic Services. (Doc 4444-RAC/501/5). 5th edition, 1954. 86 pp. Letterpress.	$1.25
Regional supplementary procedures. (Doc 7030).	$1.75
Amendment service. per year	$1.75

NB.—*Cash remittance should accompany each order. Catalogue sent free on request.*

PRICE: $0.75 (Cdn.) (Montreal)
Equivalents at date of publication:

15.00 bahts	(Bangkok)
18.00 pesos	(Buenos Aires)
L.E. 0.265	(Cairo)
14.75 soles	(Lima)
5s. 2d.	(London)
6s. 10d.	(Melbourne)
Rs. 3-12-0	(New Delhi)
265 francs	(Paris)

3/56, E/P1/1700