Ref. No. 801 Name of System Standard Commercial Decca

Type of System Hyperbolic Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

A Hyperbolic pattern of Phase difference is laid down by a master/slave pair of stations which are phase locked. A shipborne receiver displays the phase difference, which by inspection of a lattice chart gives a position line. The use of two or more slaves with a single master enables a fix to be obtained. See Admiralty Manual of Navigation Volume I 1954, A.L.R.S. Volume V 1957.

Frequency 70-130 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

A master and two or three slave stations required on shore. A special receiver and indicator and lattice charts required on board.

Range and Accuracy

In general, 300 miles by day or 75 by night. 1 ft on base line, 1 mile at limits. (75 - 240 miles by night. 0 - 5 miles at limits) depending on siting of slave stations.

Cost, Size and Weight

Shore stations comparatively large and elaborate.
Mark V shipborne receiver:- 31" x 20" x 8" approx.
display:- 17" x 14" x 11" approx. Weight 20 lb approx.

Factors affecting Service Applications

Unlimited number of simultaneous users. Shore transmissions liable to jamming. Unknown variable errors may be present. Pattern 350 Track Plotter provides tracking information.

Present Policy and Progress

Standard fitting in R.N. ships. Coverage at present over N.W. Europe and approaches to Eastern seaboard of Canada. New chains being erected in various parts of the world.

Suitability for Particular operations

Coastal navigation and pilotage. Amphibious operations and Minesweeping. S/M navigation so long as an aerial is above the water.

Remarks (801)

1. Standard Commercial Decca like other Radio Aids of this type suffers from two basic errors:-

(a) Fixed errors which can be measured and remain generally the same. They are caused by the fact that the radio paths are affected by the media over which they pass and are deflected when passing from one medium to another, i.e. at the coast. Fixed errors of Decca are published in Data sheets issued by the company.

(b) Variable errors whose maximum extent can be predicted, but which change from day to day and hour to hour. They are caused by variations in the propagation effects of the atmosphere.

2. The existence of these errors makes it difficult to make a categorical statement on the accuracy of these types of Radio Aids.

Ref. No. 802 Name of System Survey Decca

Type of System Hyperbolic Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

Survey Decca is a transportable version of Standard Decca for use mainly by Surveyors, but also used by the French for minesweeping. See the company's handbook "The Decca Navigator System as an aid to Survey". Issue 5.

Frequency 70-130 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

A master and two slave stations are set up on shore. The ship requires a special receiver, indicator and lattice chart. The receiver is not the same as that for Standard Decca.

Range and Accuracy

100 miles by day ? and 30 miles by night.
5 ft on base line, 200 ft at 100 miles.

Cost, Size and Weight

Shore installation smaller and lighter than Standard Decca and transportable.

Shipborne receiver:- 27" x 17" x 15". Weight 80 lb.
display:- 15" x 11" x 12". Weight 17 lb.

Factors affecting Service Applications

Unlimited number of simultaneous users. Greater accuracy and more limited range than Standard Decca. Shore installation has to be established and charts drawn (usually) before the chain can be used.

Present Policy and Progress

Not at present in use in the R.N., but has been used for surveying commercially in New Guinea, Minesweeping from Bizerta etc.

Suitability for Particular operations

Minesweeping and Minehunting. Surveying. Amphibious build-up operations.

Remarks (802)

1. By careful siting of the shore stations, a favourable cut can be obtained in the desired fixing area and accuracy enhanced.

2. No Lane Identification is incorporated, so greater care is necessary to avoid ambiguity of position.

3. The system may be used by aircraft and will supply the normal Flight Log or Pattern 350 Track Plotter.

4. Lattice charts are required for area fixing.

5. Various sizes of equipment can be supplied to satisfy individual users' requirements.

Ref. No. 802 Name of System Survey Decca

Type of System Hyperbolic Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

Survey Decca is a transportable version of Standard Decca for use mainly by Surveyors, but also used by the French for minesweeping. See the company's handbook "The Decca Navigator System as an aid to Survey". Issue 5.

Frequency 70-130 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

A master and two slave stations are set up on shore. The ship requires a special receiver, indicator and lattice chart. The receiver is not the same as that for Standard Decca.

Range and Accuracy

100 miles by day ? and 30 miles by night.
5 ft on base line, 200 ft at 100 miles.

Cost, Size and Weight

Shore installation smaller and lighter than Standard Decca and transportable.

Shipborne receiver:- 27" x 17" x 15". Weight 80 lb.
display:- 15" x 11" x 12". Weight 17 lb.

Factors affecting Service Applications

Unlimited number of simultaneous users. Greater accuracy and more limited range than Standard Decca. Shore installation has to be established and charts drawn (usually) before the chain can be used.

Present Policy and Progress

Not at present in use in the R.N., but has been used for surveying commercially in New Guinea, Minesweeping from Bizerta etc.

Suitability for Particular operations

Minesweeping and Minehunting. Surveying. Amphibious build-up operations.

Remarks (802)

1. By careful siting of the shore stations, a favourable cut can be obtained in the desired fixing area and accuracy enhanced.

2. No Lane Identification is incorporated, so greater care is necessary to avoid ambiguity of position.

3. The system may be used by aircraft and will supply the normal Flight Log or Pattern 350 Track Plotter.

4. Lattice charts are required for area fixing.

5. Various sizes of equipment can be supplied to satisfy individual users' requirements.

Ref. No. 803 Name of System Dectra (Decca Track and Range)

Type of System Hyperbolic Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

The basic Decca principles are used to lay down a hyperbolic tracking and ranging pattern for long range air routes mainly over water. e.g. In the Prestwick/Gander Dectra chain, two stations of the Newfoundland Decca chain lay down the tracking pattern, and the ranging pattern is laid down by one station of the Newfoundland and one of the N.W. British chains. See "Dectra, a Long Range Navigational Aid" Journal of the British Institute of Radio Engineers Volume 18 No. 5, May 1958.

Frequency 70 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

3 shore stations are required, two one end of the route for the tracking pattern and one the other end for the ranging pattern. Special shipborne receivers and displays and a lattice chart are required.

Range and Accuracy

Range up to 2000 miles. Accuracy better than 10' at 1500 miles.

Cost, Size and Weight

Shore installation basically as Decca but with taller antennae and greatly increased transmitted power.

Airborne receiver 15½" x 12" x 8".

Factors affecting Service Applications

Designed primarily for a particular route between two cross ocean air terminals, its greatest accuracy lies on the Great Circle track between the two. Existing Decca stations are used. Outside the Great Circle track, accuracy falls off, but the system is still usable.

Present Policy and Progress

Still under trial. Use by ships under investigation.

Suitability for Particular operations

Possible value for ocean navigation in limited areas.

Remarks (803)

1. For air use the Dectra signals are displayed on special lattice charts on the Decca Flight Log.

2. Dectra is basically a Long Range Radio Aid for Aircraft.

Ref. No. 804 Name of System Delrac (Decca Long Range Area Coverage)

Type of System Hyperbolic Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

Delrac is a proposed Long Range Radio Aid to give World Wide coverage with a few pairs (12) of stations. Each pair of stations lays down a hyperbolic pattern in the normal Decca manner. Two pairs of stations would be required for a fix.

See Decca Navigator System. Memo. plans 154. Issue 5 May 1954.

Frequency 10-12 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

12 pairs of shore stations would be required for world wide coverage. Special receivers and displays in ships, and lattice charts. Flight log display in aircraft.

Range and Accuracy

Up to 3000 miles. Better than 10 miles.

Cost, Size and Weight

£535,000 per pair of shore stations. Airborne equipment 60 to 70 lb (est). Shipborne equipment likely to be similar in size to Standard Decca.

Factors affecting Service Applications

Cost of erecting shore stations and of preparing charts. Value of such a system would be profound. Reception by submerged S/Ms. should be possible.

Present Policy and Progress

Projected only.

Suitability for Particular operations

World Wide surface air and submarine navigation.

Remarks (804)

1. The usual Decca phase comparison system would be used but a novel system of Lane Identification is envisaged to give unambiguous fixing throughout the coverage.

Ref. No. 805 Name of System Radux

Type of System Hyperbolic Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

Principle of operation similar to Standard Decca.

See Air Warfare Research Dept. NADC-WR-5702 March 1957.

Frequency 10-40 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

3 fixed shore stations per chain. 400-900 ft Antenna towers. Base lines up to 2300 miles. Special receivers, indicators and lattice charts required.

Range and Accuracy

Up to 4000 miles. Hoped to achieve accuracies of ½ mile at 3500 miles. Thought that 1 mile at 5000 might be feasible.

Cost, Size and Weight

Estimated size of shipborne receiver 9 cubic feet.

Factors affecting Service Applications

As for Delrac. Could be used on a time sharing basis with Frequency Shift Keying of existing W/T stations.

Present Policy and Progress

Experimental in U.S.A.

Suitability for Particular operations

World Wide surface, air and submarine navigation.

Remarks (805)

1. Compared to a Pulse comparison system such as Cytac, the advantages of Radux are that the tolerable S/N ratio at the receiver is much lower and narrow band pass receivers can be used. Hence great ranges can be achieved with lower power and smaller antenna towers.

2. An experimental Radux chain is already in operation.

Ref. No. 806 Name of System Omega

Type of System Hyperbolic Radio Aid (C.W. Phase Comparison)

Brief Description with reference to more detailed information

Omega is planned as a logical successor to Radux.

See Air Warfare Research Dept. NADC-WR-5702 March 1957.

Frequency 12 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

Range and Accuracy

Up to 5000 miles. Accuracies of better than 1 mile hoped for.

Cost, Size and Weight

Factors affecting Service Applications

Ref. No. 807 Name of System Raydist

Type of System Hyperbolic Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

Principles of operation similar to Decca, but see remarks.

See International Hydrographic Review Volume XXXII No. 1, May 1955.

Frequency 2000 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

Four portable shore stations required. Special receiver, display and lattice chart in the ship.

Range and Accuracy

70 miles by day, 50 ? by night.
3 ft on base line, 30 ft at limits.

Cost, Size and Weight

Equipment small and light.

Factors affecting Service Applications

High accuracy. Only available to one user at a time.

Present Policy and Progress

An aid to off-shore surveying extensively used in the Gulf of Mexico.

Suitability for Particular operations

Surveying. Minecountermeasures and amphibious operations using the pathfinder technique.

Remarks (807)

1. Phase comparison is done by the addition of a Relay station on shore, which measures the relative phase of the master and slave station transmissions, and transmits these to the vessel on a separate frequency. In the vessel these measurements are used as a datum for measuring the phase differences between the master and slave signals.

2. Other differences from Decca are that there is no Lane Identification facility, shorter range and higher accuracy.

3. Raydist can be instrumented in different ways to give more than 30 variations of hyperbolic, elliptical and pure range configurations.

4. The French system, Rana, works on a somewhat similar principle, and offers a wide choice of frequencies to suit particular operating conditions. (See 810).

Ref. No. 808 Name of System Lorac

Type of System Hyperbolic Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

Principle of operation similar to Decca, but see remarks.

See International Hydrographic Review Volume XXXII No. 1, May 1955.

Frequency 2000 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

Three portable shore stations required. Special receiver, indicator and lattice charts in the ship.

Range and Accuracy

Day 130 miles, Night 55 miles.
3 ft on base line. 30 ft at limits.

Cost, Size and Weight

Shipborne equipment is reasonably small and light.

Factors affecting Service Applications

High accuracy. Unlimited number of simultaneous users.

Present Policy and Progress

An aid to surveying in the U.S.A.

Suitability for Particular operations

Surveying. Minecountermeasures. Amphibious operations.
Short range Air Navigation.

Remarks (808)

1. Phase comparison is achieved by switching the slave stations at about 10 c/s to act alternately as base and relay transmitters.

2. Compared to Decca there is no Lane Identification facility, shorter range, and high accuracy is claimed.

3. The system incorporates a Homing Indicator which gives course to steer and distance to go in a straight line to target or destination.

Ref. No. 809 Name of System Berserk

Type of System Hyperbolic Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

A similar principle to Decca, but the stations are portable, and the use of a higher frequency gives greater accuracy with shorter range. No Lane Identification facility.

Frequency

Degree of dependence on Shore station or Shipborne apparatus

3 or 4 portable shore stations. Special receiver, display and track plotter in the ship. Lattice charts required.

Range and Accuracy

Similar to Lorac (808).

Cost, Size and Weight

Shore stations simple and comparatively small - trailer mounted.
Ship equipment small and light - suitable for fitting in I.M.S.

Factors affecting Service Applications

Susceptible to jamming and static interference. Equipment not tropicalised. Unlimited number of simultaneous users. Very high accuracy. Limited range. Designed for use in U.K. only.

Present Policy and Progress

Project shelved.

Suitability for Particular operations

Surveying. Minecountermeasures. Amphibious operations.

Ref. No. 810 Name of System Rana

Type of System Hyperbolic Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

Fixed and independent stations emitting pure C.W. at fixed frequency. Fixed RX station - any number mobile RX stations. Reference I.H.B. special publication No. 39 of July 1956. French design. Principle similar to Raydist.

Frequency 1600 kc/s or as required.

Degree of dependence on Shore station or Shipborne apparatus

Four shore stations required to give one position line. Special receiver display and lattice charts in the ship.

Range and Accuracy

Dependent on Frequency used. At 1600 kc/s a range of about 200 km with accuracy of a 'few' metres.

Cost, Size and Weight

Factors affecting Service Applications

Unlimited number of simultaneous users. The frequency and coverage may be adapted to suit particular operations.

Present Policy and Progress

In use by the French as a surveying aid.

Suitability for Particular operation

Surveying - M.C.M. and general purpose.

Ref. No. 815 Name of System Gee (R.N. Q.H.)

Type of System Hyperbolic Radio Aid (Pulse comparison)

Brief Description with reference to more detailed information

The original hyperbolic aid. Works on a similar principle to Standard Decca except that the receiver measures the time difference between the receipt of Pulses, transmitted at the same moment from the master and slave stations. Master and slave pulses have to be aligned by hand on a C.R.O. See H.M.S.O. "Demonstration of Radio Aids to Civil Aviation" 1946.

Frequency 20-85 Mc/s.

Degree of dependence on Shore station or Shipborne apparatus

3 or 4 shore stations per chain with base lines up to 80 miles.
Special receiver, display and lattice charts required in the ship or aircraft.

Range and Accuracy

150 miles - ships. Up to 400 miles - aircraft.
Accuracy approx. ½% of range from the shore stations.

Cost, Size and Weight

Large shore stations. Airborne equipment 9" x 12" x 18" and 9" x 8" x 18", total weight 70 lb. Shipborne equipment similar.

Factors affecting Service Applications

Primarily an airborne aid. Unlimited number of simultaneous users.
Liable to jamming. Short range. Accuracy good.

Present Policy and Progress

Widely used by R.A.F. in U.K. Not used in R.N. since 1947?
Now superseded by Decca for R.N. use.

Suitability for Particular operations

Minesweeping, Amphibious operations. Coastal navigation and Pilotage.

Ref. No. 816 Name of System Loran

Type of System Hyperbolic Radio Aid (Pulse comparison)

Brief Description with reference to more detailed information

Similar principle to Gee.

See Admiralty Manual of Navigation Volume I 1954 and A.L.R.S. Volume V 1957.

Frequency 1750-1950 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

3 shore stations up to 600 miles apart. Special receiver and lattice charts or tables in ships.

Range and Accuracy

Day 700 miles, Night 1400 miles. (Mobile version 400 miles).
0.1 miles on base line. 1 to 6 miles at limits.

Cost, Size and Weight

Large shore stations. Shipborne receiver DAS2 28" x 20" x 17"
SPN7A 23" x 15" x 15"
Airborne receiver APN9 20" x 14" x 9".
Note:- DAS2 inclusive of power pack, SPN7A separate power pack.
Estimated cost for 50% World Wide coverage £13,000,000.

Factors affecting Service Applications

Large shore stations. Limited accuracy. Long range. Difficulty of reception at sunrise and sunset. Errors depend mainly on operators' skill.
A mobile version of Loran is available.

Present Policy and Progress

Extensively used in N.A.T.O. Navies. New receivers under regular development.

Suitability for Particular operations

Long range surface, air and submarine navigation.

Remarks (816)

1. Modern Loran receivers are fitted with automatic counters for determining the Pulse time difference.

2. The U.S. Hydrographic Office supply tables for determining Loran positions in the Pacific, which are used instead of charts.

3. Propagation effects give rise to some variable errors with Loran, but the main source of error lies in the accuracy with which the master and slave signals are aligned. This is particularly difficult at sunrise and sunset when the ground wave is fading and the sky wave growing.

4. The great beauty of Loran (and Gee) unlike Decca is that the operator can judge the reliability of his fixes from the appearance of the signals.

Ref. No. 817 Name of System L.F. Loran (Loran 'C')

Type of System Hyperbolic Radio Aid (Pulse comparison and cycle matching)

Brief Description with reference to more detailed information

An L/F version of Loran.

See Air Warfare Research Dept. NADC-WR-5702 March 1957.

Frequency 90-110 kc/s.

Degree of dependence on Shore stations or Shipborne apparatus

3 shore stations per chain.

Range and Accuracy

2000 to 2600 miles.
1000 ft at 1000 miles claimed.

Cost, Size and Weight

Estimated cost for complete World Coverage £6,000,000.

Factors affecting Service Applications

Cost of erecting stations. Liability to jamming.

Present Policy and Progress

In operation. Stations on 'E' Coast of U.S.A.
Under construction. Station in 'E' Med.
Projected. Stations in N.W. Europe.

Suitability for Particular operations

Long range navigation.

Ref. No. 818 Name of System E.P.I. (Electric Position Indicator)

Type of System Hyperbolic Radio Aid (Pulse comparison)

Brief Description with reference to more detailed information

A system developed by the U.S. Coast and Geodetic survey combining some Loran techniques with some Shoran.

See International Hydrographic Review Volume XXXII No. 1 May 1955.

Frequency 2000 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

Two or three portable shore stations. Special receiver in the ship.

Range and Accuracy

500 miles by day, 100 ? by night.
Accuracy 60 to 100 feet.

Cost, Size and Weight

Factors affecting Service Applications

Only available to one user at a time. Less accurate than Survey Decca, Raydist, Lorac, Shoran etc., but longer range.

Present Policy and Progress

In use by U.S. Coast and Geodetic survey.

Suitability for Particular operations

Coastal navigation. Minesweeping or Amphibious operations using the pathfinder technique.

Surveying.

Ref. No. 819 Name of System Cytac

Type of System Hyperbolic Radio Aid (Pulse comparison)

Brief Description with reference to more detailed information

Principle similar to Gee and Loran, and a longer range successor to Loran. Developed primarily as a blind bombing aid.

See Air Warfare Research Dept. NADC-WR-5702 March 1957.

Frequency 60-100 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

3 fixed shore stations with 1200 ft antenna towers and base lines of 485 to 665 miles. Special receiver in ship or aircraft.

Range and Accuracy

2000 to 4000 miles.
Circle of probable error 100 ft at 100 miles.

Cost, Size and Weight

£19,700,000 for World Wide Coverage. Very large shore installations. Airborne receivers for L/R bombing 8 cu ft. Shipborne receiver 1.3 cu ft. G/Ms. 2.5 cu ft.

Factors affecting Service Applications

Size and cost of shore stations.

Present Policy and Progress

Experimental.

Suitability for Particular operations

Ocean Surface Navigation. Long range blind bombing. Missile guidance.

Remarks (819)

1. The limitations of Cytac are that at the more useful frequencies in the VLF band the size and cost of the Antenna structures become prohibitive, and hence Cytac range is limited. Furthermore, Pulse systems require a high S/N ratio and a wide band pass receiver, and these factors call for great transmitter power to achieve long range.

2. 100 kc/s is considered to be the lowest practicable frequency for a Pulse System.

Ref. No. 825 Name of System Shoran

Type of System Circular Radio Aid (Pulse comparison)

Brief Description with reference to more detailed information

Shoran is a system in which the Range to two portable transponder beacons is measured by a shipborne Radar set. See remarks and International Hydrographic Review Volume XXXII No. 1 May 1955, also B.J.S.M. letter HKB/5.15/1472/58 dated 8th September, 1958.

Frequency 300 Mc/s.

Degree of dependence on Shore station or Shipborne apparatus

Two portable shore transponders and a special interrogator and display in the ship. No special charts required.

Range and Accuracy

Day 40 miles, Night $^{7}/_{4}$ line of sight.
Accuracy ± 30 to 40 ft.

Cost, Size and Weight

Shore installation capable of being buoy mounted. Ship installation relatively small and light.

Factors affecting Service Applications

Only available to 20 simultaneous users. Flexibility. High accuracy. Short range.

Present Policy and Progress

Extensively used in U.S.A. for Surveying.

Suitability for Particular operations

Minecountermeasures, amphibious operations, Coastal navigation and Pilotage, surveying and short range air navigation, i.e. Helicopters.

Remarks (825)

1. Radar pulses are transmitted by the ship on two different frequencies and used to trigger off two portable shore transponder beacons. The shore beacons transmit pulses to the ship on a common third frequency. The two returned pulses are aligned with a marker pulse on a c.r.t. and the Ranges to the two beacons are then displayed on dials. Each single shore station generates one circular position line.

2. The Range of Shoran is limited by the height of the shore stations and shipborne aerials. Accuracy is unrelated to range from the shore stations.

3. The Range can be extended for aircraft use to a maximum of about 400 miles.

4. The ability to mount the transponders in buoys makes Shoran particularly suitable for amphibious and Minecountermeasures operations.

Ref. No. 826 Name of System Two Range Decca

Type of System Circular Radio Aid (C.W. Phase comparison)

Brief Description with reference to more detailed information

Basically the same as Survey Decca, except that the Master station is carried in the ship, which has to be fitted with a special transmitter mast. The ship is then always at the intersection of the two master/slave base lines, and the Deccometers provide a direct indication of range to the two slaves. See Company Handbook "Two Range Decca" Issue 2, October 1952.

Frequency 70-180 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

Two portable slave stations are set up on shore, and the ship carries the master with its associated transmitting mast, the receiver and the indicator.

Range and Accuracy

100 miles approx.
± 10 ft at 75 miles from the slave stations.

Cost, Size and Weight

£25,000 per chain. £1,000 receiver.
Size of gear similar to Survey Decca (802).

Factors affecting Service Applications

Can be used by only one user (the ship carrying the master station) at a time. No lattice charts are required. Greater accuracy and shorter range than Standard Decca. Shore stations are simple to erect.

Present Policy and Progress

The surveying service of the R.N. has five sets in use.

Suitability for Particular operations

Surveying. Pathfinder technique for Minecountermeasures, or Amphibious operations. Aircraft.

Remarks (826)

1. Two Range Decca offers the following advantages over Survey or Standard Decca.

   (a) No lattice charts are required.

   (b) Only two shore stations are required.

   (c) A relatively larger area is covered by the higher accuracy contours.

   (d) Systematic errors are greatly reduced.

   (e) The system lends itself to use on a convex coast line.

2. Lane Identification system under development.

Ref. No. 830 Name of System M/F D/F Shipborne

Type of System Azimuthal Radio Aid

Brief Description with reference to more detailed information

An M/F shipborne Radio set, with a trainable aerial, is used to detect the bearing of a shore Radio station which transmits either on request, or at stated times or continuously.

See Admiralty Manual of Navigation Volume I 1954 and A.L.R.S. Volume II 1957.

Frequency 250-600 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

One fixed or portable shore station for each position line. Shipborne receiver with trainable aerial.

Range and Accuracy

Day 300 miles, Night 25 miles.
95% probability 3^{o}.

Cost, Size and Weight

Shipborne equipment relatively small and simple. Shore stations mainly existing Coast or Airfield Radio stations.

Factors affecting Service Applications

Large numbers of existing shore stations. A universal fitting in Naval and Merchant ships and in many aircraft. Low accuracy. 10-15 minutes required for a fix.

Present Policy and Progress

No development at present.

Suitability for Particular operations

Coastal navigation. Homing techniques of particular value to amphibious operations.

Remarks (830)

1. M/F D/F suffers mainly from low accuracy, limited range, and overcrowding of the M/F band.

2. Some errors can be removed by careful calibration of the receiver, but others such as land and night effect may still be present.

3. Apart from the errors quoted above, the accuracy of the bearings depend upon the quality of reception, the efficiency of the ship's installation, and the skill of the operator.

4. The bearings obtained are Great Circles and have to be converted to True before plotting. There is some risk of reciprocal bearings.

5. Homings can be made to any transmitter in the correct frequency band, and the system has therefore wide scope for particular operations, such as laying a buoy containing a Radio transmitter off an enemy coastline for homing an amphibious assault force.

Ref. No. 831 Name of System M/F D/F (Shorebased)

Type of System Azimuthal Radio Aid

Brief Description with reference to more detailed information

The principle is the same as with shipborne M/F D/F except that the ship transmits on M/F and the shore D/F station takes the bearing. Two way communication is necessary with the shore station.

See Admiralty Manual of Navigation Volume I 1954 and A.L.R.S. Volume II 1957.

Frequency 300-600 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

One fixed shore station, which may or may not employ an Adcock aerial is required for each position line. No special shipborne equipment except an M/F transmitter.

Range and Accuracy

500 miles by day and night. 95% probability 2°.

Cost, Size and Weight

The shore stations are rather larger than in 830 and the Adcock aerial is much larger.

Factors affecting Service Applications

Lack of security due to two-way communications between ship and D/F station. Several stations may be linked to provide a fix from one ship transmission. A fair number of shore stations exist. No special equipment required in the ship.

Present Policy and Progress

Not at present under development.

Suitability for Particular operations

Coastal navigation.

Remarks (831)

1. The use of an Adcock aerial at the D/F station enables bearings to be taken at night on the Sky Waves, and hence ranges at night are far greater than with shipborne D/F.

2. The system is inherently more accurate than shipborne D/F due to Land and Night Effect being minimised, to the greater skill of the operators and usually a more efficient installation, but inaccuracies still remain due to propagation variations.

Ref. No. 832 Name of System Consol (ex German Sonne)

Type of System Azimuthal Radio Aid

Brief Description with reference to more detailed information

Somewhat similar to M/F D/F in that the ship obtains a bearing of a shore station by listening to the transmissions from it; but the shore stations, by means of three fixed aerials and a modulated C.W. rotating equi-signal lay down a pattern of bearings and the ship determines its bearing by counting the number of dots and dashes heard in each transmission.

See Admiralty Manual of Navigation Volume I 1954, A.L.R.S. Volume V 1957.

Frequency 260-500 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

3 x 300 ft antennae 1.8' apart approx. required at each shore station.
No special equipment required in the ship except a chart or tables in A.L.R.S. Volume V.
2 shore stations required for a fix.

Range and Accuracy

Day 1500 miles.	Night 25'.	0.1' at 25', 5 miles at 1500'.
	350-500'	5 miles at 500'.
	500-1500'	(95% probability error much greater - up to 24' at 1000'.)

Cost, Size and Weight

£15,000 - 20,000 per station in 1946.
Shore stations large but fairly simple.

Factors affecting Service Applications

Large shore installation. Low accuracy. Ambiguity of bearings.
System unusable within 25 miles of station. Fix requires 4 to 6 minutes.
System comparatively simple and very reliable. No special shipborne apparatus required.

Present Policy and Progress

Five stations in operation, giving good coverage throughout N.W. Europe.

Suitability for Particular operations

Surface and air ocean navigation.

Remarks (832)

1. A British development of wartime German system called Sonne. Mode of operation fully described in Admiralty Manual of Navigation Volume I 1954.

2. Consol suffers from ambiguity of bearings, unusable sectors in the twilight zone and variable errors of unknown extent caused by propagation conditions. The errors are least on the normal to the line of the aerials.

3. Reading accuracy depends upon reception conditions and the skill of the operator.

4. Various proposals for improving Consol, such as the German Lomor system, have been made, but most of them involve an increase in the number of aerials at the shore stations and hence in cost.

5. A French Esco recorder is available to make the reading of the signal automatic and to provide a visual indication of the reading.

Ref. No. 833 Name of System Popi (Post Office Position Indicator)

Type of System Azimuthal Radio Aid

Brief Description with reference to more detailed information

Similar to M/F D/F in that a shipborne receiver indicates the bearing of a Radio beacon onshore. Somewhat similar also to Consol in that the shore station lays down a fixed bearing pattern from itself. See remarks. H.M.S.O. "Demonstration of Radio Aids to Civil Aviation" 1946, and A.S.R.E. technical note TX-55-4.

Frequency 800 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

2 stations each with 4 antennae required for a fix. Special receiver and indicator. Track plotter could be used if required.

Range and Accuracy

1200 - 1500 miles.
1.5% of range from the shore stations.

Cost, Size and Weight

Shore stations of somewhat similar size to Consol.

Factors affecting Service Applications

Ambiguities of Consol not present in Popi. Low accuracy. Elaborate shore stations. Immediate fixes available, and could feed a track plotter.

Present Policy and Progress

Under development in 1946. Work since abandoned?

Suitability for Particular operations

Surface and air ocean navigation.

Remarks (833)

1. A single Radio beacon transmits phase locked signals which are reflected from 3 special radiators arranged symetrically around the beacon at distances of about ½ mile. The receiver shows the Great Circle bearing to the shore station on a scale and pointer meter. Two separate shore stations are needed for a fix.

2. The system has a certain affinity with Consol in that a fixed pattern of hyperbolae is laid down and that the hyperbolae may be assumed to be straight lines after a short distance from the station. Unlike Consol, however, there is no ambiguous sector as there are three beacon/reflector pairs at each station, and the reflectors are symmetrically placed about the Beacon.

3. Errors occur due to variations in propagation conditions and are at their worst at about 350-450 miles, where ground and sky waves have equal amplitude.

Ref. No. 834 Name of System Consolan

Type of System Azimuthal Radio Aid

Brief Description with reference to more detailed information

See Air Warfare Research Dept. NADC-WR-5702 March 1957.

Frequency 60-100 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

2 shore stations required for a fix.

Range and Accuracy

2000 miles. 0.7^{0}.

Cost, Size and Weight

£17,900,000 approx. for World Wide coverage.

Factors affecting Service Applications

Bearing ambiguities.

Present Policy and Progress

U.S.A. system. Development unknown.

Suitability for Particular operations

Ocean surface and air navigation.

Ref. No. 835 Name of System Navaglobe

Type of System Azimuthal Radio Aid

Brief Description with reference to more detailed information

See Air Warfare Research Dept. NADC-WR-5702 March 1957.

Frequency 60-100 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

1 station required for a fix.

Range and Accuracy

3000-3800 miles.

Cost, Size and Weight

£16,100,000 approx. for World Wide coverage.

Factors affecting Service Applications

Present Policy and Progress

U.S.A. system. Development unknown.

Suitability for Particular operations

Ocean surface and air navigation.

Ref. No. 836 Name of System Facom

Type of System Azimuthal Radio Aid

Brief Description with reference to more detailed information

See Air Warfare Research Dept. NADC-WR-5702 March 1957.

Frequency 100 kc/s

Degree of dependence on Shore station or Shipborne apparatus

Range and Accuracy

Cost, Size and Weight

Factors affecting Service Applications

Present Policy and Progress

U.S.A. system. Development unknown.

Suitability for Particular operations

Ref. No. 837 Name of System Navarho

Type of System Azimuthal Radio Aid

Brief Description with reference to more detailed information

See Air Warfare Research Dept. NADC-WR-5702 March 1957.

Frequency 60-100 kc/s.

Degree of dependence on Shore station or Shipborne apparatus

1 shore station required for a fix.

Range and Accuracy

2800 miles to 3700 miles.

Cost, Size and Weight

£14,300,000 approx. for World Wide coverage.

Factors affecting Service Applications

Present Policy and Progress

U.S.A. system. Development unknown.

Suitability for Particular operations

Ocean surface and air navigation.

Ref. No. 838 Name of System Microwave Beacon

Type of System Azimuthal Radio Aid

Brief Description with reference to more detailed information

Microwave Beacon for small harbour approach, gives equi-signal of ½ - 1° wide when on approach course and letter when to port or starboard of line - 60° covered either side. Reference I.N.J. April 1956.

Frequency

Degree of dependence on Shore station or Shipborne apparatus

Depends on shore beacon. Shipborne equipment small and simple.

Range and Accuracy

7 miles. Accuracy 250[x] at 7 miles.

Cost, Size and Weight

Shore:- 230V 50 c/s 2 slotted waveguide aerials. 7 kW peak power.
Ship:- 4½ lb 4 volt battery gives 400 hours continuous use
5½ x 4½ x 6" deep.

Factors affecting Service Applications

A cheap and simple system. Short range.

Present Policy and Progress

Designed for fishing boats. Experimental beacon fitted at Arbroath.

Suitability for Particular operations

Homing Amphibious warfare etc.

Ref. No. 901 Name of System Tacan

Type of System Miscellaneous tracking system

Brief Description with reference to more detailed information

A single radio beacon, which may be shore or ship mounted. Transmits on interrogation. Ship or airborne interrogator, receiver and display present the bearing and range of the beacon to the user.

See Electrical Communications Volume 33 No. 1 March 1956.

Frequency 960-1215 Mc/s

Degree of dependence on Shore station or Shipborne apparatus

A single shore or ship based beacon required. Special interrogator receiver and display required in the receiving ship or aircraft.

Range and Accuracy

200 miles. $\frac{1}{2}^{o}$ bearing. $\pm$ 600 ft for range + 0.2% of distance measured.

Cost, Size and Weight

Airborne receiver 17½" x 10" x 7½". Weight 56 lb.
Shore transmitter comparatively small.

Factors affecting Service Applications

Low accuracy. Simplicity. Fix instantly available. Area coverage could be provided by a few beacons.

Present Policy and Progress

Developed in U.S.A. for aircraft use. Combines the principles of Distance Measuring Equipment and Voice Rotating Beacons. Coming into service in F.A.A. No development at present for ship use, although there is a U.S.A. proposal to study the application of Tacan to Minecountermeasures.

Suitability for Particular operations

Airborne short range navigation. Could be made available for Amphibious and Minecountermeasures operations by mounting the beacons in buoys.

Ref. No. 902 Name of System Airborne Doppler

Type of System Miscellaneous tracking aid

Brief Description with reference to more detailed information

Basically, radio pulses are transmitted from the aircraft both ahead and astern and the shift of frequency in the received signal is measured, and is proportional to the movement of the aircraft both in the fore and aft line and at right angles to it.

See Decca and Marconi pamphlets, also remarks.

Frequency 8,800 Mc/s

Degree of dependence on Shore station or Shipborne apparatus

Independent of shore stations. Special airborne apparatus required.

Range and Accuracy

Height up to 50,000 ft.

Over land:- 0.6% of distance run plus 1 knot.
Over sea:- 1.6% of distance run plus 3 knots.

Cost, Size and Weight

Airborne equipment 2 cu ft. Weight 70 lb.

Factors affecting Service Applications

Self-contained system with World Wide application. Low order of accuracy and errors accumulate with time.

Present Policy and Progress

Being fitted in civil aircraft (DIAN, Decca Integrated Airborne Navigation System) and in Sea Vixen.

Suitability for Particular operations

Aircraft and helicopter navigation.

Remarks (902)

1. Airborne Doppler basically measures ground speed and drift, but by the addition of other computers, position, distance to go to destination and wind speed and direction can also be provided. (Decca Type 61, Marconi Type AD2300).

2. The drift of the aircraft is obtained by swinging the ahead and astern beams to port or starboard at frequent intervals, and by comparing the signals received from different positions of the aerial. The aerial is then rotated until a null error voltage is obtained, and in this position, the aerial is aligned with the ground track of the aircraft. This is, of course, a combination of aircraft heading and drift, and as heading is known, drift can be measured.

3. The ground track obtained is only as accurate as the heading reference from the compass.

Ref. No. 903 Name of System Shipborne Doppler

Type of System Miscellaneous tracking aid

Brief Description with reference to more detailed information

The principle is the same as airborne Doppler except that Asdic transmissions are used instead of radio.

See D.J.S.M. letter HKB/5.15/1514/58 dated 18th September 1958 and remarks.

Frequency 18 kc/s, 52 kc/s or ½ Mc/s

Degree of dependence on Shore station or Shipborne apparatus

Independent of shore stations. Elaborate shipborne apparatus needed.

Range and Accuracy

Depths of up to 1600 fathoms. $\frac{1}{10}$ to 1% of distance run or $\pm \frac{1}{20}$ of a knot.

Cost, Size and Weight

£53,570 per set approx.

Equivalent to a large asdic set with 3 transducers each of 2 ft diameter, and weighing 7000 lb. 4 x 6 ft electronic racks.

Factors affecting Service Applications

Self-contained system. Measures speed over sea bed and drift. Secure and does not increase risk of detection. Not vulnerable to jamming. Starting point must be known.

Present Policy and Progress

Under development in U.S.A. Sea trials have been carried out in U.S.S. Compass Island. Theoretical analysis by U.D.E. in 1953.

Suitability for Particular operations

Possible check for S.I.N.S. Amphibious and Minecountermeasures operations, so long as size can be reduced.

Remarks (903)

1. A D.R. system which measures speed over the ground and leeway to a high order of accuracy in limited depths.

2. Errors accumulate with time. If the starting point and ship's head are known, position can be obtained, and the accuracy kept at a high order by frequent comparison fixes.

3. Asdic transmissions are employed, and there are three transducers, disposed one on each bow and one right aft, inclined downwards at 45°. The frequency used can be varied according to the requirement, the greater the depth, the lower the frequency; thus for depths of up to 70 fathoms a frequency of ½ Mc/s would be suitable, while to achieve depths of 300 fathoms a frequency of 52 kc/s is employed. Limiting the operating depth enables an increase of accuracy and a saving of weight and size to be achieved.

4. The ship or transducers have to be stabilised.

5. The system is stated to be unaffected by a sloping sea bed and refraction of the sound path. Independent of differences in sound velocities at the ship and the sea bed.

Ref. No. 904 Name of System Leader Cable

Type of System Miscellaneous tracking system

Brief Description with reference to more detailed information

A cable is laid along the sea bed from a shore transmitting station to an electrode in deep water. A shipborne receiver picks up signals from the cable and indicates the position of the ship relative to the cable. There is no indication of distance along the cable.

See U.C.W.E. report No. UCW LT 476.

Frequency

Degree of dependence on Shore station or Shipborne apparatus

A fixed cable and shore station is required. The present ship installation is portable.

Range and Accuracy

Depths up to 30 fathoms approx.
Variable accuracy but ± 20 yards approx.

Cost, Size and Weight

Fixed installation simple but expensive. Shipborne equipment 6 boxes each 2 ft square approx. and weighing 50-60 lb approx.

Factors affecting Service Applications

Provides an invisible means of establishing and navigating a narrow channel with simplicity and accuracy. Channel limits vary with depth. Difficulty of finding and keeping within the channel. Difficulty of providing ships with the portable equipment. Cost of the cable.

Present Policy and Progress

Acceptance trial completed.

Suitability for Particular operations

Marking a searched channel.

Remarks (904)

1. The cable is liable to damage, and if damaged must either be spliced or relaid.

2. Although the system is workable, certain practical difficulties make it unsuitable for general acceptance and use.