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A RECEIVING AERIAL FOR A LONG DISTANCE V.H.F. TELEVISION LINK

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Introduction This paper describes the design and construction of an aerial used to receive V.H.F. television signals over a long path at a location where very severe co-channel and adjacent channel interference is present.

The television service in the Channel Islands is based upon the re-broadcasting of signals received from transmitting stations on the south coast of England. The signals used by the Independent Television Authority are received from the transmitters at Caradon Hill (Cornwall), Stockland Hill (Devon) and Chillerton Down (Isle of Wight) at the Post Office Radio Station on Alderney, the most northerly island of the group. Three links are used in order to improve reliability and to provide a choice of programme material. This paper is concerned with the design of an aerial for the reception of signals from Chillerton Down on Channel B-ll.

Incoming Signal The propagation path from Chillerton Down is 124km long and is at grazing incidence to the radio horizon. Except for a short land path at each end the path lies over the sea. The incoming signal at Alderney has a measured median field strength of +49dB relative to 1uv/m, and is subject to large fluctuations whenever propagation conditions vary. In addition, Alderney is close to a large number of french transmitting stations which provide heavy and consistent co-channel interference.

In order to ensure satisfactory reliability of the link, the GPO arrived at the following specification for a receiving aerial:

> Forward gain : Not less than 18db,
> Polarization protection : Not less than 20db,
> Azimuthal radiation pattern : To provide not less than 38db below forward gain on bearings 45,73, 108 and 165 degrees from the forward direction.

A fuller discussion of the whole system at Alderney is to be found in reference (1).

Previous Designs Before designing a new array to meet the apecification, the methods already tried at Alderney were examined. Signals from Stockland Hill are received on two large front fed parabolic dishes 30 feet in diameter. This solution is expensive and requires a site which faces in the appropriate direction. A simple yagi array mounted on the existing tower had previously been used for reception from Chillerton Down, but this lacked gain and directivity. A more ambitious array had been substituted comprising eight co-phased eight-element yagi aerials, but this too lacked sufficient rejection of the unwanted signals. An array of wire inverted 'V' aerials has

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been used for reception of signals from Caradon Hill, but it would be very difficult to meet the present specification with such an array.

Basis of Design In view of the space available on the existing tower, consideration was first given to arrays suitable for mounting on it. In order to achieve maximum polarisation discrimination and to achieve deep minima in the radiation pattern, it is necessary to keep the aerial away from the near field of currents which may be excited in tower members by incident fields. This isolation may be achieved by placing a screen of conducting sheet of rods between the tower and the active elements of the aerial. The designs first considered were arrays of dipoles mounted close to such a screen. In order to achieve sufficient discrimination against the unwanted signals the currents in the dipoles were tapered in the horizontal plane according to Tchebyscheff or binomial coefficients. The aperture efficiency of such a device i.e. the ratio of energy collected the total incident energy over the aperture, is necessarily poor when such low side lobe levels are required.

Attention was turned to the last-tried array of yagis at Alderney. It was felt that their inadequacy was due largely to close coupling of tower members and non-optimal spacing between the separate yagis. It was decided to array them in groups of eight, each group being placed in front of a screen of steel rods. Each array would contain nominally co-phased yagi aerials which would be spaced to produce the desired nulls. This solution offered the following advantages:

1. Close control of horizontal radiation pattern,
2. High aperture efficiency,
3. Possibility of using some components of an existing array,
4. The array could be mounted on an existing structure,
5. The array could be built up and tested on a convenient site, and could then be accurately rebuilt at Alderney.

The use of a polyphase feed system with the yagi aerials displaced in echelon was considered, but was rejected because it was felt that sufficient equality of aerial current amplitudes could not be achieved.

Design Details Each array was considered first as two identical tiers of four yagi aerials. Neglecting the mutual impedances between aerials one can derive various combinations of horizontal spacings which would produce nulls in the two directions where they are required in the forward hemisphere. Some of these spacings will be too large for convenience and others so small that large couplings would exist between aerials - so modifying the currents flowing in them and destroying the desired nulls. In this case it was decided to use a set of small spacings and to reduce the mutual impedances by offsetting alternate aerials vertically. This process may alternatively be seen as placing the individual yagis so that they each intercept a separate portion of the incident field.

No exact information could be found from which the overall size of the screen could be determined; the size used was estimated from previous experience. Suitable rod sizes and spacings were determined from equations developed by Moullin (2).

The input impedance of each array was matched by standard methods, each array being provided with an impedance centreing unit.

Testing and Adjustment Owing to the large weight of the array and the precision of measurement required in the directions of the nulls, horizontal radiation patterns were not measured by rotating the array, but rather by fixing the array and making field strength measurements at points around it. A complete array was mounted at 50 feet above ground level and a theodolite was used to determine accurately the bearings on vhich the nulls should occur. Field strength measurements showed small errors in the positions of the nulls in the forward hemisphere; these errors were corrected by introducing slight phase shifts between different yagi aerials. The performance in the backward hemisphere is principally determined by the presence of the reflecting screen and was not affected by these small adjustments. The measurements of rejections finally achieved on each of the two complete arrays are shown in table 1.

The forward gain of the whole array was determined by a substitution measurement to be 9.ldb above that of a single constituent yagi. As the gain of a single yagi had previously been measured by radiation pattern integration as 11.3db over an isotropic radiator, it was inferred that the gain of the whole array was 20.4dbi. This represents an aperture efficiency of 55 per cent. The polarisation protection was measured as 33db.

All components of the arrays were carefully marked to ensure that their relative positions were maintained when they were erected on site at Alderney.

Commissioning After ereotion at Alderney a further set of field strength measurements was carried out to check the rejection of interfering signals. A site was chosen in each of the five most significant directions, and with a signal generator connected to the array the field strength at each site was measured. The measurements were less accurate than those made previously as the terrain was uneven, but served to check that no drastic change had taken place.

Conclusion Under normal propagation conditions interference on the picture received from Chillerton Down has been reduced to a level at which it is only just perceptible. Multipath propagation of the signal from Chillerton Down, which occurs under certain abnormal tropospheric conditions, now provides the most objectionable form of interference.

The project shows the order of performance which may be obtained by careful application of conventional methods.

Bearing (degrees from forward direction)	Field strength relative to forward field	
	Array A	Array B
45	38db	50db
73	37db	39db
108	34db	41db
165	63db	41db
180	45db	45db

Table 1

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References

(1) Elkins N.A. P.O. Elect. Engrs. J. 1968; 61; Pt. 1; P48.

(2) Moullin E.B. Radio Aerials. O.U.P., 1949.