

THE DECCA NAVIGATOR SYSTEM

The English Chain of Stations.

CHAIN 5B

The English Chain of Decca Navigator Stations is a 'star' pattern Chain consisting of a Master Station and Three Slaves, sited in the south of England, as follows:

- A. Master Station - Buntingford, Hertfordshire.
- B. Red Slave - Stoke Holy Cross, Norfolk.
- C. Green Slave - East Hoathly, Sussex.
- D. Purple Slave - Wormleighton, Warwickshire.

These stations are in full daily operation with transmission continuing unbroken over the 24 hours of each day.

The following notes give general details of the layout and composition of the Decca Navigator Ground Stations and the operational cover of the English Chain.

Site area and Layout.

The overall maximum dimensions of a typical site are 1100 feet by 700 feet. The actual ground area occupied by the station, however, may be reduced by laying the earth system radials under the ground for the greater part of their length. In this case, if the earth wires are placed about 18 inches below ground from the point at which they extend beyond the area covered by the mast, normal cultivation may be carried out over this part of the ground without affecting the system and a considerable saving of space is achieved. By the adoption of this method the actual station site dimensions may be reduced to no more than 750 ft. by 150 ft. or approximately an area of $2\frac{1}{2}$ acres. The typical layout of a Decca Navigator Station is shown in Drawing DNC 226A.

Buildings.

Simple single storey buildings of the pre-fabricated type set on concrete foundations are most suitable. A typical layout of the buildings in relation to the Mast radiator and Earth system is shown in Drawing 226A, and in the photograph of a Decca Navigator Slave Station at Figure 1. The number of buildings with their approximate dimensions, as used on the English Chain, is given below:

Master Station

Transmitter Building approx.	60ft. x 20ft. x 8ft.
Power House	" 19ft. x 12ft. x 8ft.
Coil House	" 12ft. x 12ft. x 8ft.
Ablution	" 12ft. x 12ft. x 8ft.

Slave Station.

Transmitter Building approx.	48ft. x 20ft. x 8ft.
Power House	" 19ft. x 12ft. x 8ft.
Coil House	" 12ft. x 12ft. x 8ft.
Ablution	" 12ft. x 12ft. x 8ft.

Mast Radiator.

The Mast and Aerial System on the Decca Navigator Ground Station is of special design and has an unusually high degree of efficiency at the low frequencies employed. Field strength measurements show that the radiation efficiency is some 45%. The transmitter output being 2 Kilowatts, the radiated power is therefore 900 watts, which provides a liberal margin to overcome unfavourable reception conditions.

A view of the Mast Radiator is shown in Fig. 1. and a detailed representation in Drg. 5/CE/1346. The Mast is self-supporting and of galvanised steel lattice construction, its overall height is 325 ft. and the base forms a square some 60 ft. wide. The four high level booms supporting the specially designed umbrella type aerial array, are each 75 feet long.

The Mast itself forms part of the aerial system and is mounted on four insulators with concrete supports and foundations. Mast head lighting arrangements are incorporated.

Earth System.

A good earth system is necessary to ensure the high efficiency of the Decca Navigator Transmitting Station. An extensive pattern of radial earth wires is therefore employed, as shown in Drg. 226A. This consists of 90 radials of 7/18 guage copper wire each 325ft. long, equally spaced and radiating from the centre formed by the Aerial Coil House. These radials may be laid above ground for the whole of their length and supported on light wooden posts extending about 18 inches above the ground. To reduce the area covered by the Earth system and to free land for agricultural purposes, it is quite practical and efficient to carry the earth wires above the ground to the extent of the area covered by the Mast and from that point to run the wires about 18 inches below the surface.

Transmitters.

On the English Chain of Stations a modified standard type of CW transmitter having a power output of 2 Kilowatts, is in use. Two of the three transmitters employed on one station, are shown in Figure 2. At each station there are three complete transmitters of this type, one being operational, one immediate standby with filaments on and all ready to take over should the operational transmitter fail, and the third is available for maintenance. This arrangement is made to ensure continuity of transmission and automatic relays are operated immediately the working transmitter fails so that the standby is brought into service in less than 1½ seconds.

A completely new Decca Navigator transmitter has, however, been designed, and is now in production, to obviate the need for triplicate installation and at the same time give absolute insurance against failure of transmission. This is known as the Decca Navigator Unit Type Transmitter and is illustrated at Figure 3. One complete transmitter consists of eight power amplifier units and two drive units, working in parallel, to provide a transmitter output of 640 watts. Each unit is completely self-contained with its own power supply. Spare power amplifier and drive units are provided so that any one unit can be withdrawn from the transmitter and replaced by a spare without interrupting the main transmission.

This Unit principle makes it unnecessary to have complete standby transmitters and gives facilities for efficient and regular maintenance.

To provide a transmitter power output of 2.5 Kilowatts a 'bank' of four Unit Type transmitters, each giving 640 watts output, are arranged in parallel.

Aerial Feeder Run.

Under typical conditions the transmitter building is placed some 600 feet from the Aerial Coupling Coil which is housed directly under the aerial mast. On the English Chain an open-wire feeder system is used consisting of two parallel Litz wires placed 3 inches apart transposed at intervals and supported on insulators on 10 ft. wooden gantries spaced 30 ft. apart. Alternatively it is practical to use suitable coaxial cable laid along the ground in shallow conduit.

Slave Station Phase Control Unit.

Transmissions from the Slave Station are phase locked to the Master transmission by the action of the Phase Control Unit. This Unit is installed only on the Slave Stations. Its action is to receive the crystal-controlled Master transmission to provide a drive for the Slave transmitter, and to phase-lock the two transmissions by continuous comparison and automatic correction of the Slave transmission as necessary.

From the 'Block' diagram of this Unit shown at Fig. 4 it will be seen that the Unit has three separate receiving channels. The first two channels compare the phase of the Slave transmission with respect to the Master and provide automatic control for holding the Slave frequency in phase. The third channel receives the Master signal and by means of a process of multiplication and division, produces the appropriate drive frequency for the Slave transmitter.

The output of the third channel is fed to the transmitter through an automatic phase control circuit, the controlling signal for this being obtained from the output of the first two channels. A reference oscillator is also built into the unit to enable the phase shift of each channel to be checked against a known standard.

On the English Chain, the following frequencies are in use, and it will be observed how the Slave frequencies are arrived at by multiplication and division of the Master frequency:

Master 85.0 Kc/s
 Green Slave127.5 Kc/s = 85 x 3/2
 Red Slave113.33 Kc/s = 85 x 4/3
 Purple Slave ... 70.83 Kc/s = 85 x 5/6

Each Slave Station also requires a different comparison frequency to be compared with the Master frequency in the Phase Discriminator. These are as follows:

Green....255 Kc/s = 85 x 3 or 127.5 x 2
 Red.....340 Kc/s = 85 x 4 or 113.33 x 3
 Purple...425 Kc/s = 85 x 5 or 70.83 x 6

Associated with the Phase Control Unit on the Slave Stations is a 30ft. tubular steel mast and aerial for reception of the Master signals. This is shown in the foreground of the photograph in Fig.1.

Power Supplies.

The ground station equipment works from the normal 230 volt 50 cycles per second, 3-phase power supply. The power consumption of the operational equipment, with the Decca Navigator Unit Transmitter in use, does not exceed 11 Kilowatts, the lighting and heating requirements being additional. Under normal conditions the power for the equipment on the English Chain of Stations is derived from the public mains power supply with standby provision in the form of Diesel and Petrol Electric Generators in case of mains failure. The standby generators on each station consist of two 5.6 KVA Diesel driven generators and one 22.5 KVA petrol-electric. One Diesel Generator is constantly running in readiness for immediate changeover. With the use of the new Decca Navigator Unit type Transmitter, it is possible to feed part of the equipment from the mains supply and part from a Diesel-driven generator, with switching arranged so that one of these two sources of power will take over the full load in the event of failure of the other supply.

Monitor Stations.

The operation of the Slave Station Phase Control Unit maintains the stability and accuracy of the System by means of automatic phase-locking to the Master transmission and this eliminates the need of employing continuous monitoring for the purpose of phase control, as is necessary in other navigational systems. On the English Chain, however, Monitor Stations have been set up for research and measuring purposes and to provide constant cross-checking of the operation of the chain in its earlier stages.

Operational Cover of the English Chain.

The operational area of the English Chain on a 24 hour basis of working is at present claimed to extend to a range of 300 miles from the centre of the Chain. This range is limited by the effect of the skywave at night but it is expected that measurements now being

carried out under working conditions will show that the operational range at any time of day and night will exceed 300 miles.

In Figure 5, the positions of the four Stations forming the English Chain are shown with the 300 mile area of cover bounded by the circle drawn in heavy line. A further circle of dotted line shows the extent of cover at a range of 350 miles. It will be observed that the 300 mile circle encloses an area of good accuracy coverage which extends from as far North as the Firth of Forth in Scotland to south of Paris, and entirely covers Holland, Belgium, the southern part of the North Sea and westwards over the Irish Sea to Dublin and Belfast.

The Decca Navigator English Chain - Geographical Data.

A. Master Station

Address: Hamels Park Farm, Buntingford, Nr. Ware, Herts.
Lat: 51° - 54' - 32.865"N
Long: 00° - 00' - 05.471"E
Tel. No.: Puckeridge 166.

B. Red Slave

Address: Abbots Farm, Stoke Holy Cross, Shotesham, Nr.
Norwich, Norfolk.
Lat: 52° - 33' - 07.683"N
Long: 01° - 19' - 59.989"E
Tel. No.: Brooke 213.

C. Green Slave

Address: Park Corner, East Hoathly, Nr. Lewes, Sussex.
Lat: 50° - 54' - 33.417"N
Long: 00° - 08' - 43.974"E
Tel. No.: Halland 269.

D. Purple Slave

Address: New House Farm, Nr. Wormleighton, Warwickshire.
Lat: 52° - 11' - 48.551"N
Long: 01° - 21' - 52.787"W

Red Monitor

Address: Platt's Lane, Tostock Green, Nr. Bury St. Edmunds,
Suffolk.
Lat: 52° - 14' - 22.104"N
Long: 00° - 52' - 02.113"W
Tel. No.: Beyton 298.

Green Monitor

Address: The Haven, Meopham, Kent.
Lat: 51° - 22' - 05.7"N
Long: 00° - 22' - 25.9"E
Tel. No.: Meopham 2266.

Purple Monitor.

Address: Broughton Fields, Broughton, Bletchley, Bucks.
Lat: 52° - 03' - 09.1" N
Long: 00° - 40' - 46.5" W

The Decca Navigator English Chain - Lattice Data

- Notes. (1) In the calculations given the velocity of propagation is taken as 2.9925×10^5 Km/sec.
 (2) All transmitting and comparison frequencies are multiples of a basic frequency (f_0) = 14.167 Kc/sec.

Transmitting Frequencies

	<u>Frequency</u> (Kc/s)	<u>Wavelength</u> (metres)
A Master	85.000	3,521
B Red Slave	113.333	2,640
C Green Slave	127.500	2,347
D Purple Slave	70.833	4,225

Comparison Frequencies

Red	24 f_0	340.000	880
Green	18 f_0	255.000	1,174
Purple	30 f_0	425.000	704

Red Lattice

Base length = 115.741 Km = 71.917 miles
 Lanes per zone = 24
 Total Lanes = 263.003 = 10 zones 23.003 lanes
 Lane numbering A0 upwards. Decimal notation 0 - 263
 Lane width on base line = 440.074 metres = 481.28 yards
 Lanes per Km on base line = 2.272348
 Lanes per mile on base line = 3.656956.

Green Lattice

Base length = 111.679 Km = 69.393 miles
 Lanes per zone = 18
 Total lanes = 190.330 = 10 zones 10.33 lanes
 Lane numbering A30 upwards. Decimal notation 300 - 490
 Lane width on base line = 586.765 = 641.7 yards
 Lanes per Km on base line = 1.704260
 Lanes per mile on base line = 2.742715.

Purple Lattice

Base length = 99.023 Km = 61.531 miles
 Lanes per zone = 30
 Total lanes = 281.268 = 9 zones 11.268 lanes
 Lane numbering A50 upwards. Decimal Notation 500 - 781
 Lane width on base line = 352.059 metres = 385.02 yards
 Lanes per Km on base line = 2.840434
 Lanes per mile on base line = 4.57119

Decca Navigator English Chain - Lattice Data - continued.

Monitoring Coordinates

Red Monitor, Tostock Green.

Red	G.13.328	(157.328)
Green	B.33.543	(321.543)

Green Monitor, Meopham.

Red	B.14.521	(38.521)
Green	F.45.360	(405.360)

Purple Monitor, Broughton.

Red	A.19.385	(19.385)
Green	B.30.420	(318.420)
Purple	E.70.420	(640.420)

Admiralty Monitor, Sheerness.

Red	C.21.349	(69.349)
Green	F.36.798	(396.798)