DECCA NAVIGATOR
AIR DATA SHEET
ISSUE 1.
MARCH 1949
No. A1

THE DECCA NAVIGATOR SYSTEM

INTRODUCTION

The Decca Navigator is a radio system which enables the position of an aircraft to be established rapidly, simply and accurately. Radio signals continuously emitted from four transmitting stations form a pattern of radio position lines in space. These signals when received in the aircraft by the Decca Navigator receiver automatically operate three meters designated Red, Green and Purple whose indicators depend upon the aircraft's position. Charts covering the service area of the "Chain" of four stations are gridded with a series of Red, Green and Purple lines which are identified by colour, letter and number (see Fig. 1) These lines correspond to the radio pattern formed by the transmissions from the ground stations.

At any time when the aircraft's position is required, it is merely necessary to read off the indications of two of the meters, say Red and Green, and then find the corresponding Red and Green lines on the chart. The point of intersection of the two lines is the position of the aircraft. Combinations of Red/Purple and Green/Purple are similarly used, the pair giving the best angle of cut being chosen.

BASIC PRINCIPLE

The principle of all hyperbolic systems, of which Decca is an example, is that of measuring the difference in time for radio waves to travel to the observation point from two synchronised transmitters. In Decca the time difference is measured indirectly. Suppose A and B in Fig. 2 to be two continuous-wave radio stations transmitting in synchronism, i.e. the crests and troughs of signals at the two transmitting aerials are in step or "In-phase," and that an aircraft is situated on the right bisector of the line joining A and B. Since the radio signals received in the aircraft will have traversed equal distances at a speed assumed to be constant, they will still be in-phase at the aircraft and the Decca receiver will detect this in-phase condition and indicate to the observer that the aircraft is on the line PQ. PQ is therefore a line of position of the aircraft and is one of a family of such in-phase lines shown in Fig. 2.

Except for PQ the lines are curved and "hyperbolic" in form. The interval between two in-phase lines is called a "lane." The meters, or "Decometers," driven by the Decca receiver are, in fact, phase indicators. With an aircraft on an in-phase line such as PQ the Decometer reading will be zero, indicating no phase difference between the two signals. If the aircraft moves away from PQ the meter needle will rotate indicating a changing phase relationship between the two received signals. On arrival at the next in-phase line the Decometer pointer will again indicate zero and the aircraft will have traversed one complete lane. By means of a second geared pointer the number of lanes crossed is recorded. The lanes are for convenience of numbering grouped into "Zones" designated by the letters A to J and the lane pointer in turn drives a lettered disc indicating the zone.

Once the Decometer has been set correctly for zone letter and lane number it will continuously and automatically indicate the hyperbolic position line on which the aircraft is situated, so long as the receiver is switched on and the aircraft is in range of the stations. To obtain a fix, another position line is required and in practice three families of hyperbolae are generated which operate three Decometers and give fixing at all points within the coverage of the Chain (see Fig. 1).

The transmitter at the centre of the chain is termed the "Master" since the other three transmitters necessary to generate the three hyperbolic patterns, the "Slaves," are phase locked to it. To overcome

the problem of identifying the transmissions each station transmits a different frequency. For the English Chain the Master transmits on 85.000 Kcs., the Red Slave on 113.333 Kcs., the Green Slave on 127.500 Kcs., and the Purple Slave on 70.833 Kcs. In the receiver these frequencies are multiplied to give common Master/Slave frequencies (Red 340 Kcs., Green 255 Kcs., and Purple 425 Kcs.) and the phase of each Slave is compared with the Master signal at these frequencies.

LANE IDENTIFICATION

To enable the Decometers to be set up correctly, at the start of a flight or when entering the coverage of a particular chain, or after any interruption of normal reception, a fourth meter known as the Lane Identification Meter is provided. This has three coloured scales corresponding to the scales on the Red, Green and Purple Decometers. Every minute each scale is illuminated and the correct lane reading is indicated on the appropriate scale. Thus at minute intervals an independent check on each Decometer reading is provided. This meter is fully described in Air Data Sheet No. A3. Full Lane Identification facilities exist on the English Chain and are being installed on the Danish Chain. Users will be advised when the latter is fully operational.

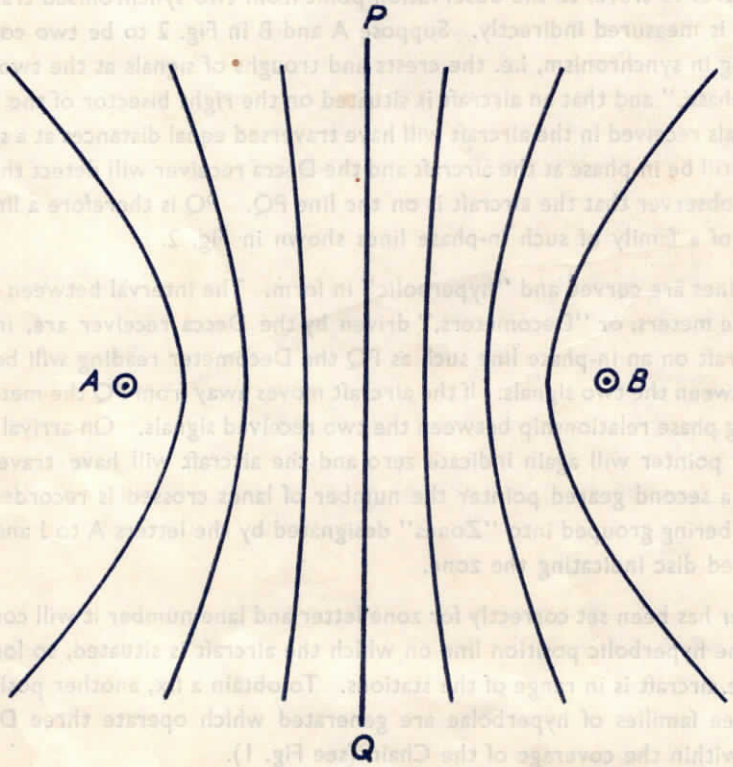

FIG. 2.

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THE DECCA NAVIGATOR INSTALLATION
MARK VI AIR RECEIVER

The complete aircraft installation consists of four main components—the Receiver Unit, the Power Unit, the remote Control Unit, the three Decometers and the Lane Identification Meter. The Receiver Unit and the Power Unit are mounted together or separately in S.B.A.C. standard aircraft racking. These units can be installed in any convenient position in the aircraft. The Receiver is remotely connected to the Control Unit and Decometers, which are fitted adjacent to the pilot or navigator position. All controls for operating the equipment are contained on the Control Unit and Decometers.

THE RECEIVER UNIT (see *Fig.* 1)

The Mark VI. Air Receiver can operate in conjunction with five separate Decca Chains. At present, the English Chain and the Danish Chain are in service and, therefore, the Receiver can select either of these.

THE POWER UNIT (see *Fig.* 1)

This unit steps up the aircraft D.C. supply to 320 volt D.C. It contains a carbon pile voltage regulator which needs occasional adjustment by a ground engineer. The main Decca fuses together with spares are located in this Unit.

CONTROL UNIT (see *Fig.* 2)

The Control Unit is remotely connected to the Receiver and includes five chain selection push buttons, the main "On-Off" switch for the Receiver and a dimming switch for the Lane Identification Meter.

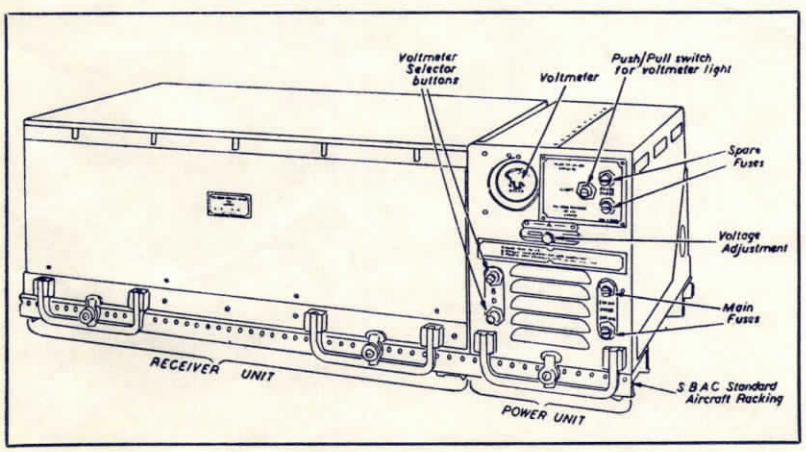


FIG. 1

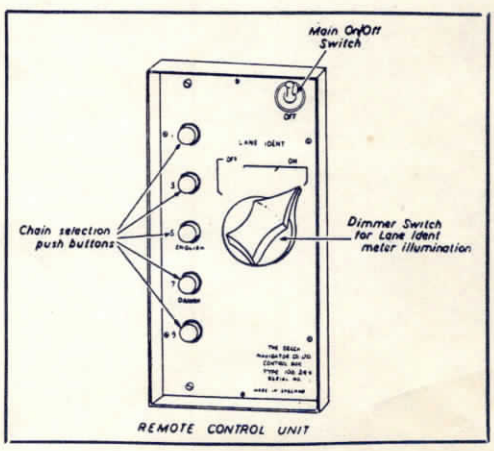
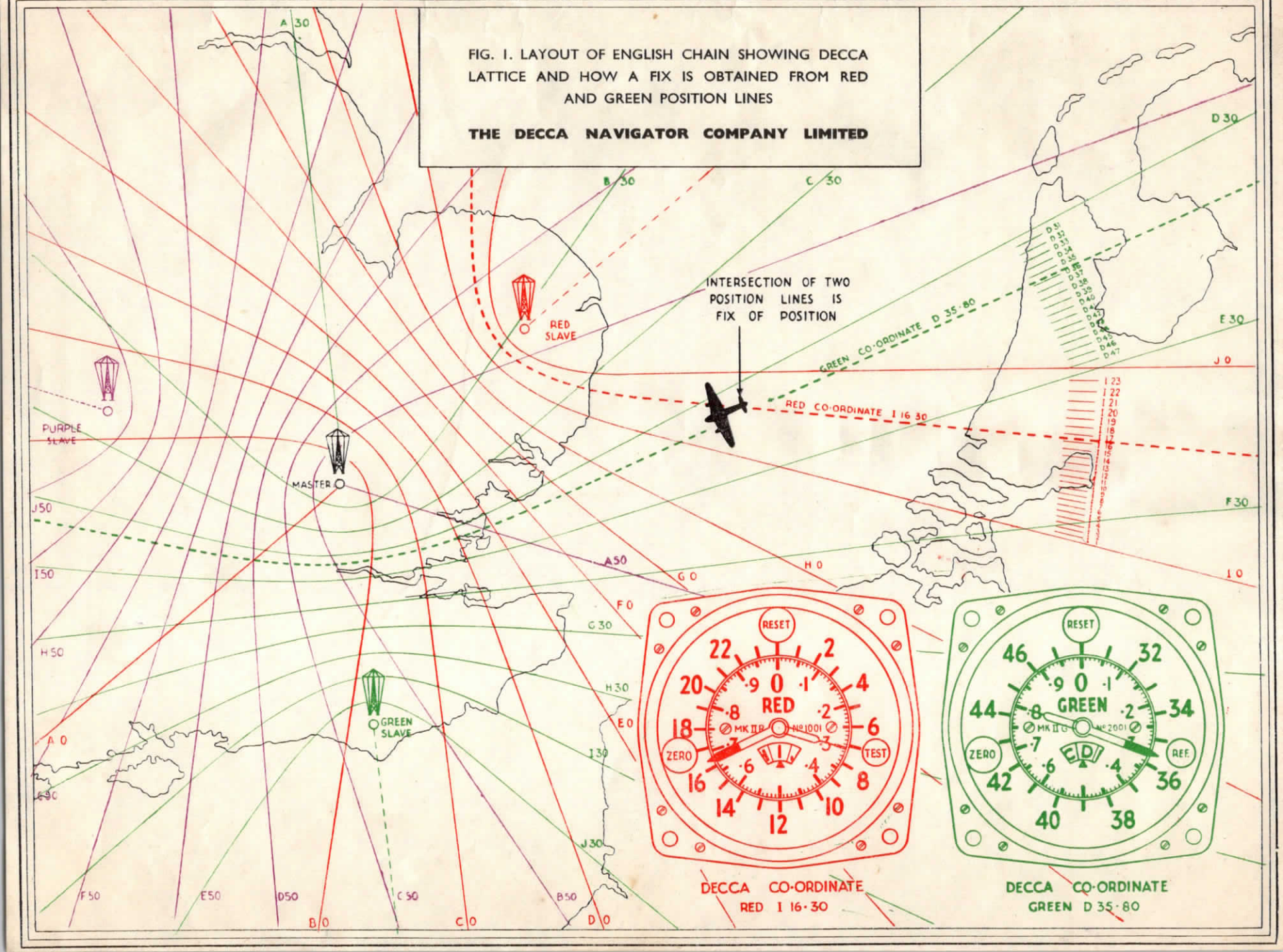


FIG. 2

FIG. 1. LAYOUT OF ENGLISH CHAIN SHOWING DECCA LATTICE AND HOW A FIX IS OBTAINED FROM RED AND GREEN POSITION LINES

THE DECCA NAVIGATOR COMPANY LIMITED



THE DECOMETERS AND LANE IDENTIFICATION METER (see *Fig.* 3)

Three Decometers associated respectively with the Red, Green and Purple lattices are installed in a position convenient to the pilot. All controls for operating the Receiver, once it has been switched on and the required Chain selected, are fitted to the Decometers.

The signals fed to each Decometer from the Receiver, control the position of the Fractional Pointer. This pointer will make one complete revolution if the aircraft travels across one lane of the pattern (a lane is the interval between adjacent whole numbered hyperbolae). The fractional pointer is geared to the Lane pointer, which makes one revolution for every Zone traversed. A Zone comprises 24 Red, 18 Green and 30 Purple Lanes. The Lane pointer in turn is geared to the Zone indicator. If the Receiver is switched on anywhere in the Decca pattern, *the correct lane fractions* will be displayed on the Decometers but the Lane numbers and Zone letters may be in error. The *correct lane number* and Zone letter of each Decometer can be set by reference to the Lane Identification Meter or to a latticed Airfield Chart or Air Map.
A detailed description of the Lane Identification Meter is given in Data Sheet No. A.3.

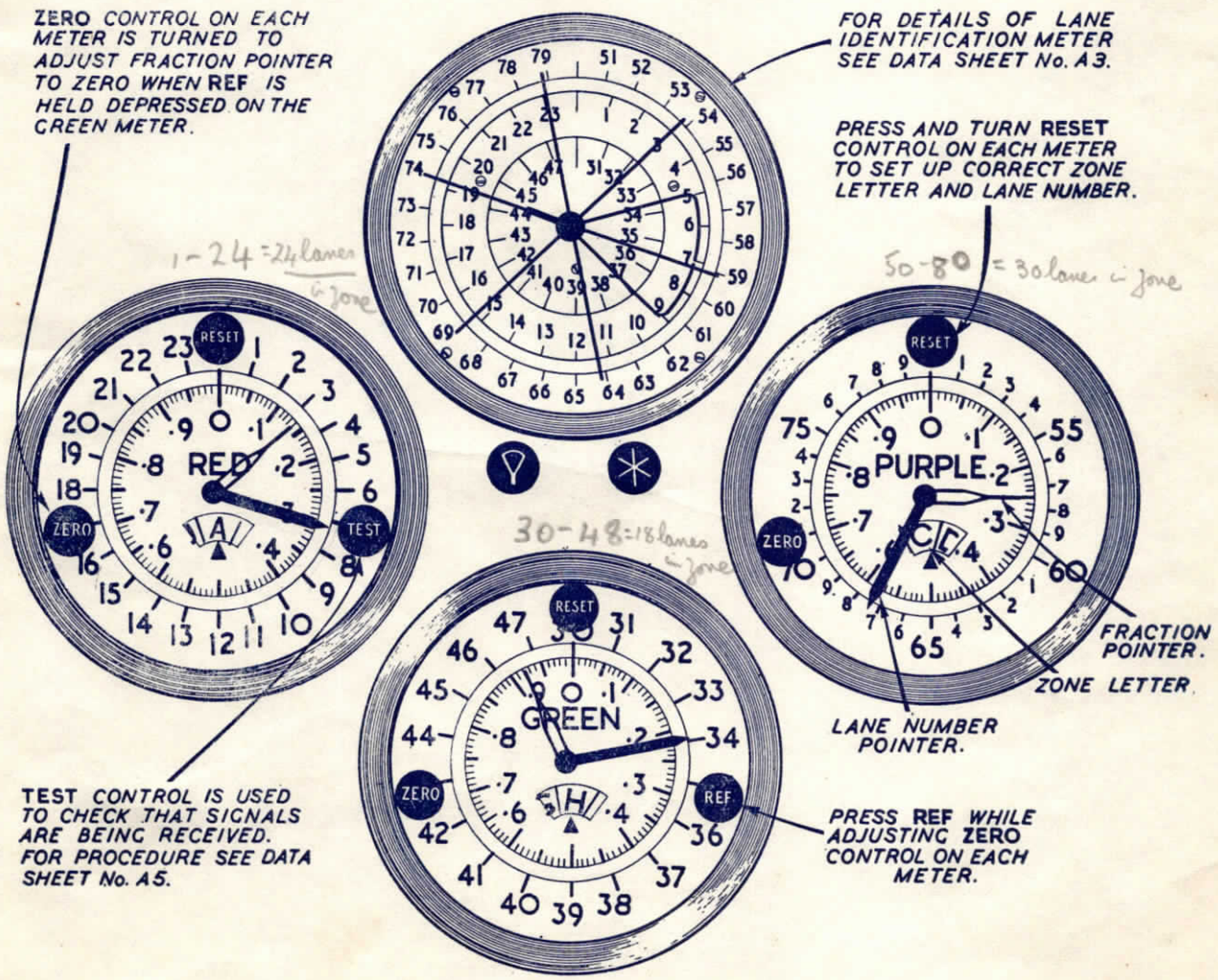


FIG. 3

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THE LANE IDENTIFICATION METER

1. OPERATION OF LANE IDENTIFICATION

Lane Identification enables you to set up your Decometers when entering the coverage of the Decca System, and to cross-check at any time when working within the coverage of the System.

The Lane Identification signals are transmitted **ONCE EVERY MINUTE** in the order **RED, GREEN, PURPLE,** with the following time intervals: **RED** followed by **GREEN** and **PURPLE** at 15 second intervals, followed by a 30 second interval until **RED** appears again. **DISREGARD ALL SETS OF READINGS WHEN THE LIGHTS DO NOT COME UP IN THE RIGHT SEQUENCE.** The indication for each colour remains set on the meter for approximately **FIVE** seconds, during which time the meter scale is illuminated in the appropriate colour and the pointers turn to indicate the lane number. You will notice that when Lane Identification signals arrive, the Decometers may give a slight kick.

2. HOW TO READ THE LANE IDENTIFICATION METER

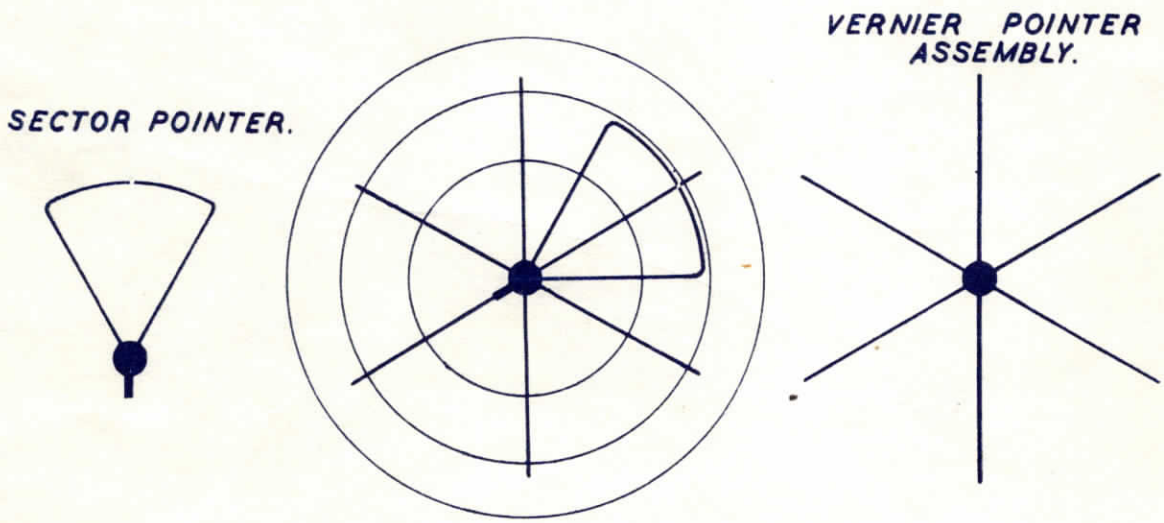
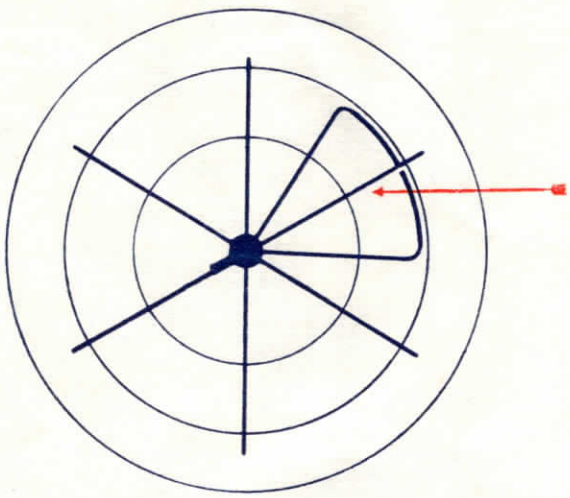


Fig. 1

In the above diagram of the Lane Identification Meter, it will be seen that there are two sets of indicators; one is called the **SECTOR POINTER,** shown separately on the left; the other is the **VERNIER POINTER** assembly (containing six pointers) as shown on the right. The reason for these two separate indicators is that Lane Identification is in fact a double system. The Sector pointer selects and indicates

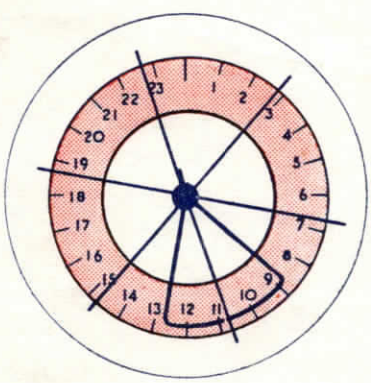
which of the six Vernier pointers should be used. The method of reading the Meter is to note the lane number indicated by ***the Vernier which is ENCLOSED by the Sector pointer,*** thus:—



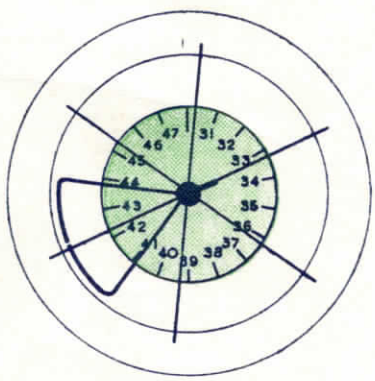
This Vernier is enclosed in the Sector Pointer and indicates the Lane Identification reading. The remaining five vernier pointers are ignored.

Fig. 2

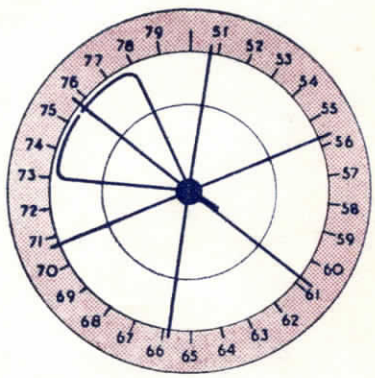
As each Lane Identification is received, one of the coloured scales on the Meter lights up, and both the Sector and Vernier pointers swing round and come to rest. When the scale is illuminated, the lane numbers on the scale can be read easily; **ONLY THE ILLUMINATED SCALE SHOULD BE READ** in turn for **RED,** for **GREEN** and for **PURPLE.** In the following diagram, specimen readings are given for each colour:



RED Scale illuminated
L.I. READING 10.7



GREEN Scale illuminated
L.I. READING 42.3



PURPLE Scale illuminated
L.I. READING 75.7

Fig. 3

NOTE:— ILLUMINATED SCALE *ONLY* SHOULD BE READ.

ALL READINGS ARE MADE ON THE *VERNIER POINTER* ENCLOSED IN THE SECTOR.

THE WHOLE NUMBER *AND DECIMAL* INDICATED BY THE VERNIER POINTER SHOULD BE READ

3. HOW TO REFERENCE THE LANE IDENTIFICATION METER

BEFORE USING THE LANE IDENTIFICATION METER IT MUST BE REFERENCED

This operation must always be as accurate as possible. The procedure is exactly the same as for the Decometers. Press the "REF" button on the Green Decometer. All pointers, both on Decometers and Lane Identification Meter, will then turn back towards ZERO. First set all Decometers to Zero, then set the Lane Identification **SECTOR** pointer to **ZERO** by turning the **left-hand** knob below the Meter, and the Lane Identification **VERNIER** pointer by adjusting the **right-hand** knob. The "REF" button must be depressed during the whole of this operation, but care must be taken to check that lanes are not lost on the Decometers.

NOTE:

(i) There may be a slight mechanical interaction between the two Lane Identification pointers and it is good practice to tap the front of the Lane Identification Meter with the finger when referencing, to ensure that both pointers have reached Zero.

(ii) The Sector pointer is referenced to the small black line on the outer edge of the pointer.

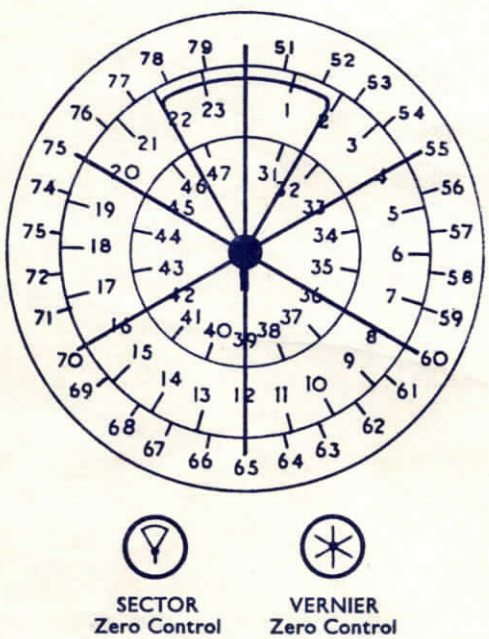


Diagram showing Lane Identification Meter correctly referenced.

Fig. 4

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DECCA CHARTS

All Decca Air Charts are obtainable direct from The Decca Navigator Co. Ltd., 1-3 Brixton Road, London, S.W.9. Government Departments can obtain the small scale Plotting Charts for the English Chain from the Ministry of Civil Aviation.

SMALL SCALE PLOTTING CHARTS.

Fig. 1 shows Plotting Charts available for the English Chain and the Chart for the Danish Chain (available at the end of March, 1949). The English Chain charts are on a conical orthomorphic projection at a scale of 1/1,000,000 and their average size is 30×40 inches. The Danish Chain chart is overprinted on a composite ICAO plotting chart, on a Mercator projection at a scale of 1/2,000,000 and measures 30×31 inches.

In order to relate the Decometer readings with specific position lines, it is necessary to designate these lines by a system of numbering. On the Decometers, the Decca 'lane' has been made the unit of measurement. A 'lane' is the distance between two adjacent whole number hyperbolae. The air Decometers are graduated to tenths of lanes. The lanes of each pattern are grouped in Zones, which are given identifying letters A—J. Thus any position line is defined by COLOUR, ZONE LETTER, LANE NUMBER AND FRACTION OF LANE.

The Zones are lettered outwards from Master to Slave commencing at A and reaching J. If the base-line length is sufficient to produce more than ten Zones, the Zones start again at A.

The Lanes are similarly numbered in each Zone, in the direction Master to Slave. There are 24, 18 and 30 lanes respectively in a Red, Green and Purple Zone. To avoid confusion the Lanes are numbered Red 0 to 23, Green 30 to 47 and Purple 50 to 79. At the centre of the System every sixth lane is shown on the English Chain charts, increasing to every third lane and then to every single lane, as space permits.

LARGE SCALE AIRFIELD CHARTS.

Decca latticed charts of the main European airfields at scales varying from two inches to six inches to a mile are available from The Decca Navigator Co. Ltd. These Charts are for use in homing to airfields in bad visibility and for setting up Decometers.

FLIGHT PLOTTER CHARTS (ROUTE GRAPHS)

The Decca Flight Plotter is a direct form of presentation suitable for pilot navigation and eliminates the delays involved in interpreting a hyperbolic chart.

Simple Route Graphs prepared by The Decca Navigator Company Ltd. for all European routes are inserted in the Flight Plotter, and the pilot only needs to rotate the knobs of the Flight Plotter to bring the perspex cursor to correspond to the Decometer readings at any point on his flight to obtain a position, and bearing and distance to destination. The pilot is entirely free to make any deviation from route that circumstances necessitate.

Route Graphs can be made for any route or combination of routes, and the Flight Plotter enables regular and very rapid checks to be made on the aircraft's position. Further detailed information on the Flight Plotter and Route Graphs can be obtained from The Decca Navigator Company Limited.

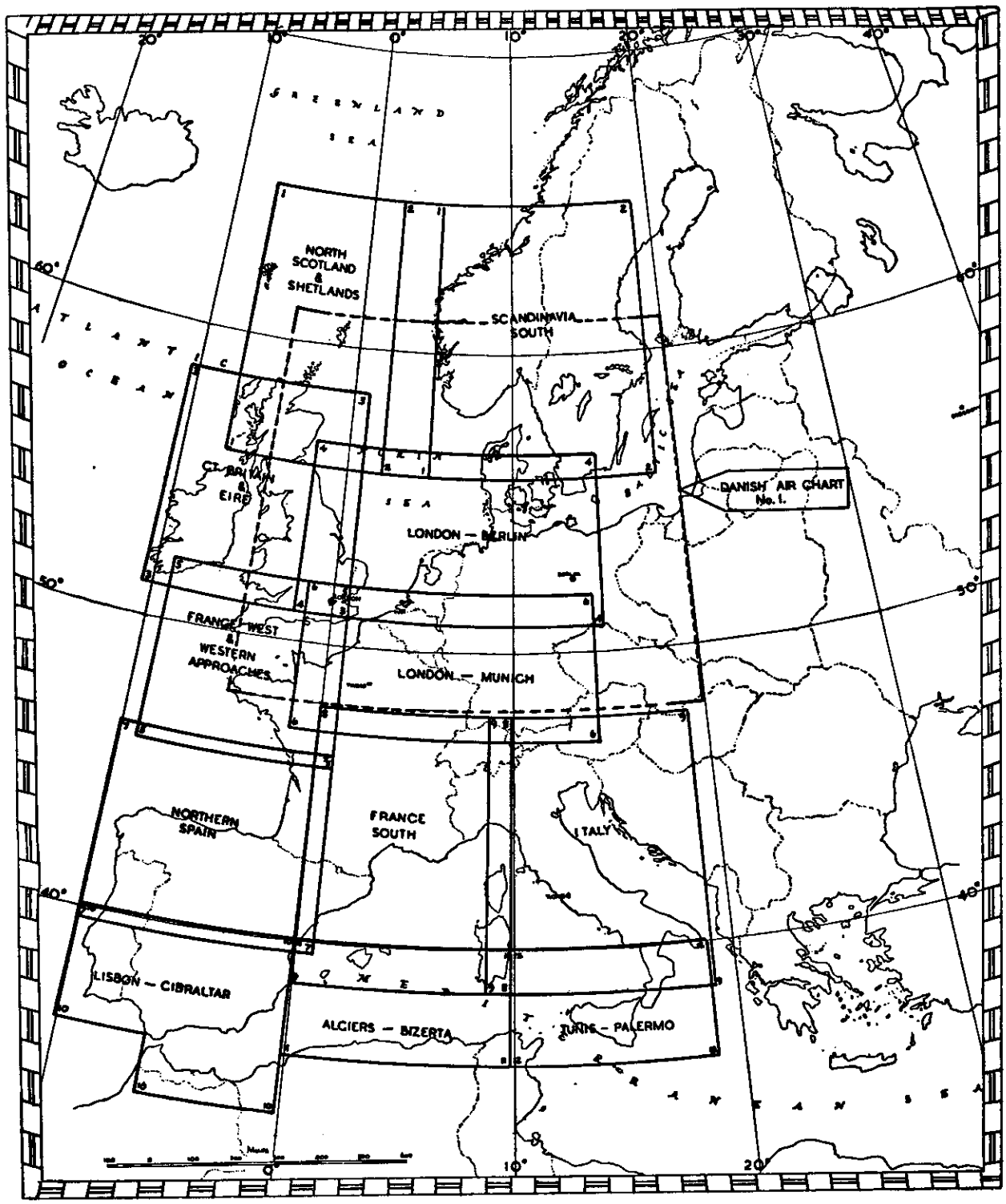

Fig. 1 Index of Air Maps latticed for the English and Danish Chains

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THE DECCA NAVIGATOR SYSTEM

OPERATING PROCEDURE

PRE-FLIGHT CHECKS

Decca signals can be received at considerable range from the Ground Stations and with the aircraft standing out of the hangar on an airfield anywhere in Europe it is possible to check and set up a Mark VI Receiver to either the English or Danish Chains. The checks given below should be carried out before take-off.

For long range aircraft flying into Decca coverage from outside, the same checks should be made in the air about half an hour before it is desired to use the System.

The Decca Navigator Receiver should be switched 'ON' and at least five minutes allowed for it to reach operating temperature. After the receiver has warmed up select the desired Chain by pressing the appropriate button on the Control Unit. Press the 'REF' knob on the Green Decometer and, keeping it pressed, adjust all the 'Zero' knobs so that the fraction pointers of the three Decometers indicate zero. Adjust the Sector and Vernier 'zero' knobs of the Zone Identification Decometer so that the spot on the sector pointer and one of the vernier pointers coincide with zero on the Scale. (See Data Sheet A3).

Holding the 'REF' knob depressed as above, press the knob marked 'Test' on the Red Decometer and the fraction pointers on the Red, Green and Purple Decometers should deflect anti-clockwise the following approximate amounts: Red .20, Green .15, Purple .25 of a lane. The Sector pointer on the Lane Identification Meter should move anti-clockwise approximately one Red lane and the Vernier one sixth of a Red lane. This 'Test' checks that the receiver installation is working correctly and that the Master Station signals are being received. To check that the Slave transmissions are being received press the Test knob without pressing 'REF'. If a Decometer shows no deflection the associated slave transmission has ceased or is out of range.

Carefully set up all three Decometers by means of the 'RESET' knob to the Decca co-ordinates of the aircraft's position. The fraction pointer will take up its own correct position. The lane number can be set from the Lane Identification meter or by reference to the Air Map. The Zone letter must be taken from the Air Map.

FLIGHT CHECKS

As soon as the aircraft begins to move and during all subsequent flight within coverage of the selected Chain, the Decometers will move under control of the Decca signals.

No manipulation whatsoever is normally required during flight AND CARE SHOULD BE TAKEN NOT TO SWITCH THE RECEIVER OFF or lanes will be lost. Similarly the 'REF' knob should only be used when absolutely necessary to check the meter Zero's. Pressing the 'REF' knob in flight can cause lanes and even Zones to be lost on the Decometer. Within 100 miles of the Master Station the fixing error likely to arise due to Zero error is very small and can be neglected for all normal purposes of air navigation.

'Test' knob checks can be made at any time. Deflection of the meters by the following approximate amounts: Red .20, Green .15, Purple .25 of a lane anti-clockwise checks that the receiver is picking up satisfactory ground signals.

Cross checking between the Lane Identification Meter and the Decometers is the best overall check in the System and should be regularly employed according to the procedure given overleaf.

CHECKING DECOMETERS FROM LANE IDENTIFICATION METERS

The Decometers and the Lane Identification Meter provide two independent systems and the cross check they provide gives a very high degree of reliability to any fix. It is therefore a good practice to check that the Lane Identification Meter and the Decometer for each colour are in agreement to within half a lane. This can be done in flight by a quick glance at each instrument when the appropriate scale lights up on the Lane Identification Meter.

If a difference of more than half a lane is noted DO NOT IMMEDIATELY RE-SET THE DECOMETER. If the difference persists for three successive readings re-set the Decometer but if the difference varies by more than half a lane leave the Decometer untouched but check five minutes later.

REMEMBER THE DECOMETERS REGISTER THE CORRECT READINGS WITH GREAT ACCURACY PARTICULARLY NEAR THE CHAIN AND WILL ONLY INFREQUENTLY SLIP TO A WRONG VALUE.

NOTE : At the time of issue of this Data Sheet full Lane Identification facilities are available on the English Chain only. Lane Identification equipment is now being installed on the Danish Chain and advice will be issued to all users when the transmissions commence.

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THE DECCA NAVIGATOR SYSTEM

NAVIGATIONAL PROCEDURE

POSITION FIXING BY DECCA

Each Decometer of the Decca System provides a position line and the readings of two Decometers taken simultaneously therefore provide a Fix. The Decca Air Maps are overprinted with all three colours. By inspection note the two colours that give the best CUT and read the two corresponding Decometers, noting in order **TIME—FRACTION—LANE—ZONE.** Plot each reading on the chart, the intersection is the FIX, and mark TIME taken.

By this means an accurate PLOT may be maintained. Whenever facilities permit write down the results in the navigation log.

NOTES ON FIXING

1. Unless three position lines are required as a check, always use the TWO most suitable position lines from a consideration of their lane width and angle of cut.

2. It is a good practice to take fixes at predetermined position lines. Thus if the Red Decometer is rotating so that it will indicate A12, wait until it does so exactly and then read the other appropriate Decometer. This saves time as the observer is already looking at the chart in the right place where A12 cuts the aircraft's track, and interpolation is only required on one position line.

3. When using timed fixes for ground speed checks, read the faster moving of the two relevant Decometers at the required times, and then the slower moving Decometer. Errors due to the readings not being simultaneous are thus minimized.

4. Remember that at short ranges errors due to interpretation of a 1/1,000,000 chart are liable to be much greater than Decca errors. At long ranges the Decca fix errors will be greater in directions towards and away from the centre of the System; for example when flying towards the Master from long range, track will be more accurately defined than ground speed. Thus runs of suitable length should be used for ground speed checks. Similarly if flying at right angles to this track, ground speed will be defined more accurately than track made good.

5. It is good airmanship to check position at regular intervals, and to compare the track made good and distance gone with the track and ground speed established by former Decca fixes. It is suggested that every quarter of an hour is a good working interval.

SETTING UP BY LANE IDENTIFICATION

When entering the coverage of a Decca Chain or when transferring from one Chain to another the Lane Identification Meter must be used to establish or check the Lane numbers of the Decometers.

The following procedure should always be observed:

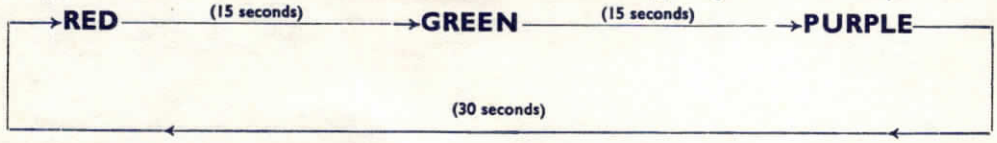
(1) Switch on Receiver and allow five minutes to warm up

(2) Select required Chain

(3) Reference all meters as in Data Sheet A5.

(4) Plot estimated position of aircraft on Decca Chart and from this plot, take off and set up on Decometers the estimated ZONE and LANE for each colour. **THE ZONE MUST BE CORRECTLY ESTIMATED,** but the Lane need only be an approximation

(5) Check that LANE IDENTIFICATION METER is lighting in correct sequence.



DO NOT ATTEMPT TO USE LANE IDENTIFICATION UNTIL THIS CORRECT SEQUENCE IS OBTAINED.

(6) With correct lighting sequence obtained, for each colour in turn note the difference in reading between the Lane Identification Meter and the Decometer, take three such readings in succession. Record them as below:

RED LANE IDENTIFICATION	RED DECOMETER	DIFFERENCE
11.5	11.1	0.4
12.8	12.7	0.1
14.1	13.8	0.3

In the above example the difference is less than half a lane for all three readings and it can be assumed therefore that the RED DECOMETER has been correctly set up.

If, however, the readings had been:—

RED LANE IDENTIFICATION	RED DECOMETER	DIFFERENCE
11.5	9.1	2.4
12.8	10.7	2.1
14.1	11.8	2.3

it would be clear that the Red Decometer was two lanes low, and it should be set up by that amount. Similarly for the other colours.

When it is found that the three readings do not give a difference which is consistent to within half a lane then skywave errors are preventing accurate Lane Identification and there is clear evidence that the System is being used at too great a range. If this occurs postpone setting up until consistent differences are obtained.

PRECAUTION IN THE USE OF THE DECCA NAVIGATOR WHEN IN CONVECTION CLOUD.

Heavy Cumulus and Cumulo-nimbus often give rise to severe static. This does not itself affect the Decca Navigator receiver but if the aircraft becomes highly charged, and it is not properly protected by a discharge device, the continuous discharge of the airframe may cause the Decometers to stop integrating. This will usually be obvious since the rate of rotation of the Decometers will change abruptly and erratically. Pilots are warned to keep close watch on the Decometers when flying near or in heavy Cumulus or Cumulo-nimbus. Normally such periods of loss of torque will be very short and rare, especially in aircraft fitted with static suppressors.

After such occurrences Lane Identification will show that lanes have been lost and will enable the Decometers to be reset manually.

It may be possible for the period of loss of torque to be long enough for the Zone indication to be in error, especially where the lanes are narrow as in the London area, and the aircraft's track lies across such lanes. If the aircraft's position is checked approximately every five minutes the Zone should be determinable by simple D.R.

The whole process of periodic checking and reckoning of position is greatly facilitated by the use of the Decca Flight Plotter (see Data Sheet A4).