$$S = \frac{1+|\rho|}{1-|\rho|} \qquad \{3.9\}$$

If the line has no attenuation, the standing wave ratio S is everywhere the same.

CHAPTER IV

DESINING AND CONSTRUCTION OF HIGH GAIN NARROW BEAMWIDTH ANTENNA ARRAY FOR RIOMETER

4.1 INTRODUCTION:

As we know the ionosphere extending from 60Km to about 1000 Km altitude plays a major role in aiding long distance HF (3-30MHz) communication and in deteriorating the performance of satellite radio system in the VHF (30-300 MHz) UHF (300-3000MHz) and even at higher frequency band. Therefore ionospheric study is very important and it can be studied by using several techniques. Ionospheric study, using riometer is new, particularly in India, and first time in Kolhapur.

Department of physics, Shivaji University, Kolhapur, in collaboration with IIG Mumbai has set up a riometer to study the cosmic radio noise at 30 MHz. The existing antenna is a half wave dipole with wide beam (width $\sim 60^0$) and low gain, and therefore, this antenna receives apart from cosmic radio noise, lot of interference (mainly anthropogenic) also. Therefore to minimize the reception of interference it is undertaken to design a high gain narrow beam antenna.

To get a narrow beam it is necessary to increase the capture area of the antenna array. In Shivaji University, Kolhapur, it has been designed and built, high directional antenna and it consists of 44 full wave dipoles connected in 4 columns of 11 full wave dipoles.

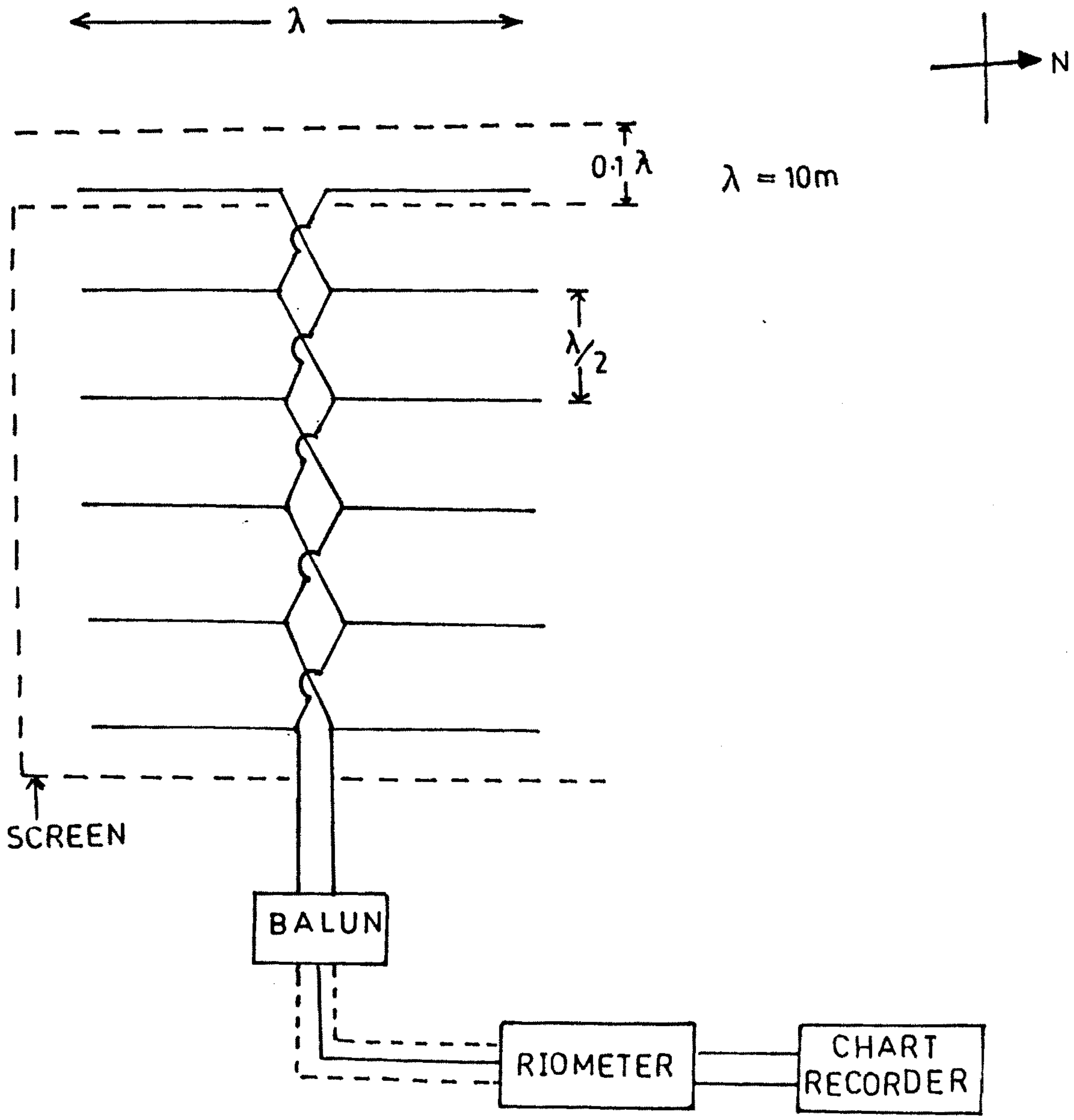
Before installing an antenna at a particular site it is essential to know the radio noise level of that place. The noise survey was conducted using 30 MHz radio receiver.

4.2 PILOT ANTENNA: Broad –Side Array

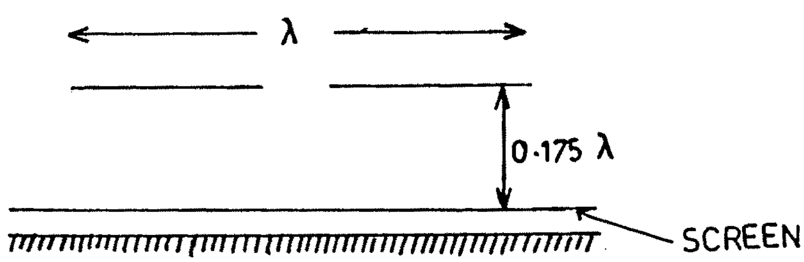
Before constructing a 2000 m^2 filled aperture antenna, it was necessary to make some measurements on a single full-wave dipole. For this purpose, a single full wave, was constructed using bamboos, and measurements for impedance were carried out. Copper wire of 2.03mm was used for making the full wave dipole. The full wave dipole was assumed to offer a resistive impedance of about 2000 ohms, taking into consideration l/d ratio of the antenna wire.

Where l- length of the wire and d- diameter of the wire.

It was decided to construct one array of 6 dipoles. This is shown in Fig {4.1}. This is a broadside array, it is backed by a parallel wire reflecting screen stretched along the ground at a distance of



(a)



(b)

FIG. 4.1 a) SHOWS TOP VIEW OF THE PILOT ANTENNA AND EQUIPMENTS.

b) SIDE VIEW OF THE PILOT ANTENNA.

0.175λ from the dipole elements. The distance between adjacent wires of the reflector is 0.1λ. The physical area occupied by reflector is 10% more than the physical area of the antenna array. This spacing of 0.1λ between adjacent reflector wires increases the gain of the antenna by a factor of about 2 and maintains constant reflectivity in different seasons. The polar diagram of pilot antenna is directed vertically upwards. For broadside array of this type a spacing of 0.5λ between adjacent antenna elements is particularly convenient, since the right phase relationship is easily obtained by transposing the feeder lines. The total impedance is easy to estimate, since all the elements effectively are connected in parallel. The beam width of an antenna array to half power points is approximately given by 57.3 λ/a in degrees, where 'a' is the length of the array in terms of wavelength. In this pilot antenna the length in E-W direction is 2.5λ and along N-S direction is 1λ. This means that the beamwidth of our pilot antenna to half power points is about 22.9° in E-W plane and 57.3° in N-S plane. The power gain of a pilot antenna is 18xn with respect to the gain of λ/2 dipole. If a conducting screen is placed below the array, the whole energy is concentrated in one direction and the gain is increased by a factor of 2 for a separation of 0.1λ between the wires of the reflecting screen. The absolute gain of the pilot antenna becomes 18x2xn is equal to the 13.3 db.

The design of the mechanical parts used in the final array of 2000 m^2 aperture were also finalized while constructing this pilot antenna.

4.3 ANTENNA MATERIAL FOR THE LARGE ARRAYS:

The top view for the broadside collinear array antenna for narrow beamwidth is shown in Fig {4.2}. Here, the actual materials used for the construction of the antenna are mentioned. To reduce the cost of the construction of the antenna, cheap and best materials were used.

The following table gives the type of the materials and quantity used in the construction.

TABLE 1.1

SL.NO.	NAME OF THE MATERIAL	QUANTITY
1.	Copper wire (2.03mm diameter)	30 Kg
2.	Galvanized iron wire (2.03mm diameter)	50 Kg
3.	Bamboos	99 Nos.
4.	Insulators (Bobbin type)	250 Nos.
5.	Coaxial cable	100 feet

The table (1.2) gives the specification of the coaxial cable

Cable type – RG6F

TABLE 1.2

SL. NO.	SPECIFICATION	MEASUREMENTS
1.	Maximum resistance (ohm/km) at 20^0 C	21
2.	Loop resistance (ohm/km) at 20^0 C	28.50
3.	Nom. Capacitance (PF/m)	53
4.	Nom. Impedance (ohm)	75
5.	Nom. Velocity ratio (%)	85
6.	Nom. attenuation at 25^0 C (dB/ 100m) i) at 5 MHz ii) at 55 MHz	 1.9 5.25

The table (1.3) gives the construction parameters of the co-axial cable.

Cable type – RG6F

TABLE 1.3

SL.NO	CONSTRUCTION PARAMETERS	TYPE
1.	Inner Conductor i) Nom.diameter (mm) dielectric ii) Nom. diameter (mm)	Solid bare copper 1.02 Foam PE – 4.57
2.	Outer Conductor First Second Nom. coverage (%)	 Bonded Al braid Al braid 60
3.	Jacket Nom diameter (mm)	PVC (Black) 7.20

The total cost incurred for the construction of the antenna, including labour charge is approximately Rs.14000/- excluding trivial materials costs.

As already mentioned, the antenna array consists of 4 columns, each column consisting of 11 full wave dipoles. So, 99 bamboos are required. To avoid eating of bamboos by white ants, bamboos were painted with black tar. Bamboos were cut to proper size and good quality of bamboos were used.

4.4 THE FINAL ANTENNA STRUCTURE:

Fig. {4.2} shows a schematic diagram of the top view of the directional antenna used in conjunction with a riometer for the cosmic radio noise observations on 30 MHz at Kolhapur. It is broadside collinear array consisting of 44 full wave dipoles spread in 11 rows and 4 columns. The antenna is backed by a parallel wire reflecting screen stretched along the ground at a distance of 0.175λ from the dipole elements. The distance between adjacent wires of the reflector should not be greater than 0.1λ. The physical area occupied by reflector is 10% more than the physical area of the antenna array. This spacing of 0.1λ between adjacent reflector wires increases the gain of antenna by a factor of 2 and maintains constant reflectivity in different seasons. The polar diagram of pilot antenna is directed vertically upwards. For broad side array of this type a spacing of 0.5λ between adjacent antenna elements is particularly convenient, since the

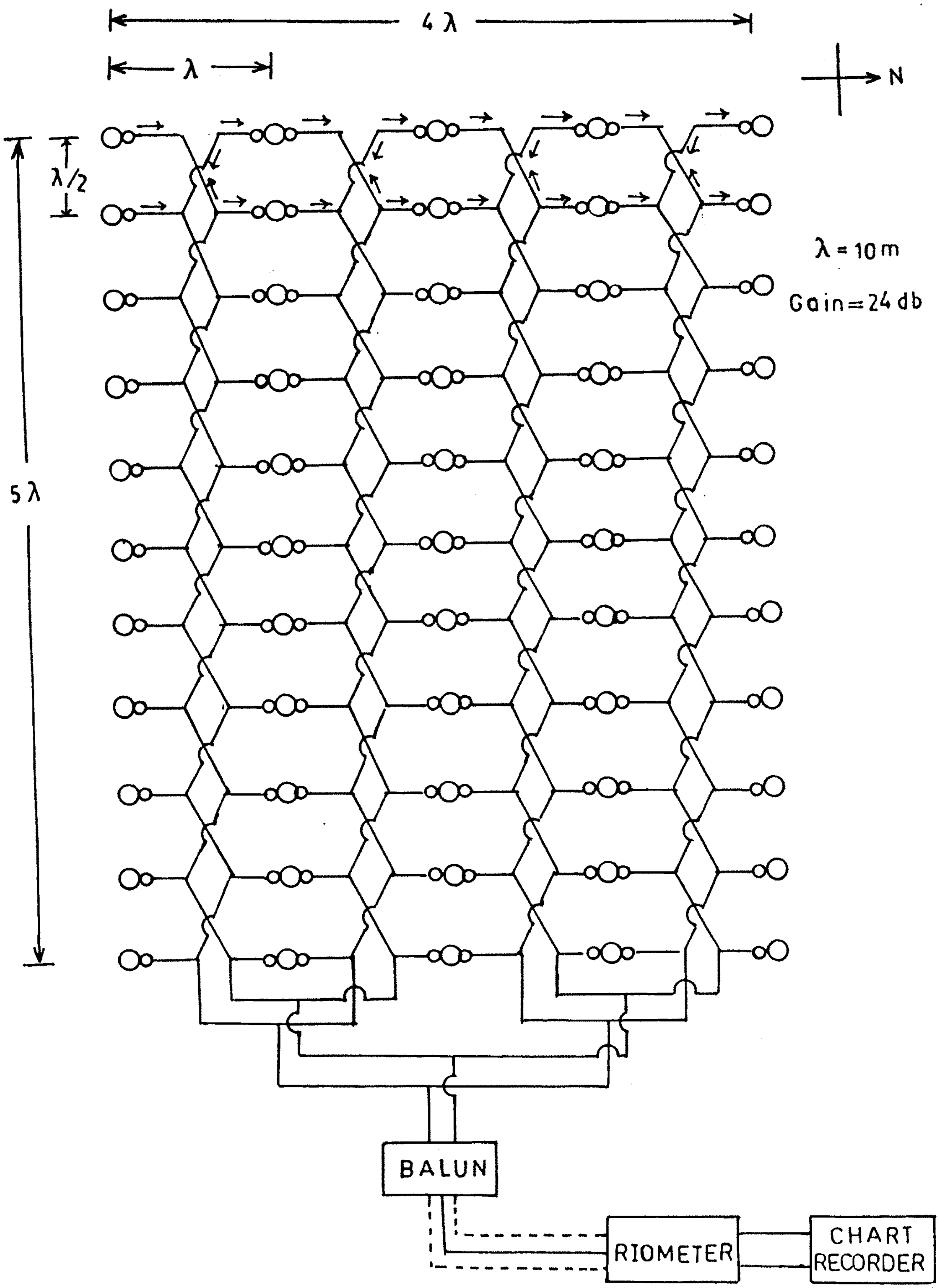


FIG. 4·2 - SHOWS TOP VIEW OF THE FINAL ANTENNA ARRAY WITH EQUIPMENTS.

right phase relationship is easily obtained by transposing the feeder lines. The total impedance is easy to estimate, since all the elements effectively are connected in parallel. The beam width of an antenna array to half power points is approximately given by 57.3λ/a in degrees, where 'a' is length of the array in terms of wavelength. In the case of final antenna, the length in E-W direction is 5λ and the width along N-S direction is 4λ. This means that the beam width of our antenna to half-power points is about 11.46 degree in E-W and 14.32 degree in N-S planes. The power gain of an array over a single dipole is equal to the number n ' of full wave antennas and the absolute gain is equal to 18xn, with respect to the gain of λ/2 dipole. If a conducting screen is placed below the array, the hole energy is concentrated in one direction and the gain is increased by a factor of 2 for a separation of 0.1λ between the wires of the reflecting screen. The absolute gain of the array then becomes 1.8x2xn is equal to 1.8x2x44is equal to approximately 22db.

In this antenna four transmission lines and their dipoles were supported by 2″diameter bamboos. The lengths of each poles were 7-5 ft, out of which 1.5 ft were put inside the earth and fitted with the small stones and soil. The transmission lines are stretched and tension on each line is adjusted in such a way that there is little sag on the transmission lines. Transmission lines are transposed between each adjacent pair of dipoles. The current directions on the antenna wires and the transmission lines are shown in fig (4.2). Galvanized iron wire was stretched parallel to the antenna wire at distance of 0.175 λ from the plane of the antenna as a reflector.

The separation between the wires of the transmission lines is 1.5cm. and is maintained by inserting two insulators between wires and binded with insulating material. This spacing of 1.5 cm; corresponding to characteristic impedance of 300 ohms is maintained constant along the transmission lines. The length of each full wave dipole is 10 m (i.e.1λ). this actual length of each dipole determined experimentally so that it presents a purely resistive impedance to the transmission lines at 30 MHz. The alternative dipoles are transposed to give proper phasing and an insulating material is inserted so that the transmission line wires do not contact each other.

The full wave dipoles are made from 2.03mm diameter copper wire, which were originally in the form of round bundles; so each dipole remains slightly curved even after making every effort to straighten it.

4.5 SPECIFICATIONS OF THE ANTENNA:

Type	:	Filled aperture full wave dipole array.
Frequency	:	30 MHz
Polarization	:	Linear in N-S plane
Configuration	:	Broadside collinear array
Reflector screen	:	A plane reflector screen installed About a 0.175λ below the dipoles, consists of galvanized iron wires,spaced 0.1λ apart
Physical area of the antenna array	:	2000 m^2
Effective area of the antenna array	:	1800 m^2
Gain	:	24 db
Beam width (at half power)	:	11.46° E-W 14.32° N-S
Impedance at each antenna array	:	45-50 ohms ± 3pF average.