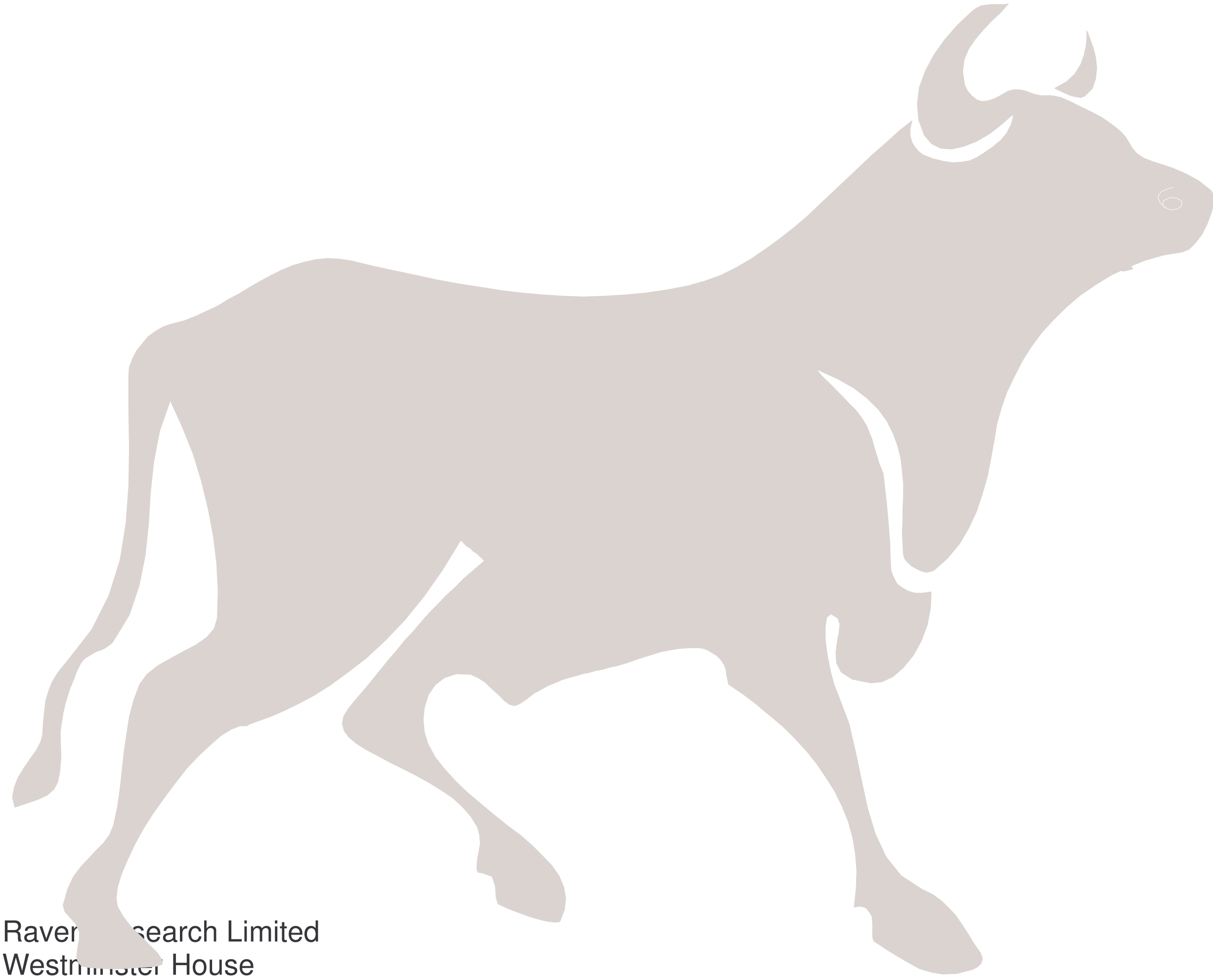
Raven Research Limited

TAURUS

Multiple Beams, High Frequency Receiving Antenna System

For 1.5-30 MHz



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1 Introduction

This brochure describes the Raven Research Multiple Beam High Frequency receiving antenna system, designed for operation over the frequency band 1.5 to 30MHz.

This receiving antenna system has been developed for use at locations where there is a need to receive high frequency signals from the entire 360 degrees of azimuth plane, such as a monitoring station. This is a compact system; ideal for use where the available ground area prevents the use of rhombic antennas. In most parts of the world for most of the time it provides externally noise limited conditions, thus rendering the deployment of large antenna farms unnecessary.

The system comprises two circular arrays of antennas connected by feeder cables to beam forming networks. The two arrays are deployed concentrically to effect a valuable economy of ground area and the beam forming networks are housed in a building at the centre of the array.

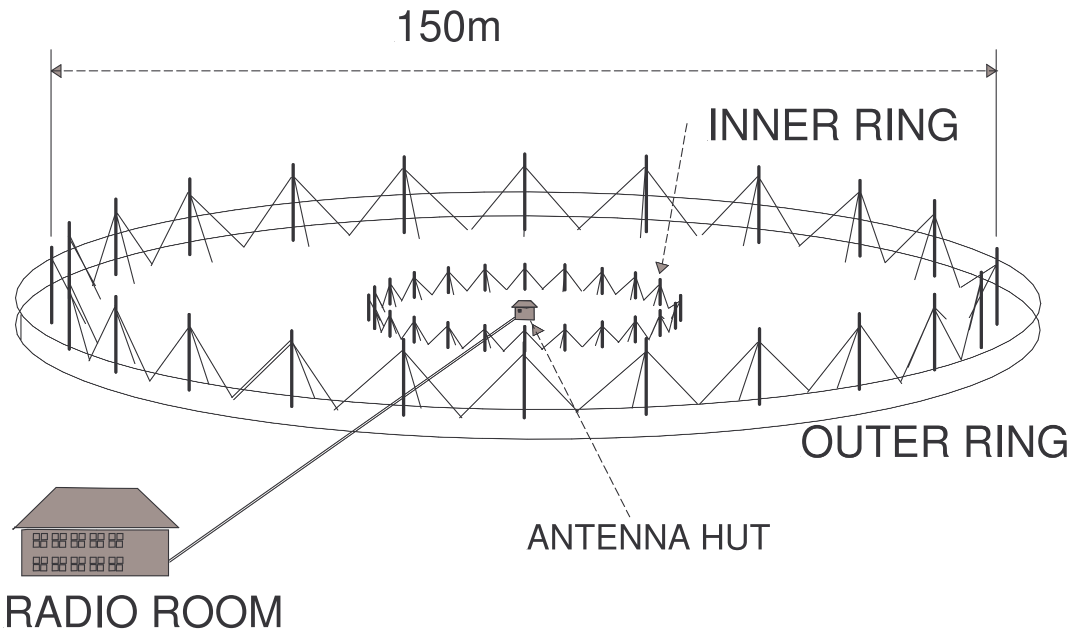

Figure 1 - Artist's Impression of Taurus Site

The system gives 24 fixed beam outputs which are available simultaneously and which are spaced on 15-degree intervals in azimuth. The beams provide significant directive properties up to an elevation angle of 60 degrees.

The two arrays are very compact and for their frequency coverage, occupying less than 10% of the area required for a corresponding array of rhombic antennas, giving a similar degree of all-around coverage over the same frequency band. Reception tests have indicated that the Taurus system gives a performance equal to or better than such an array of rhombic antennas.

Each beam output may be used to feed a large number of receivers for various monitoring purposes by the use of the Raven Research signal exchange equipment, which is widely deployed in NATO countries. The signal exchange equipment and the receiver banks would normally be installed in the main receiving station building at some distance from the antennas. To illustrate the significant place of the Taurus antenna system, the functional block diagram of a typical radio monitoring station is given in Figure 2

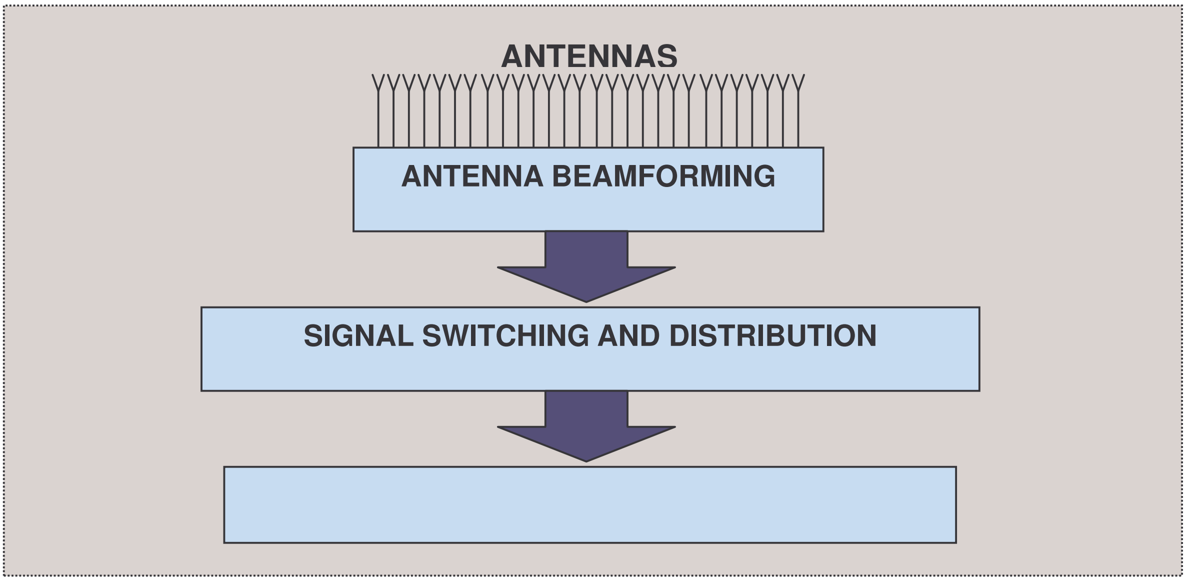

Figure 2 - Monitoring System Block Diagram

The antenna system can also be used in conjunction with the RR1875 High Frequency Direction Finding equipment, to provide highly accurate information on the azimuthal bearing of a selected signal at any point in the operating band. This valuable extension facility in no way inhibits the use or performance of the antenna system for HF. signal intercept and monitoring.

The complete antenna system, which can be erected quickly, represents a flexible solution to the problem of providing at short notice a high grade receiving system in an area of restricted space for permanent or temporary operations.

A more detailed description of the purpose and design of the equipment is given below.

2 Design Objectives

The main design objectives of the antenna system are as follows.

- Frequency Coverage 1.5-30MHz (with extended coverage to 40Hz)
- Improvements in Signal-to-Noise Ratio (by directivity gain)
- 360 degree Azimuthal Coverage for reception
- Maximum Elevation Coverage
- Minimum Ground Area requirement

The two most prominent features of the HF spectrum are the anomalous propagation of the HF via both ground wave and sky wave and external noise limitation of the minimum discernable signal.

The main reception mode of HF signals in commercial use is by sky wave, allowing this part of the spectrum to be used for long haul (intercontinental) transmission of both speech and data. In this regard, the medium is still one of the cheapest forms of radio communication. To monitor such signals, it is highly desirable that the receive antenna can cope with both low and high angles of elevation and all around 360 degrees of azimuthal angle.

The external noise associated with this part of the spectrum is both natural and man-made and is observed at a very much higher level than the thermal noise of the receiving circuits. It is of critical importance to the monitoring station because it limits the minimum discernable signal level (MDS).

However, in practical terms we can take advantage of the situation by introducing an antenna with directivity but not necessarily absolute gain. This will reduce the effective level of noise and lower the MDS (increase the sensitivity) of the monitoring system. Note that there is no need to resort to low noise front end amplifiers as for VHF/UHF reception.

The noise levels at a typical receiver site are illustrated in Figure 3.

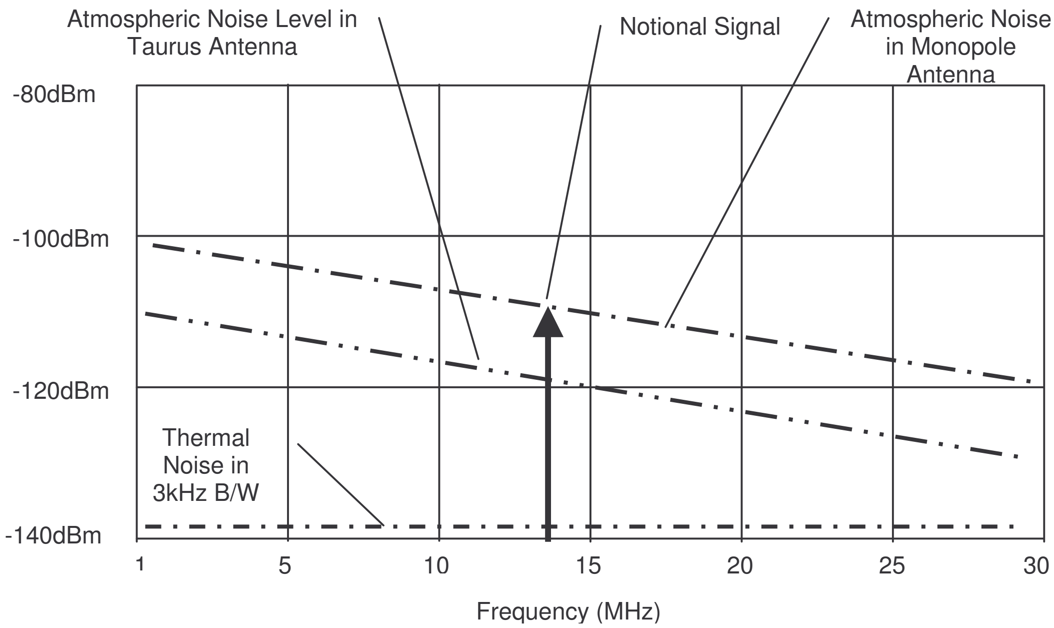

Figure 3 - Noise Levels at Typical Receiver Site

The external noise level in a 3kHz bandwidth at 2MHz will be as much as 40dB above the thermal (KTB) noise in the system, when using a simple monopole antenna. This would mean that the minimum discernable signal might be (say) 10dB above this noise level at –90dBm. The Taurus antenna has a nominal directivity of 9dB, which has the effect of reducing the effective noise level by this amount and hence improving the signal–to-noise ratio by the same amount. This places signals down to –99dBm within the detection limit of the system. The Taurus antenna has combining losses of about the same level (9dB), which apply to both the signal and the external noise. However, there is still no need to include amplification at the front end because the signal (and noise) level is still many dB above the internal (thermal) noise level.

3 Description of Antenna System

3.1 Principles of Beam Forming

The 24 antennas of each ring are equally spaced around the circumference of the concentric circles. The outer ring is employed to receive signals in the lower part of the frequency band, that is up to 10MHz approximately and the inner ring is used for reception between this frequency and 30MHz. Each beam is synthesised from the outputs of eight adjacent monopoles used as a curved broadside array. Figure 4 shows the plan of one ring with the antennas numbered in an arbitrary sequence and indicates as an example the optimum direction of arrival of signal for the beam formed from antennas numbered 21-24 and 1-4 (denoted beam number 1).

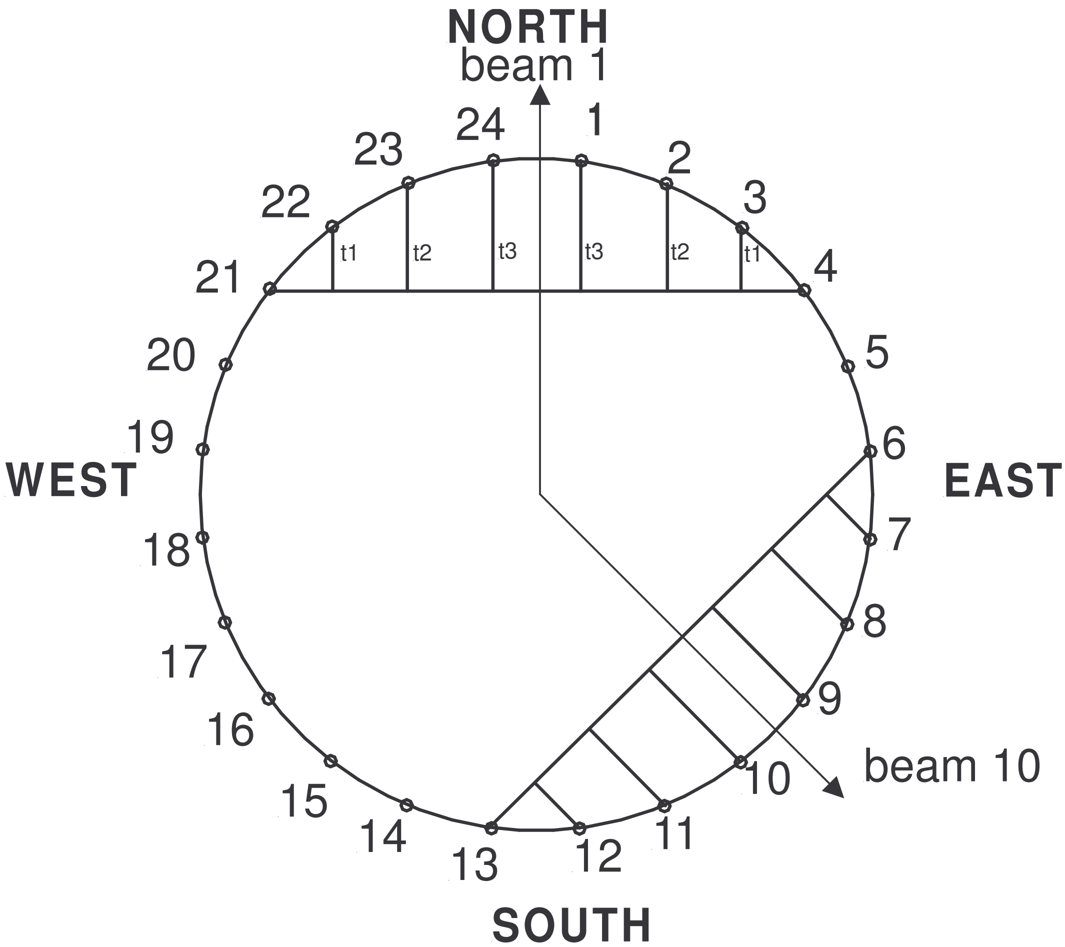

Figure 4 - Formation of Curved Broadside Array from 8 Antennas

The next beam is formed from the next set of eight e antennas (namely 22 through 5) forming beam 2 and so on. The method results in the formation of 24 beams, each spaced on a 15° pitch around the full 360 degrees of azimuth as illustrated in Figure 5.

The antenna signals are processed by means of delay, signal splitting and combining circuits, located in the central building. In this manner, 24 similar but individual beams are formed from each ring. These beams point in directions separated by 15-degree intervals in the azimuthal plane.

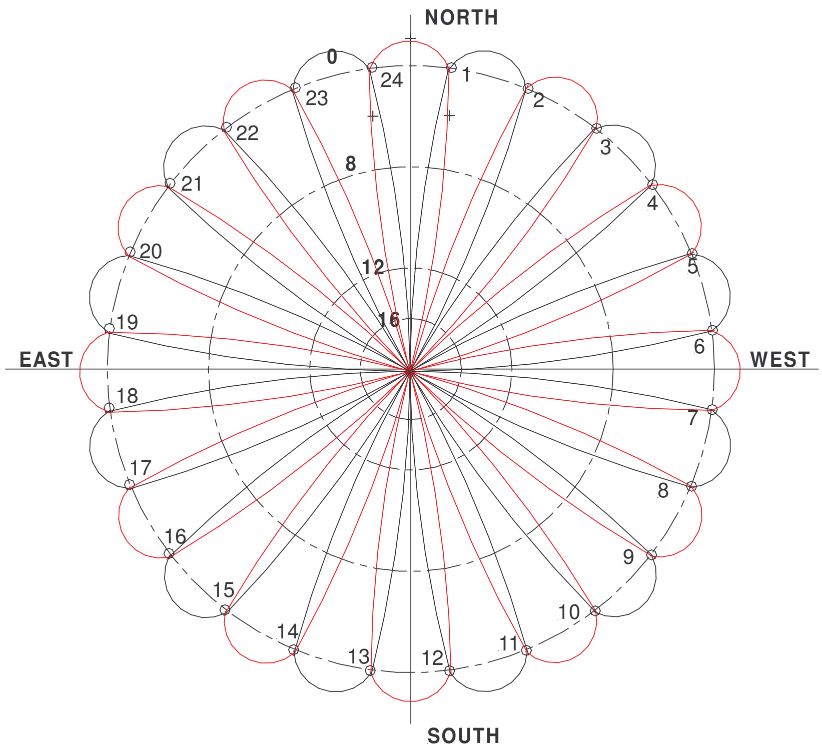

Figure 5- 24 beams formed from 24 monopoles.

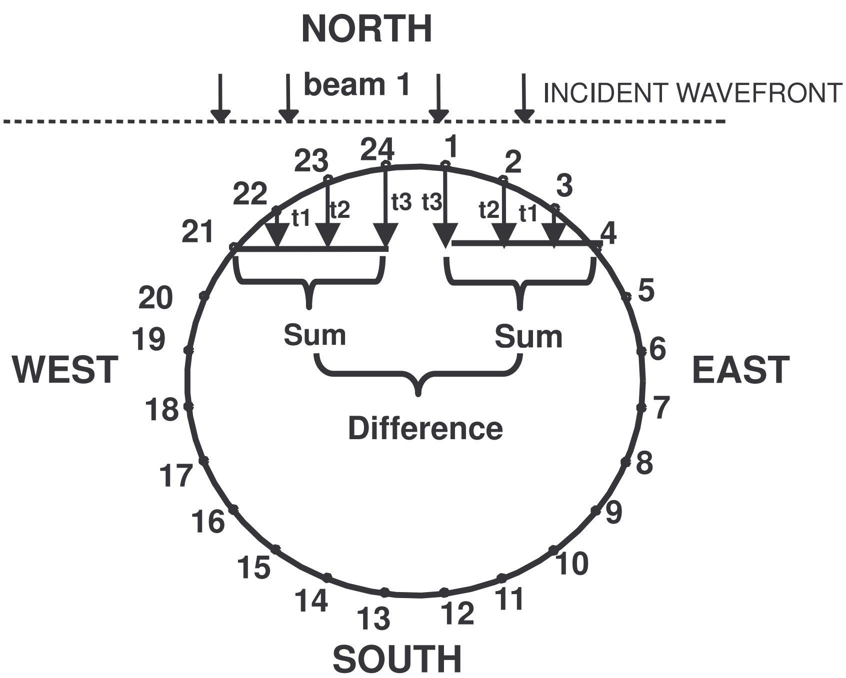

Figure 6 - Beam Forming signals - difference

The two groups of antennas (hi and lo band) lie on the same 24 radials of the circles and therefore the beams derived from the two arrays point in the same set of directions and can be regarded as 24 pairs.

These beam pairs, which are synthesised in the beam forming cabinet, are subsequently combined in diplexers, also mounted in the same cabinet, to provide 24 beams covering the full frequency band 1.5MHz to 30MHz.

The beam forming equipment provides both the Sum beams (the vector Sum of all voltages on the 8 monopoles in the beam), but also the Difference voltage. The Difference voltage comprises the difference between the sum of the first four elements in an array and the last four elements in the array. This is illustrated in Figure 6.

The polar diagrams of the sum and difference beams are illustrated in Figure 7 and Figure 8, respectively. The sum signal is used for signal interception and monitoring. The difference signal is used primarily by the direction finding subsystem.

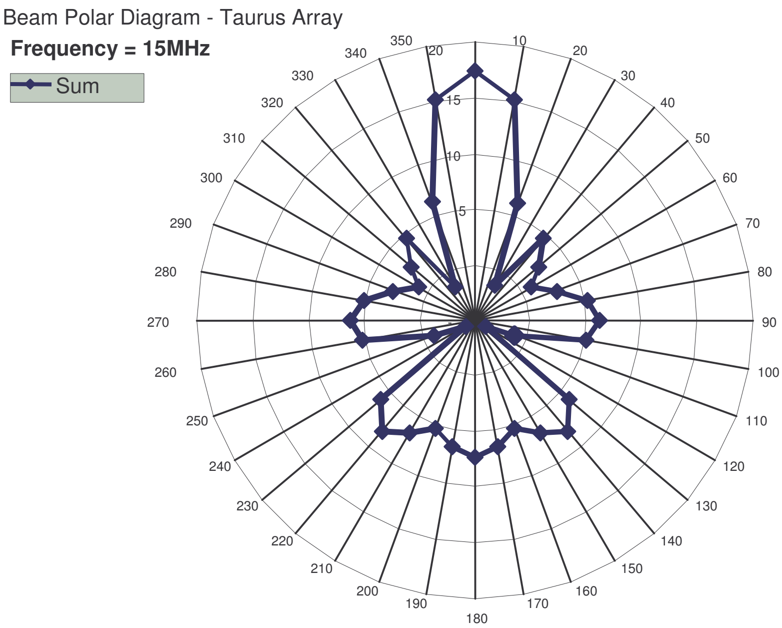

Figure 7- polar plot of antenna gain for 'sum' beam

The antenna system is normally sited some distance from the main receiving station and coaxial cable are employed to feed the beams from the antenna building to the receiving station using cross-site amplifiers to overcome and compensate for feeder losses where necessary.

The beam forming equipment is designed for operation in a ground benign but remote unmanned environment. The antennas and all other external parts are designed for fully exposed (outside) operation anywhere in the world.

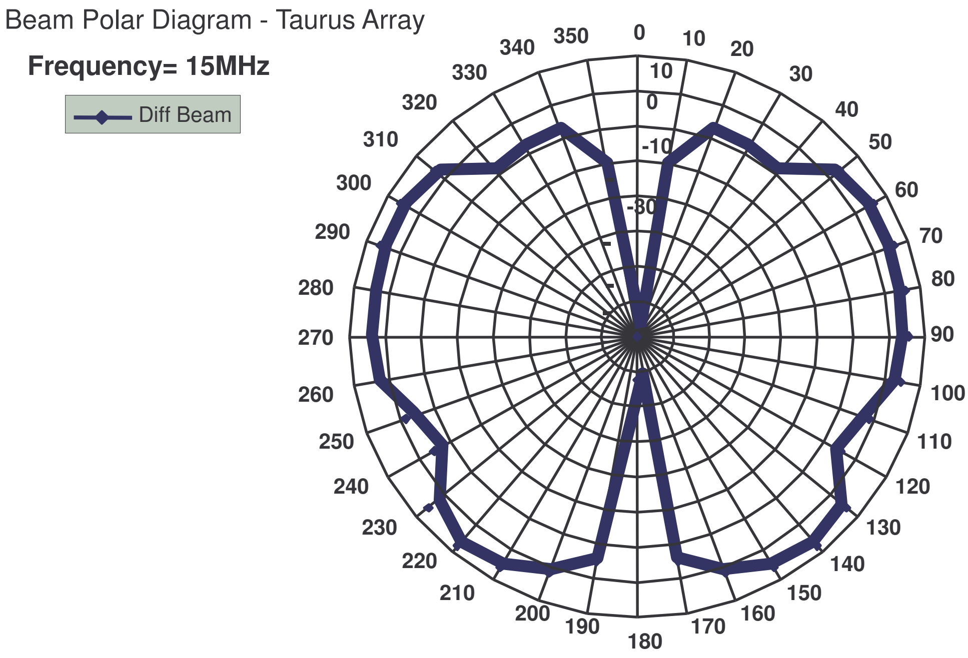

Figure 8 - polar plot of antenna gain for ‘diff’ beam

3.2 Outer Antenna Ring

The outer antenna ring installation is designed to cover the frequency band 1.5-9.7MHz, which is determined by the frequency response of the diplexer/filter. It employs 24 antenna equally spaced on the circumference of a circle of 150m diameter.

The antennas are elevated feed monopoles 12m high. This design was chosen because it has better low angle coverage than its ground fed equivalent, particularly at the upper edge of the frequency band. It also has advantages when using ground subject to flooding or on saltings. The impedance of an elevated feed monopole is less dependent on the ground conductivity than that of a similar ground fed monopole.

Each monopole comprises three 4m lengths of high-grade aluminium tubing of 80mm diameter, chosen to combine high strength with maximum resistance to corrosion. A glass fibre insulated feed-point section is included to join together the first and second sections at a height of 4m above ground level. The top two sections are screw fitted.

The base of the antenna stands on a 300mm square plate to which is attached eight radial wires 7.5m long, terminated in aluminium stakes driven into the ground. The employment of this earth mat, or counterpoise, serves to stabilise the impedance of each antenna, particularly where the ground impedance of the site is not uniform from place to place, or where it is subject to variation with change of season.

The use of earth mats is more important in realising the potential accuracy of the direction finding equipment, when the system is operating in that role.

The antenna is guyed to three anchor points with nine pre-stretched Terylene ropes of 25mm circumference, at three optimum spacings on the monopole to provide maximum safety under extreme environmental conditions. Two of the three anchor points of each antenna are shared with two guys from the adjacent antennas.

The antenna feed point insulator houses an impedance transformer and a sealed voltage surge protector, the latter striking at about 90V. This is provided to minimise the effect of an electrostatic discharge (ESD), caused by a nearby lightning strike.

The system currently uses a 75-ohm feeder cable. The transformer through which the signals are passed to the feeder cable is a ferrite-cored construction with an impedance ratio of 408/75 Ohm. This value presents an optimised loading to the antenna, over the 1.5-10MHz band.

Other exposed parts of the antenna are made of stainless steel and the antenna was originally designed to the relevant British/NATO Defense standards for outdoor use anywhere in the world.

The assembled antenna weighs 25kg and the associated guy ropes and anchors a further 15kg. The earth mat with stakes for each antenna weighs 10kg in addition.

The antennas and guys are designed for safe operation in wind speeds up to 270km/hour.

The ground area occupied by the outer ring of antennas, and hence of the complete installation including the inner ring, is less than 2 hectares, which compares favorably with a farm of rhombic antennas, designed for similar all-around coverage of the frequency band 5MHz to 10MHz, which would require 20 hectares. Note that the rhombics still cover a more limited frequency range than the Taurus.

3.3 The Inner Antenna Ring

The inner antenna ring installation is used to cover the frequency range 10MHz – 30MHz. as determined by the response of the dual band filter diplexers. The 24 antennas are equally spaced on the circumference of a circle of 50m diameter, placed concentrically within the ring of low band antennas and lying on the same set of 24 radials. There is no measurable mutual interaction, over the 1.5-30MHz range between antennas of the two circles.

The antennas of the inner ring are very similar in design to those forming the outer ring, with consequent advantages to spares ranging. The following description indicates where dimensional differences occur.

The inner ring antennas, also of elevated feed design, are 6.1m high, comprising a 4m upper section and a 2.1m lower section of aluminium tubing. The insulated feed point section joins the two tubes together at a height of 2.1m above ground level. The radial wires of the earth mat are 2.5m long. Each antenna is guyed to three anchor points with three Terylene ropes, which are connected to a plate below the top of the structure. The antenna-matching transformer has an impedance ratio of 675/75 ohms to present to the antenna an optimised loading over the frequency range 9.7-30MHz.
The assembled antenna weighs approximately 12kg and the associated guy ropes and ground anchors a further 12kg. The earth mat and stakes for each antenna weigh an additional 8kg.

The ground occupied by the inner antenna ring is no more than 10% of the area required for a farm of rhombic antennas covering the frequency range 15-30MHz.

3.4 The Antenna Feeder Cables

The antenna signals are passed to the beam-forming networks by means of 75-Ohm cable. The 24 cables connected to the outer ring of the monopoles are closely matched in electrical length in order to preserve the relative phases of the signals of the antennas. The physical length of these cables is 94m nominally and their maximum insertion loss (at 9.7MHz) is 1.75dB. The feeder cables serving the inner ring of the array are similarly matched in electrical length having a nominal physical length of 35m and a maximum insertion loss (at 30MHz) of 1.25dB.

4 The Beam Forming Equipment

4.1 General

The beam forming circuits for the two circular arrays of monopoles are housed in a single freestanding 19" equipment cabinet of height 37U and x 660mm depth, the weight being approximately 182kg. The block diagram of the system is shown in Figure 9. The complete beam forming cabinet is illustrated in Figure 10.

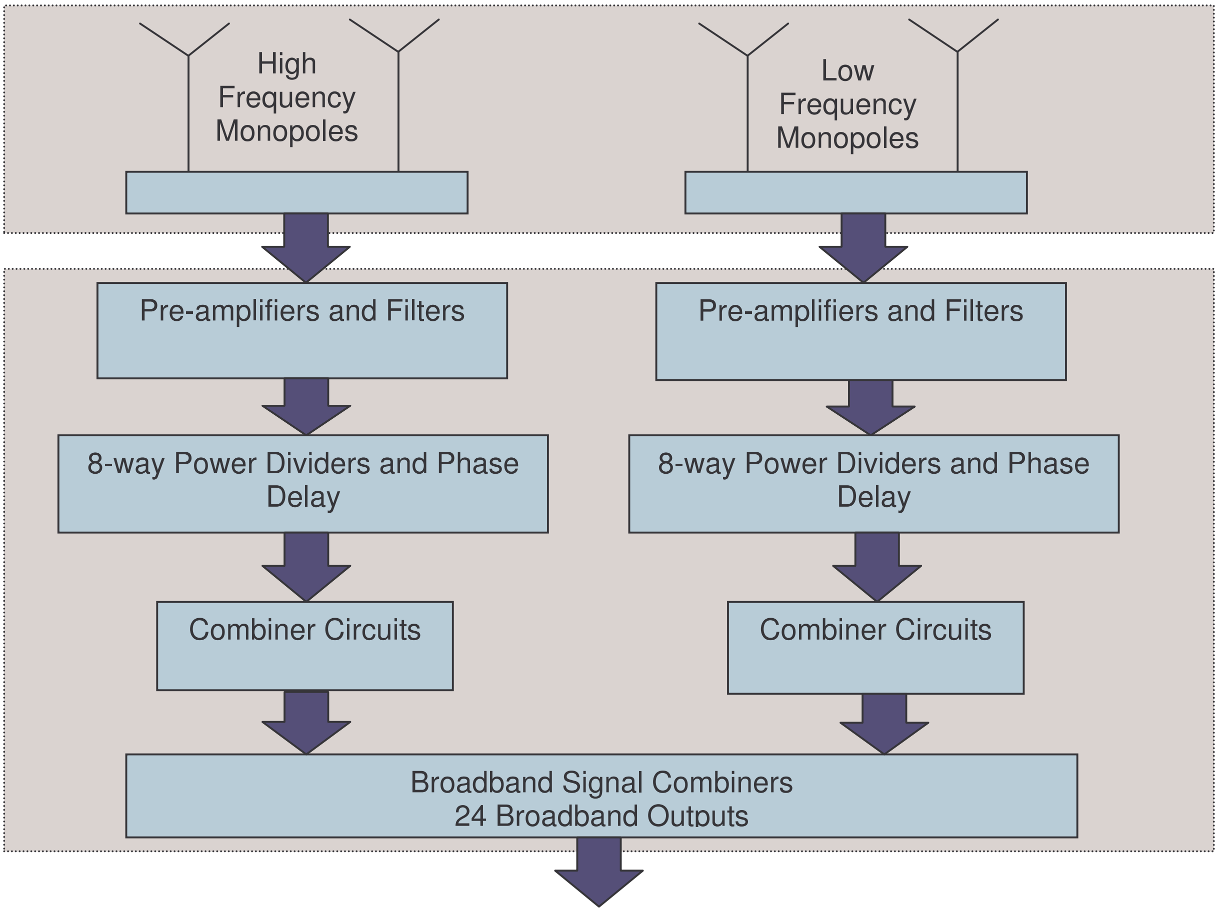

Figure 9 - Block Diagram of Beam Forming Subsystem

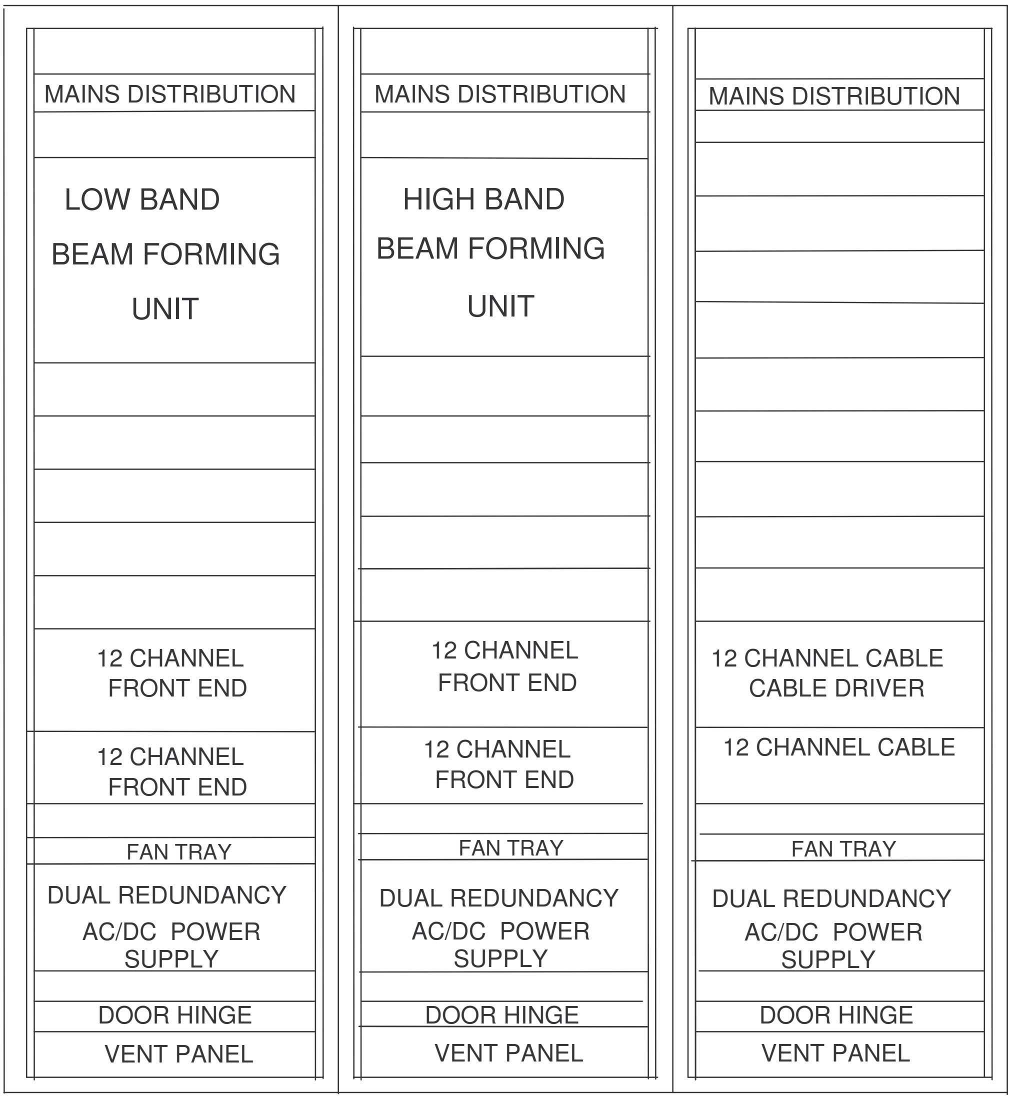

Figure 10 - Front Panel Fascia of the Beam Forming Units within the Antenna Hut.

The beam forming network, including pre-amplifiers, occupies the upper half of the cabinet while the dual band pass beam combining filters and the power supply of the amplifiers is housed in the lower half of the cabinet.

4.2 Beam forming Networks

There are two beam-forming networks fitted into rack-mounting units. One is used for the outer (low-band) array, while the other for the inner (hi-band) array. Each unit, which also includes the coaxial connectors for external connection, measures 6U high

The beam-forming network comprises one signal splitter circuit for each antenna and one signal combiner circuit for each beam.

The circuits are in the form of plug-in printed circuit cards of standard eurocard size. These plug in to a motherboard and the interconnections are made with an array of coaxial cables.

The cards are illustrated in Figure 11 and the equipment cabinet in Figure 12.

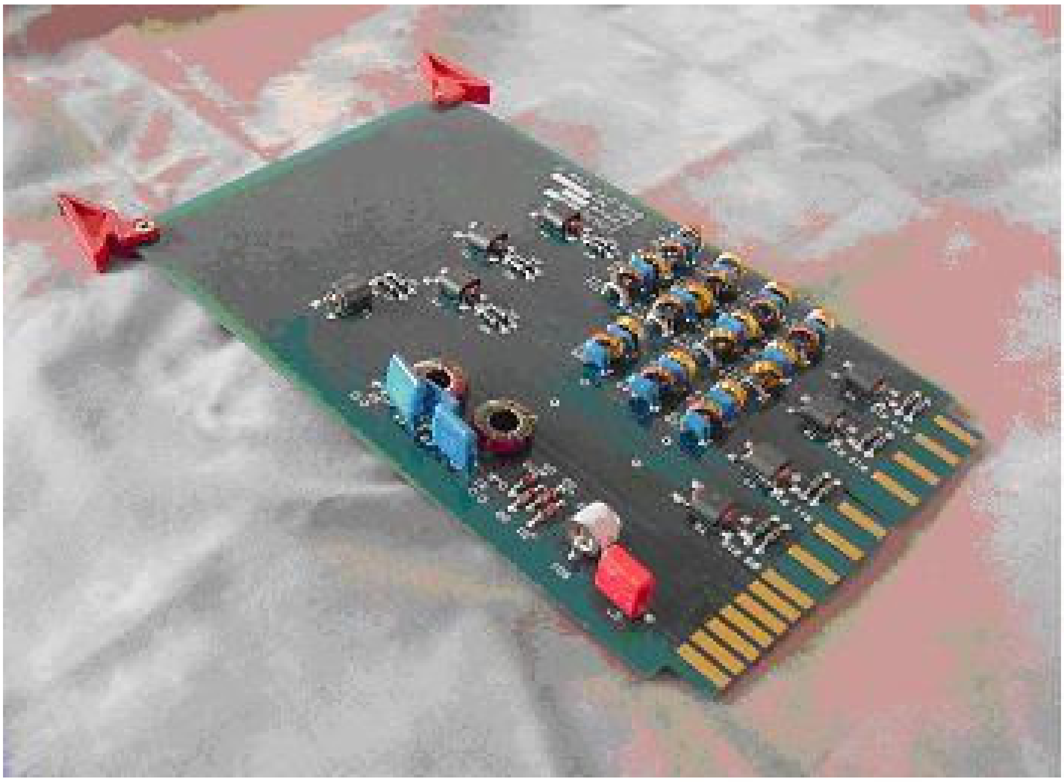

Figure 11 - Signal Splitter/Delay Circuit Board

Figure 12 -- Beam Forming Unit

Figure 13 illustrates a typical portion of the beam-forming network, showing the method by which beam number three is derived from these antennas. The upper central part of the diagram represents schematically an antenna signal splitter network, of which there are 24 for each ring. The lower central part of the diagram represents a combining network of which there are also 24 for each ring.

Each of the 24 antenna splitter networks, used in a unit, has a nominal 75Ω input impedance and comprises a number of sub-circuits as follows.

- Secondary lightning protection. The secondary lightning protection circuit serves to limit any surge on the feeder cable resulting from an induced lightning stroke, which might reach the unit.

- A high pass filter with a nominal cut-off frequency of 1.1MHz (lo- band) or 6MHz (hi-band). The high pass filter immediately following is included to reduce the level of unwanted MF broadcast signals.

- A signal splitting hybrid transformer to drive the beam forming networks and an antenna auxiliary output (which may be used to supply signals to the direction finding equipment). The hybrid units split the signals into 9 different paths. One of these is the antenna auxiliary output, which makes the antenna signal available at +5dB relative to the antenna feeder signal with the amplifier in circuit. The other eight paths include various time delays produced by delay lines in the form of lumped-constant low pass filters comprising capacitors and ferrite inductors.

Signal-splitting hybrid transformer units and lumped constant delay lines appropriate to the 150m diameter antenna array for the lo-band or to the 50m diameter antenna array for the hi band. The value of the delays are proportional to the time intervals required for the radio waves to travel the various distances from the individual antennas along the perpendicular paths to the chord joining the outer most antennas of the beam array. The delays are designed to give optimum reception to signals arriving from elevation angles of between 12 and 15 degrees.

The amplifier has a 10dB gain and although it can be expected that in most parts of the world the system can be used without amplification and would still provide externally noise limited conditions when using receivers with noise figure of 10dB or less, it is considered that the inclusion of an amplifier is a desirable facility for low noise areas.

The use of the amplifiers is however, optional. As a further option, they can be electrically controlled and can be switched in/out of the RF paths as desired.

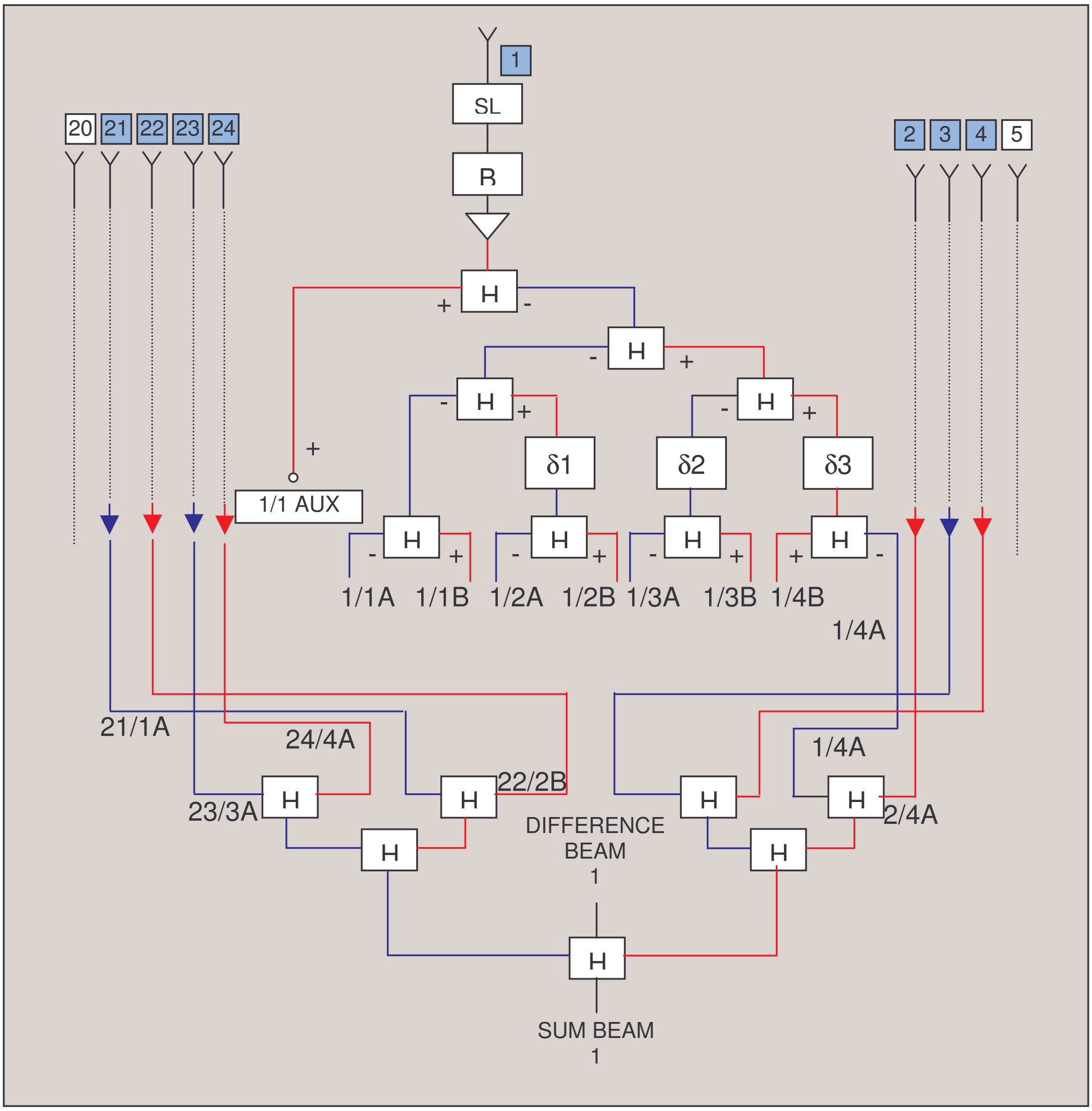

Figure 13 - Beam Forming Subsystem - Block Diagram

Referring to Figure 13, each of the 24 beams is formed by adding together in a combining unit one particular delayed signal from each of the eight adjacent antennas as illustrated for beam number 3. This signal addition process is achieved by the use of similar hybrid transformers.

The combining unit yields two beams of nominal 75Ω output impedance namely a sum and a difference beam. These outputs are formed respectively by taking the vectorial voltage sum of and difference between the sub-beams formed by the two halves of the array formed by the 8 adjacent antennas.

The sum beam outputs are terminated in a 50Ω coaxial plug at the end of a length of coaxial cable and are used for the normal HF directional reception of signals. They are connected to appropriate frequency band inputs of the dual band-pass filters in the lower half of the cabinet.

The difference outputs are terminated in coaxial sockets on the unit and can be used for the DF subsystem or other special monitoring applications. The symmetry of the array produces a null response at the difference beam output to a signal whose direction of arrival gives maximum response of the corresponding sum beam. All beams, both sum and difference, are independent and can be used simultaneously with separate receivers. The use of one beam for one specific purpose does not preclude the use of other beams for other applications.

Although the value of the delays optimises reception at an elevation angle of between 12 and 15 degrees, the sum beams have a satisfactory uniform response from very low angles up to 45 degrees and the system is usable up to 60 degrees elevation.

Adjacent beams having pointing directions at 15 degree intervals in the azimuthal plane overlap to ensure that even at the upper ends of the two frequency ranges sensitivity varies only a little with direction.

4.3 Power Unit

The dc supply for the amplifiers in the upper and lower frequency beam-forming chains is provided by the RR1815 multiply redundant 24Vdc power supply, located in the bottom of the beam-forming rack

4.4 Beam Combining Filters

Twelve pairs of dual band pass filters are fitted at the end of the beam-forming chains. Each dual band filter covers the frequency range 1.5-9.7MHz and 9.7-30MHz and is provided with an input socket for each band and combined output socket for the two bands. Pairs of high and low frequency sum beams, of corresponding direction, are applied to the appropriate input sockets of the dual band filters. The combined filtered beam outputs thus cover the spectrum 1.5 –30MHz This method of addition produces beam signals which are derived solely from the antenna ring which has the better directional properties. It is noteworthy that the electrical lengths of the low and high band antenna feed cables are designed to yield an optimum beam response at the crossover point of 9.7MHz. Use of the filters also permits the 48 beams produced from the two antenna rings to be routed to the main station along 24 feeder cables only. In installations where the radio site is a considerable distance from the array it may be desirable to introduce suitable line amplifiers, such as the RR1750 series, to overcome feeder losses. Economy in the number of beams then results in a saving of 24 amplifiers.

A feed through panel is positioned under the filters and is used when it is convenient to route the filter output cables under the cabinet.

5 Ancillary Equipment

5.1 Antenna Signal Exchange Unit

Each of the 24 beams produced by the Taurus antenna can be connected separately to a dedicated receiver and operate independently of other beams. However this lacks both surveillance capacity and the flexibility to place more than one receiver on the same beam. The addition of the RR1900 series Beam Switching Matrix allows the operator to assign a pool of receivers to the system, allocating a chosen number of receivers to each beam, as the mission requires.

The Beam Switching Matrix is a high performance front-end system, which provides matrix switching from antenna beams to receivers. The system is non-blocking (full fan-out) in the forward direction. That is, any given input can be connected to any output or all of the outputs simultaneously, as required. A block diagram of the switching system is given in

In the HF monitoring station, the minimum number of receivers usually assigned to the Taurus system is 64, with some NATO stations boasting more than 500 receivers. The Beam Switching matrix can be conveniently established at a minimum level of 64 receiver outputs and then expanded to include more receivers at a later date, in multiples of 32 outputs.

The Beam Switching Matrix is usually located in the main radio building and controlled remotely from a supervisor's position within the building. A local (front panel) control is provided for maintenance purposes and emergencies.

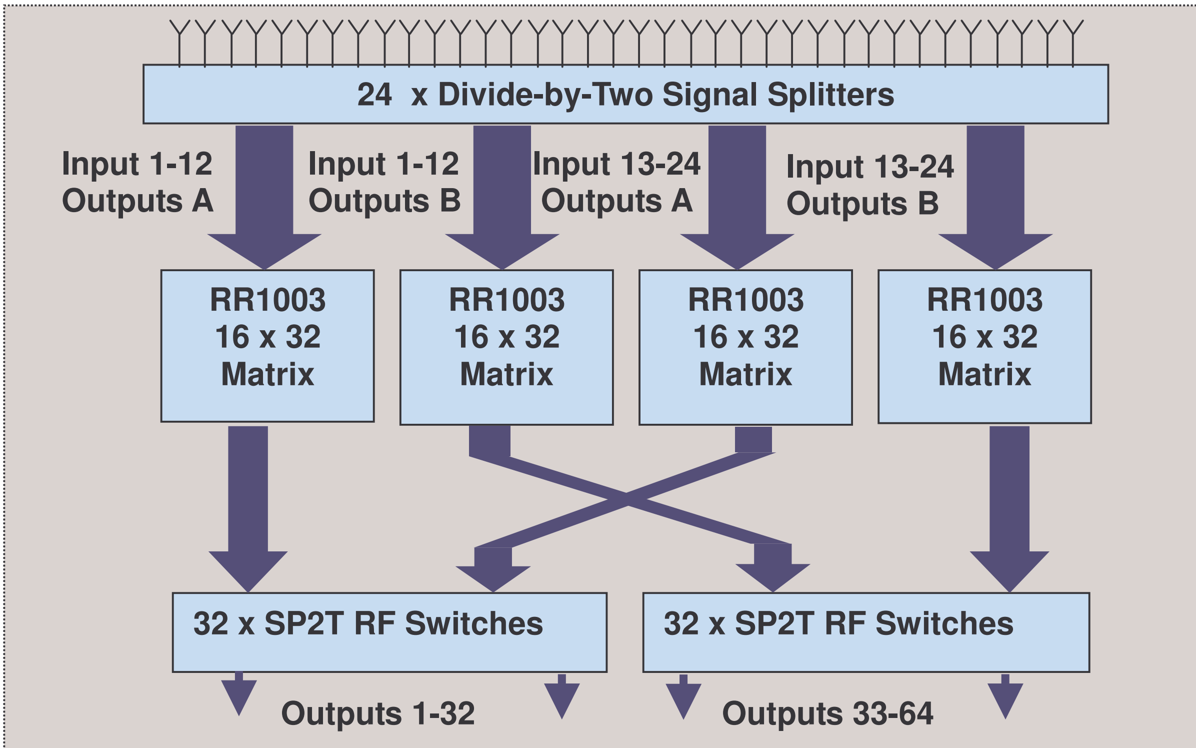

Figure 14 - 24 x 64 Switching Matrix - Block Diagram

5.2 Antenna Assembly (Test Monopole)

The test monopole can be supplied as a test facility for use with the Antenna system. Employed in conjunction with the switching system described above, it can be operated to check in particular the antenna and feeder parts of the installation.

The antenna assembly is a short transmitting monopole, normally mounted on the roof of the antenna hut at the electrical centre of the antenna circles. Signals propagated from it are received at each antenna in a ring array having equal strength and phase. The monopole is powered from a signal generator located in the Antenna hut. It is controlled remotely from the receiving station, via a twisted pair control cable. The test monopole is of particular value when used in conjunction with Direction Finding equipment, to which reference was made in the introductory section and below. This equipment provides a display at the receiving station, which gives immediate unambiguous indication of a faulty antenna feeder path.

5.3 Direction Finding Equipment

The RR1875 DF Unit is used to provide direction-finding facilities from the beam forming antenna system. It is an independent subsystem (not requiring additional receivers), which can be installed with the Taurus antenna array.

The unit processes the incoming signal from a single channel and uses the signal strength on three antenna adjacent beams to derive the direction of arrival of the signal.

Using signal distribution multicouplers, a series of direction finding subsystems can be added to the system to increase the number of signals simultaneously processed for DF by the station.

6 Planning the Installation of the Antenna System

6.1 Siting the System

It is important to select the antenna site carefully in order to realise the high level of performance of the Taurus system. Sites having large variations in ground level should be avoided and any site considered for this purpose should be free of sizable metallic structures such as iron barns or pylons for a concentric area of at least 8 hectares. This is particularly important if the system is to be used in a direction finding role.

For normal beam reception, a steady slope of up to 4 degrees across the site would be acceptable. For direction finding use, the slope should be restricted to 2 degrees. Sudden changes of soil type across and close to the circular area should be avoided.

6.2 Antenna Installation

The installation of the Taurus antenna is expedited by marking out the positions of both rings of antennas at the same time. These measurements are required to be accurate to within 100mm of the nominal radial distances from the centre of the 50m and 150m arrays.

On most sites it will be possible to stand the antenna bases directly on the ground, which is advantageous. It is desirable to bury the earth mat wires to a depth of a few centimeters to avoid damage by vehicles on site. The earth stakes should if possible be driven fully into the

ground to minimise the monopole-to-earth resistance. The antenna guys are anchored at the ground with earth screws, a total of 48 being required for each ring of monopoles.

It is occasionally necessary, for example on hard rocky ground, to use concrete blocks with anchor rings, in place of the earth screws.

On normal ground, a team of three riggers could mark out the site, assemble the antennas and erect them in less than 10 days.

6.3 Antenna Feeder Cables

The feeder cables are usually supplied ready to install. The cables are connected to the antenna feed points, laid on the ground or, preferably, on sand in a shallow trench along the radials of the antenna circles and input through the floor of the building at the centre of the array (antenna hut) to the beam forming cabinet.

The cables are assembled to a precise electrical length, which must not be altered. Any surplus physical lengths can be coiled up at the antenna hut, (in the turning pits). Some removable protective covering for the feeders is advised to avoid damage from site vehicles.

6.4 Antenna Hut (Array Centre Building)

It is only possible to specify the size required for the antenna hut once a decision has been made on the amount of equipment, which it will be called upon to house.

Typically the hut will be required to house the rack containing the pre-amplifiers, beam forming units and two other units for RF sum beam amplifiers and termination panel. A worktable and a storage rack for items of test gear are advisable.

If it is intended to expand the system to include the DF sub-system then space allowance must be made.

The equipment cabinets are less than 2m high and would easily be accommodated in most buildings. The equipment cabinets are 19” equipment bays and will pass through a standard 75cm door but the cabinets are heavy and it is recommended that double doors be provided at the building entrance.

It is also recommended that a raised floor suitable for passing the cable under be incorporated. Access from outside to the under floor space is required on all four walls of the building to provide a reasonably direct route for the feeder cables from the monopoles to the beam forming cabinets.

The roof of the building may be required to support the antenna assembly (Test Monopole), which must be installed at the array centre to within 100mm. The monopole stands on a 300mm square plate and is held vertical by four guy ropes, which may be, anchored either on the roof or the ground as is convenient.

The estimated maximum tension in each rope is 50 Kg. The monopole has a deadweight of approximately 20 Kg and an estimated down thrust of 120 Kg, when guyed. It is designed to be serviced in position. If the roof is used to support the monopole, a ladder will be required for servicing. The roof structure must be strong enough to withstand the weight of a person standing near the foot of the antenna.

6.5 Power Requirements

The power requirements for the equipment in the building are unlikely to exceed 2kW during running conditions, although there is an additional starting transient on the linear power supplies used in the system.

There are no restrictions on the arrangements for lighting, heating/air conditioning, except that if the building has a non-conducting roof, overhead lighting conduit should be returned to floor level, to other earth connections, so that the lighting circuit does not couple with the test monopole.

6.6 Access to the Array Center

It is possible to drive vehicles of Landrover size under the antenna guys to the antenna hut if a track is laid with one edge running on a radial through one outer and one inner monopole base. In the case of larger vehicles it would be necessary to undo guy ropes and lower two monopoles (one from each ring) to the ground.

Vehicles standing close to the building produce no noticeable effect on the system performance but it is important, particularly when the DF system is installed and in use, that vehicles are parked no closer than about 10m to a monopole.

6.7 Feeders to the Main Receiving Station

These comprise the coaxial feeders for the 24 RF sum beams, together with any control cables that may be necessary. The latter are normal twisted pair cables while the coaxial cable depends on the cost and performance considerations. All of these cables, which can be run together, should be laid below the ground surface in approximately a radial direction for at least 120m. The mains power cable should be run separately in a similar fashion. In planning this aspect of the installation, it is recommended that the possible requirement for the deployment of the DF system in the future be considered, so that all the cables likely to be needed can be installed at the initial stage.

7 Abridged Technical Data

Frequency Range: 1.5-30 MHz crossover point between low and high band occurs at 9.7 MHz
Number of sum beams: 24, pointing directions at 15 degree intervals in azimuth
Azimuthal coverage: All directions with adjacent beams overlapping
Elevation Angle: Optimum reception up to 20 degrees; usable up to 60 degrees

Antenna Arrays: Monopoles Equally spaced on 150m diameter circle, 24 per circle. Electrically equal feeder lengths convey antenna signals to beam forming networks at circle centre.

Antennas: Each antenna comprises a 80 mm diameter aluminium tube monopole. The base of the monopole stand as on a 300mm square foot, to which are attached earth mat wires.

A glass fibre moulding at the feed point includes an impedance transformer and an induced lightning voltage surge protector, working at 90V.
The antenna height is 12 meters, with the feed point at 4m above ground level.
The low band antenna is protected by three sets of Terylene guy ropes. The high band antenna is supported by 1 set of guys, attached to the top of the monopole.

Antenna Environment: The antenna will safely withstand a wind speed of 270km per hour.
Working temperature range, -60 to +60 degrees Celsius.

Antenna Feeder Cables: URM57 for operation over the temperature range –30 degrees to +60 degrees Celsius. Special feeder cables can be supplied for lower temperature environments.

Beam Forming Networks: Housed in 19” rack mounting units System impedance 75 Ohms

Antenna Pre-amplifiers: Gain 10 dB+/-1 dB. Noise figure 5dB maximum
Intermodulation Products: Suppression of 2nd and 3rd order intermodulation products of two tones at 0 dBm is 80 dB minimum.

Sum beam Output levels: not lower than +3dB above single monopole output level, measured at the feeder cable input to the beam forming network.

Other outputs from each set o n beam forming networks:

24 difference beams yielding a null output for signals arriving from the beam-pointing directions, which may be used for monitoring, testing or other purposes. The null is not less than 20dB below the corresponding sum beam level.

24 antenna auxiliary outputs at a level not lower than +5dBm relative to the antenna feeder level to the networks. These outputs may be used for monitoring, testing and the direction finding equipment.

Pass Bands of Beam Combining Filters: 1.5-9.7MHz and 9.7-30MHz
Power requirements: 1500W at 230Vac
Beam Forming Cabinet Environment: -10 to +50 degrees C.
Weight of Complete System: TBD

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