Gauribidanur Radio Heliograph

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The Gauribidanur Radio Heliograph will produce images of the solar corona at several frequencies in the range of 40 to 150 MHz. These will be used in conjunction with the data obtained from satellites like SOHO,CORONAS,YOHKHE,ULYSESS etc for coronal studies . These images will also form a basis for further high resolution and fine structure studies with the Giant Metrewave Radio telescope being built by TIFR.

At present the Gauribidanur radio Heliograph is the only instrument in the world which would be capable of making pictures of the solar corona at meter decameter wavelengths.

These data in conjunction with optical and satellite data will be used to study the density, temperature and magnetic field structure of the solar corona and interplanetary disturbances.

Technical details

Introduction

A Log periodic dipole array operating in the frequency range of 40 to 150 MHz is built at the Gauribidanur radio observatory of Indian Institute of Astrophysics and Raman Research Institute.

Antenna system

This telescope is in the form of letter T with the long arm along the East West direction and short arm along the South direction. The dimensions are 1.2 KM along the East West direction and 450 Metres along the south direction as shown in Fig. 1. This telecope consists of 192 antenna elements 128, in the East West arm and 64 in the South arm.

Basic element

The basic element used in this array is a Log periodic dipole designed to operate in the frequency range of 30 to 150 MHz with a VSWR < 2. This dipole is made up of aluminium tubes and are mounted on wooden poles.Its impedance is 50 Ohms and has a gain of 8 dB. The beamwidth is 60 degrees in the E plane and 100 degrees in the H plane.These elements accept linear polarization. Technical details of the Log periodic dipole element are given in Appendix I.

Array Configuration

In the East west arm 128 elements are arranged with an interelement spacing of 10 metres. The East West arm is divided into 32 groups of 4 elements each. The signal from each element is passed through a high pass filter and a broadband amplifier. The filter has a low frequency cut off around 40 MHz. The amplifier has a gain of 30 dB and a noise figure of 2.8 dB. The

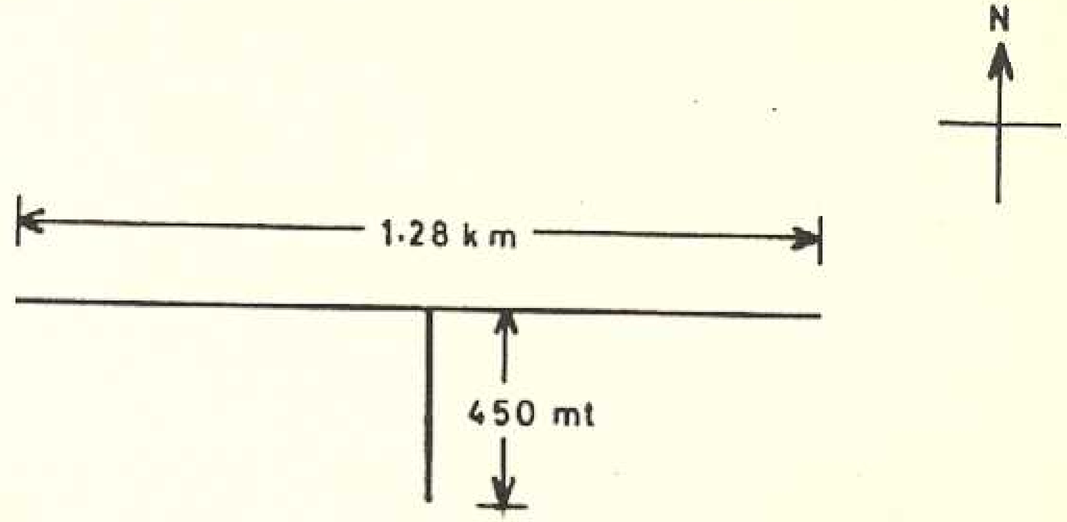

Fig. 1. Layout and dimensions of the Log periodic dipole array at Gauribidanur.

signals from the 4 elements are combined in a branched feeder system using power combiners and RG8U cable as shown in Fig.2.

In the south arm 64 elements are arranged with an interelement spacing of 7 metres. The filtered and amplified outputs from the 4 elements are combined using delay shifters, power combiners and cables as shown in Fig.3. The completed East West and South arm are shown in Fig.4.

Receiver system

The signal from each group of East, West and South will be brought to the receiver building by optic fibres.The RF signals from each group are converted into an IF after double mixing as shown in Fig.5. The 32 outputs from the EW arm and 16 outputs from the South arm will be correlated in a 1024 channel digital correlator.The multifrequency operation is achieved by time sharing with each frequency being sequentially observed for about 100 milliseconds.This is achieved by multiplexing the first local oscillator in the receiver system.

Tracking in the East West arm

Since the interelement spacing is 10 metres in the East West arm grating lobes occur in the East West direction. At 150 MHz the first grating lobe occurs at 12 degrees away from the mainlobe.At 50 MHz the first grating lobe occurs at 35 degrees away from the mainlobe. Because the Sun is the strongest source at these wavelengths, contribution by other sources present in the grating lobes is very small compared to that of sun in the mainlobe. Except for two months when CAS A and Cyg A are present in the grating lobe, we can track the Sun for $\pm$ 2 hours.Very high resolution maps of the sun obtained by GMRT will be referred to for fine details of the structures observed with Gauribidanur

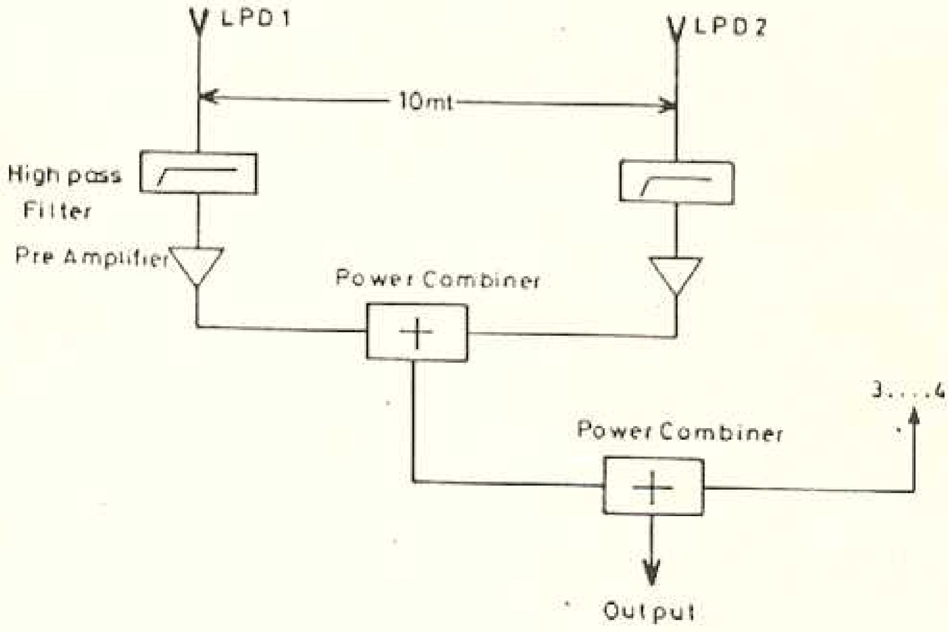

Fig. 2. Combination of four Log periodic dipole Elements in the East west arm.

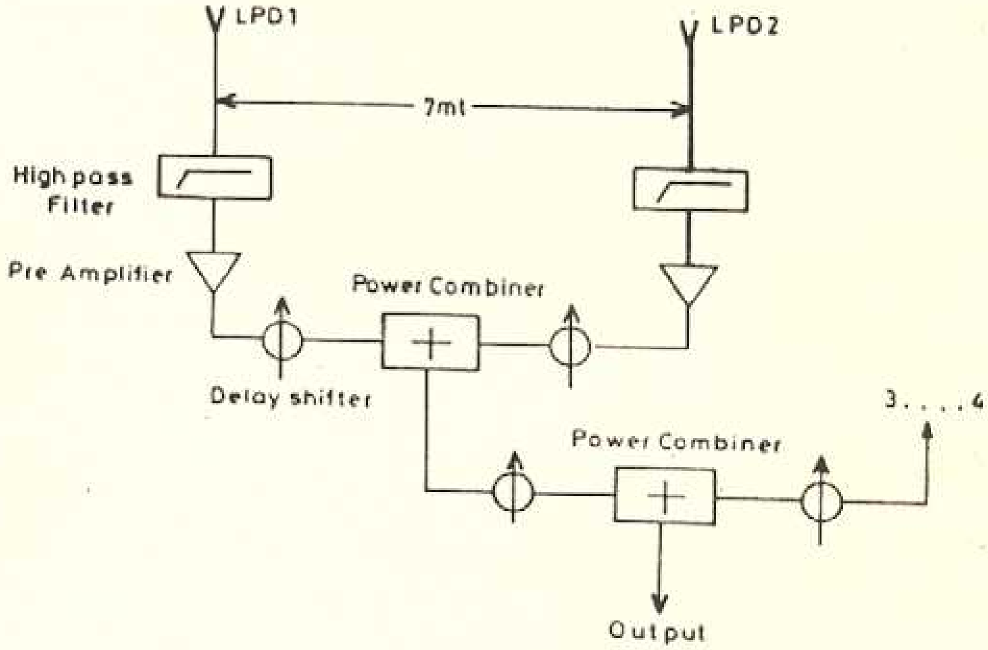

Fig. 3. Combination of four Log periodic dipole
Elements in the South arm.

Fig. 4. Completed East West arm and South arm

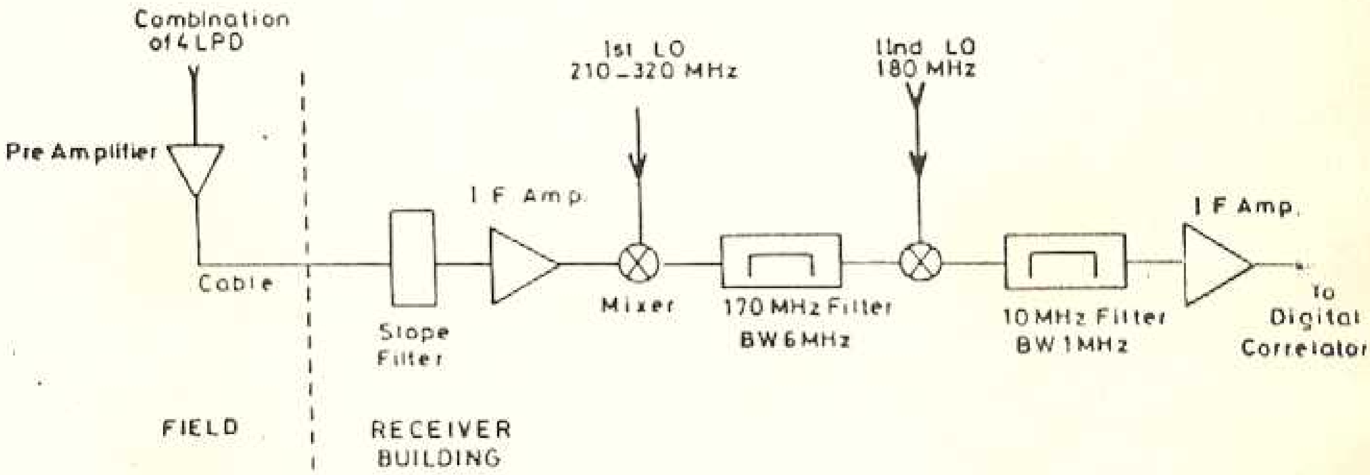

Fig. 5. Front end receiver system.

Radio Heliograph.

<u>Parameters of the Gauribidanur Radio Heliograph</u>

Frequency of operation	40 - 150 MHz.
Instantaneous bandwidth	1 MHz.
Total collecting area	$96\lambda^2$.
Resolution 150 MHz	5'x 8' (RAxDEC)
Sky coverage	± 45 Degrees
Sensitivity (τ=10s,BW=1 MHz)	5 Jy (1σ) at 150 MHz.

The radio heliograph will produce 10x8 pixel images of the sun at 150 MHz.The field of view and the angular resolution of the heliograph are frequency dependent.The field of view is approximatley $3^\circ \times 4^\circ$ at 150 MHz scaling inversely with frequency. A 1024 channel digital correlator is being built,which has the advantage of finer sampling of the radio brightness of the source,compensation of delays and phase,removal of terrestrial interference and ionospheric effects which are very important at low frequencies. A technical description of the digital correlator system is given in Appendix II.

The signals from each one of the 32 groups in the East West arm and the 16 groups in the South arm have to be brought to the receiver building for digital correlation. The signal from each group would have a loss of 120 dB at 150 MHz if RG8U cables are used to bring the group outputs to the receiver building. This requires the use of too many line amplifiers. It is also required to keep the phase and gain of these amplifiers constant for proper operation of the radio heliograph. These cables require regular maintenance and are sensitive to lightning etc. Optic fibres which has a low loss of 5dB/KM and immune to noise are to be used for bringing the group outputs to the receiver building.

PRESENT STATUS

At present, the signals from the group outputs from the East and West arm are combined in the field using RG8U cables and power combiners and brought to the receiver building. The East and West arm outputs are correlated in analog receivers. Fig.6. shows drift scan on the sun and record of CAS A at different frequencies.

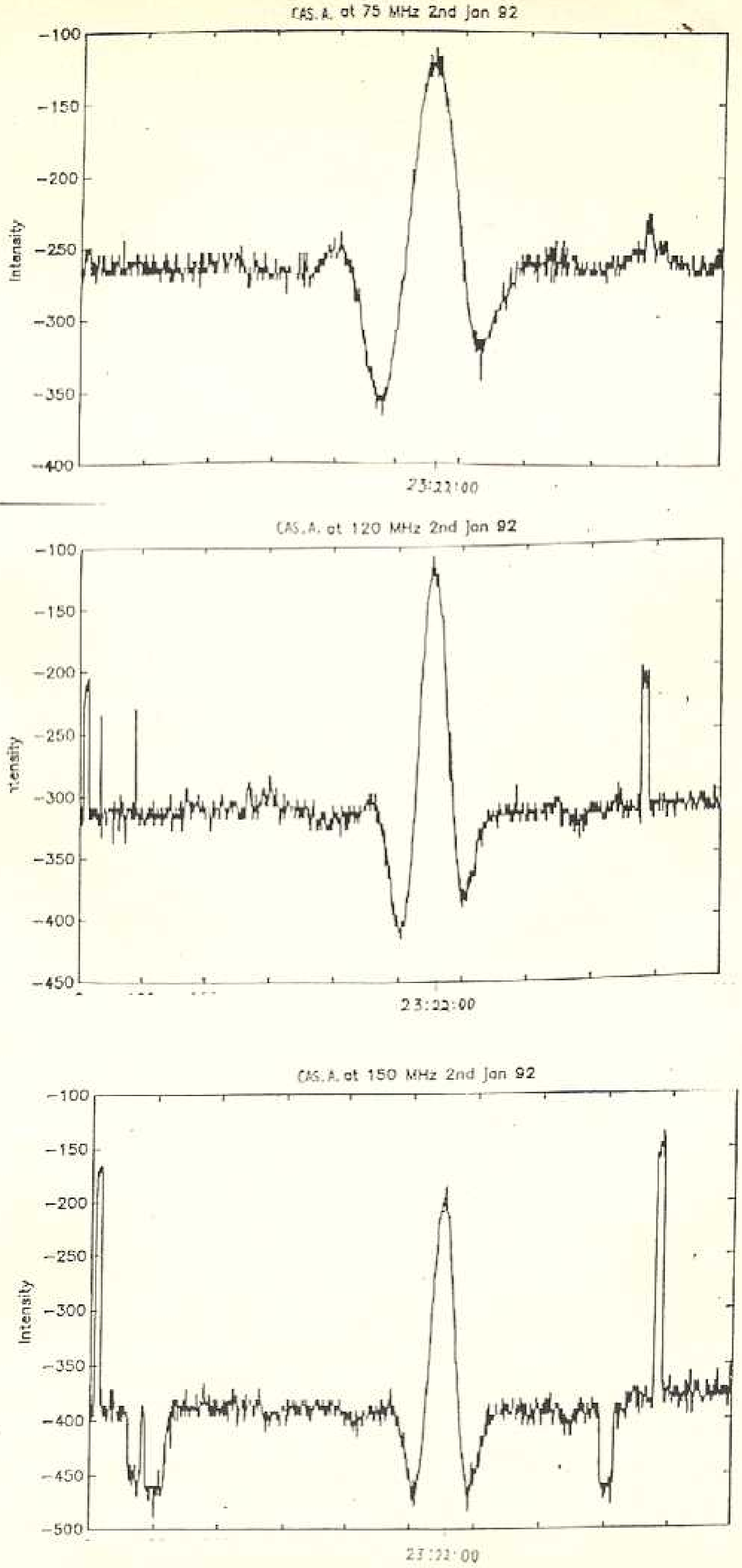
CAS. A. at 75 MHz 2nd Jan 92
Intensity
-100
-150
-200
-250
-300
-350
-400
23:22:00
CAS. A. at 120 MHz 2nd Jan 92
Intensity
-100
-150
-200
-250
-300
-350
-400
-450
23:22:00
CAS. A. at 150 MHz 2nd Jan 92
Intensity
-100
-150
-200
-250
-300
-350
-400
-450
-500
23:22:00

Fig. 6.

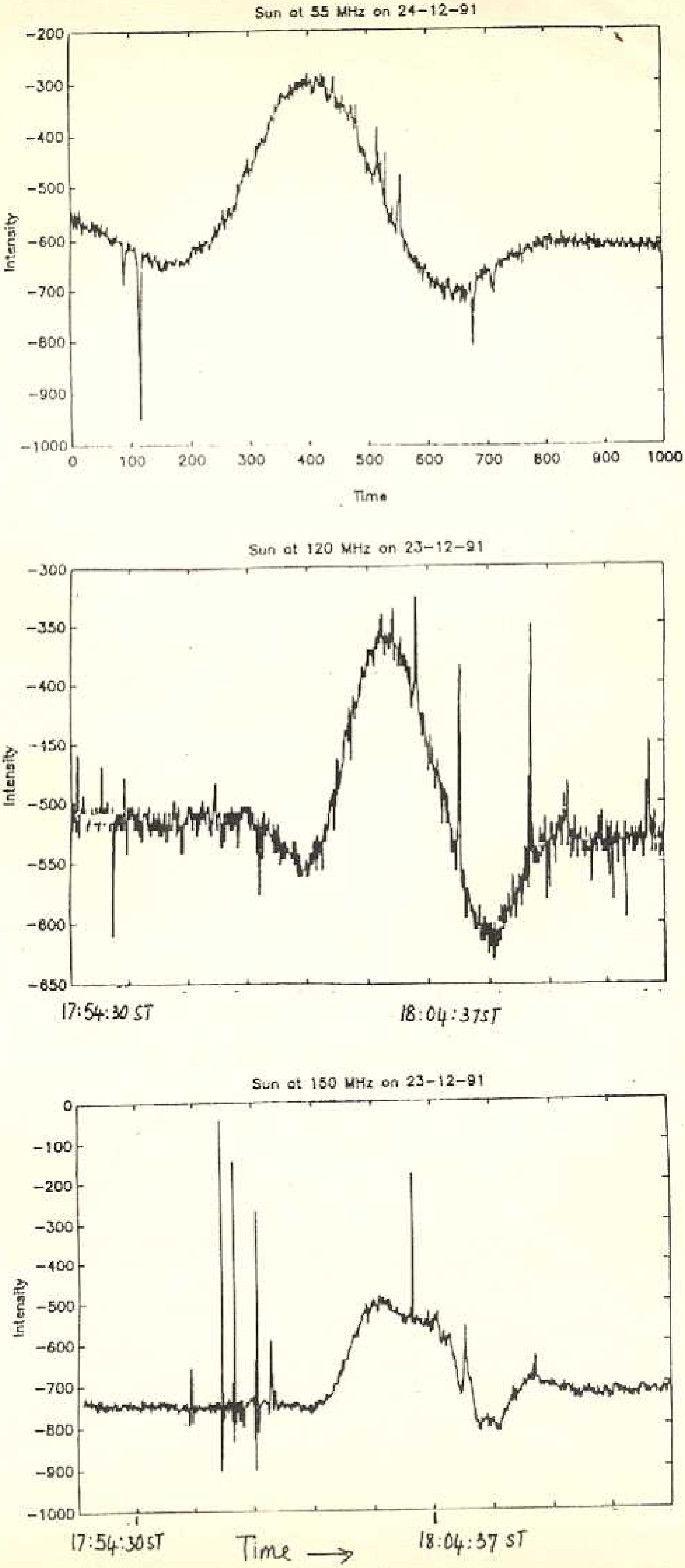
Sun at 55 MHz on 24-12-91
Intensity
Time
Sun at 120 MHz on 23-12-91
Intensity
17:54:30 ST
18:04:37 ST
Sun at 150 MHz on 23-12-91
Intensity
17:54:30 ST
Time →
18:04:37 ST

Fig. 6.

Appendix I

LOG PERIODIC DIPOLE

General description:-

A log periodic dipole is used as the basic element of a broadband array for solar observations. This dipole is designed to operate in the frequency range of 30 to 150 MHz. Fig.1. shows the Log periodic dipole. Fig.2. shows a photograph of the same.

Mechanical specifications:-

Boom	25 mm square tube
Boom length	550.5 cms
Material (Boom & Elements)	Aluminium
Elements	12.5 mm dia tube
No of elements	19

Dimensions of elements 1 to 19 fixed on boom 1 are given below:

1	275.5 cms
2	245 cms
3	218.5 cms
4	194.5 cms
5	173.0 cms
6	154.5 cms
7	137.5 cms
8	122.5 cms
9	109.0 cms
10	97 cms

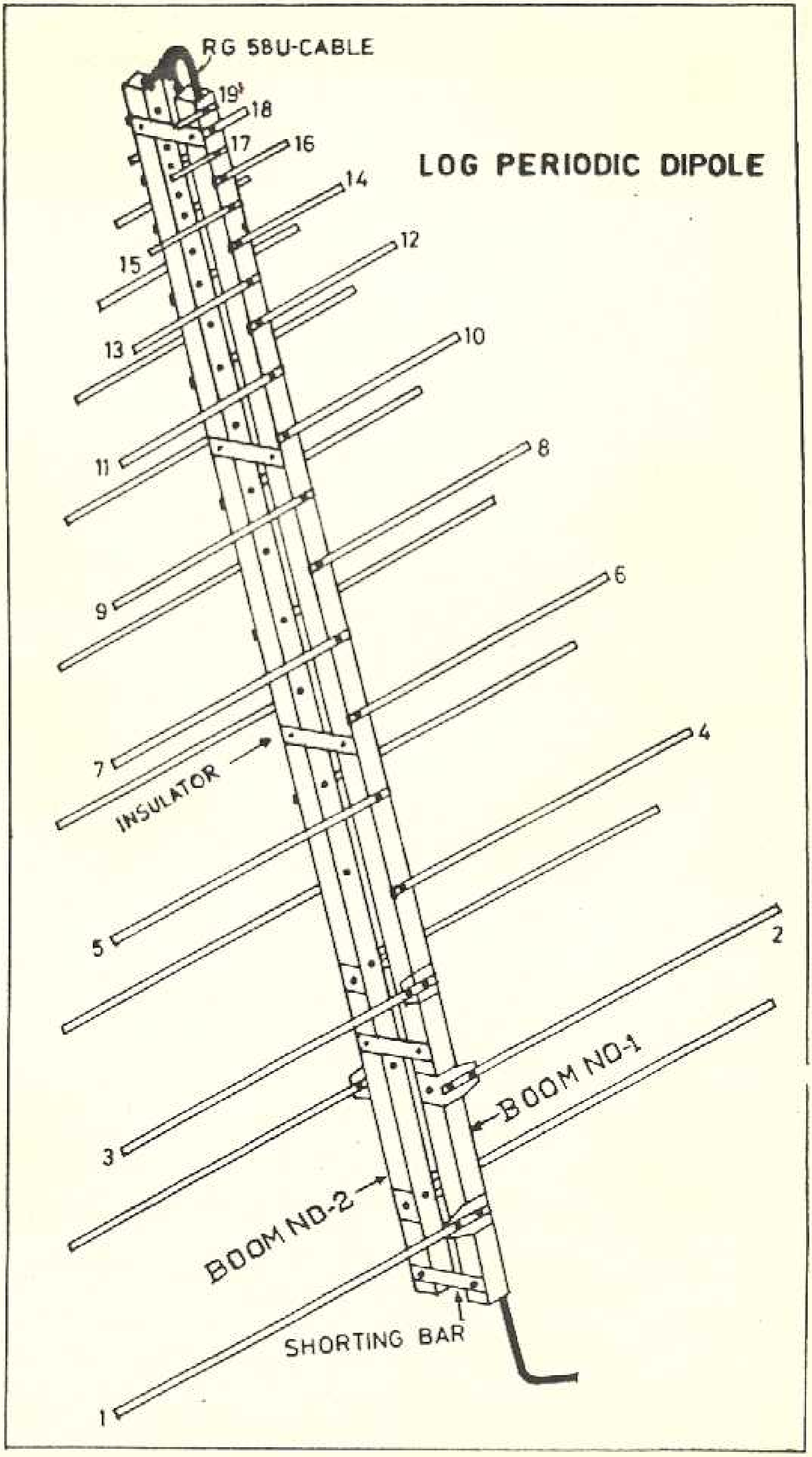

Fig.1. Structure of Log periodic dipole.

Fig.2. Log periodic dipole used in Gauribidanur Radio Heliograph.

11	87 cms
12	77 cms
13	68.5 cms
14	62 cms
15	55 cms
16	49 cms
17	44 cms
18	39 cms
19	35 cms

The dimension of the corresponding elements fixed on boom 2 are the same as above.

Spacing between the elements are given below:

Bottom of the boom to the 1st element	107 cms
1st to 2nd element	54.8 cms
2nd to 3rd element	48.7 cms
3rd to 4th element	43.4 cms
4th to 5th element	38.6 cms
5th to 6ht element	34.4 cms
6th to 7th element	30.6 cms
7th to 8th element	27.2 cms
8th to 9th element	24.2 cms
9th to 10th element	21.6 cms
10th to 11th element	19.2 cms
11th to 12th element	17.1 cms
12th to 13th element	15.2 cms
13th to 14th elememt	13.8 cms
14th to 15th element	12.0 cms

15th to 16th element	10.7 cms
16th to 17th element	9.5 cms
17th to 18th element	8.5 cms
18th to 19th eleemnt	7.6 cms
19th to top of the boom	6.7 cms

Boom to boom spacing at the bottom is 2 cms and at the top is 1.5 cms. To maintain the taper spacing between the boom, four insulators made of perpex are used at the appropriate places. The booms are shorted with a aluminium strip of length 7 cms at the bottom as shown in the Fig.1. All elements are fixed to the boom using 2 inch long 2BA brass screws. Instead of directly fixing the elements to the boom , L shaped clamps are used between the boom and the elements to give more support to the elements. Also to give extra stength and to avoid corrosion and loose joints the elements are brazed to the boom. Special wooden clamps and iron brackets are used to mount the Log periodic dipoles on wooden poles.

<u>Electrical characteristics</u>:-

Frequency	30 to 150 MHz
Gain	8 dB
Impedance	50 ohms
VSWR	< 2 (shown in Fig.3.)
Polarization	Horizontal or vertical as mounted
Radiation pattern	60 Degrees HPBW (E Plane) (shown in Fig.4.)

VSWR OF LOG PERIODIC DIPOLE

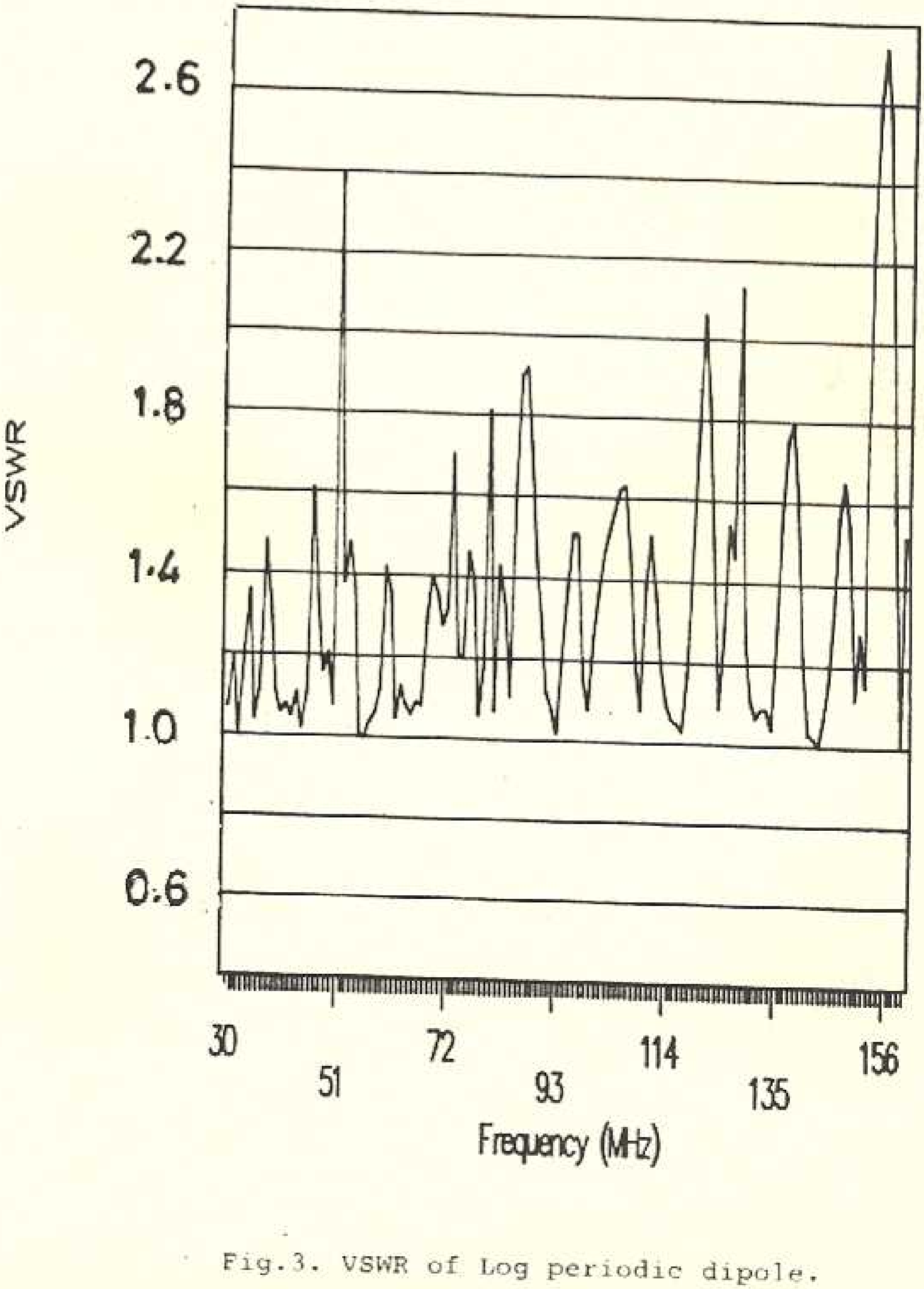

Fig.3. VSWR of Log periodic dipole.

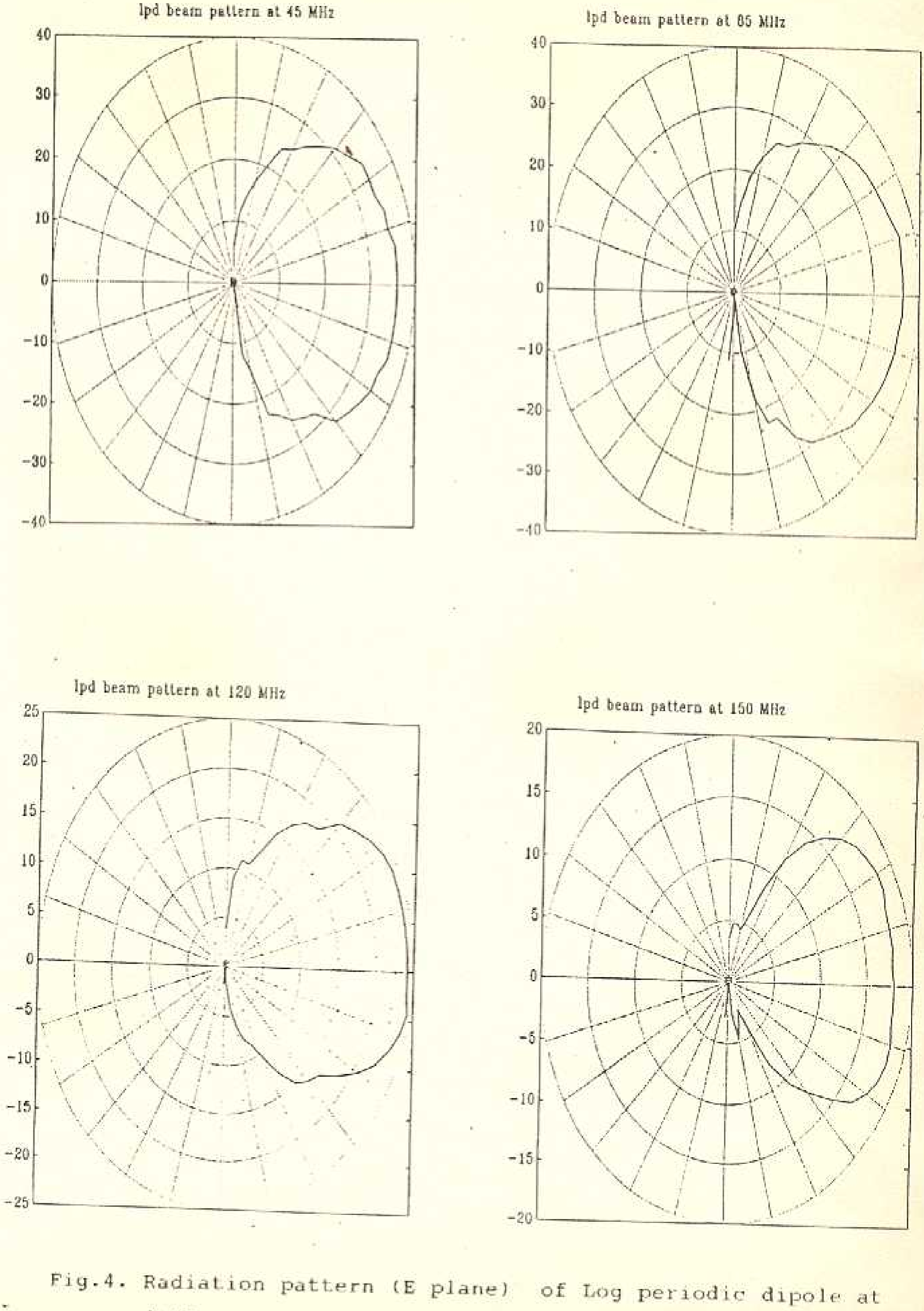

Fig.4. Radiation pattern (E plane) of Log periodic dipole at different frequencies.

Log periodic dipole is a balanced device. This has to be fed by a cable (unbalanced device). This is done by connecting center core of the cable to one boom at the top and shield to the other and taking the cable through the boom which is grounded. Six metre length of RG58U cable is used for this purpose.

Appendix II

DIGITAL CORRELATOR SYSTEM

The various subsystem of the 1024 channel digital correlator are described below.

Samplers

These are constructed using comparator chips, window comparators for getting the magnitude information and zero cross detectors for extracting the sign information.

Correlators

Correlators will be constructed using 74F/74AT/74ACT series IC's,which consists of combination logic,counters and latches.

Recirculating memory

These correlator IC's have operating speeds in excess of 40 MHz. Instead of constructing 1024 correlators operating at 2 MHz, there will be only 64 correlators operating at 32 MHz. Each correlator will process data for 16 channels. This data will be stored in a memory bank. Each memory bank has two memories,one to store the sampled data and the other to recirculate the data. Memory which stores sampled data is called active memory and memory which is used to recirculate the data is called passive memory. When sampled data is getting stored in an active memory for one integration time, data which was stored for an earlier integration will be read from each passive memory 16 times at 32 MHz rate. The role of active and passive memory will be reversed for every integration time.

Correlated data will be read and stored in a PC and then transfered to an Exabyte recorder.

PRESENT STATUS

The design of the 1024 channel digital correlator system is completed and is expected to become operational by the end of 1993. A system to correlate 8 EW signals and 8 South signals is being constructed and is expected to become operational shortly.

BUDGET ESTIMATE

	Cost	
	Rs	Foreign Exchange
1. Optical fibre system	40,00,000	(Negotiation with ECIL and other companies are being carried out)
2. Digital Correlator system		
(i) Samplers	60,000	800 U$
(ii) Recirculators	2,00,000	8000 U$
(iii) Multipliers	1,25,000	600 U$
(iv) PC interface	50,000	
(v) Clock circuit + distribution + control	50,000	
(vi) Power supply units	50,000	
(vii) Racks,Chasis etc	30,000	
3. Data Acquistion system	2,00,000	
XY plotter		4000 US
Printer for PC	50,000	
4. Test Instruments		
(i) 400 MHz Oscilloscope	2,75,000	
(ii) Vector Voltmeter		10,000 U$
(iii) Spectrum Analyser		15,000 U$
(iv) Frequency synthesiser		5000 US
(v) Frquency Counter	30,000	
Total	51,20,000	43,400 U$

Collaborators & addresses

1. Dr.G.Thejjapa (On leave from IIA)
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The Gauribidanur Acousto Optic Spectrometer

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Abstract

An Acousto - Optic spectrometer with 30 MHz bandwidth and 1760 channels used for solar burst observations at Gauribidanur is described.

Introduction

The dynamic spectra of solar radio bursts have been used to obtain the characteristics such as drift rate,bandwidth harmonic structure etc which are related to the physical characteristics of the source. Dynamic spectra of solar bursts have been obtained by using swept frequency spectrograph,Multichannel spectrograph and Auto correlation spectrometer in the last decade. In recent years Acousto optic spectrometer (AOS) have established themselves as a reliable and versatile tool for the study of radio bursts from the Sun and Jupiter. Here we describe the AOS system used for solar bursts observations at Gauribidanur.

Principle of AOS

AOS makes use of the diffraction of light by ultrasonic waves, an effect predicted by Brillouin in 1921 and Raman & Nath in 1935.

The acoustic wave is generated from an electrical signal by a pizeoelectric transducer. This transducer is attached to one end of a medium with, an absorber at the other end to suppress the reflected wave. As a result of the acouto optical interaction the diffracted light entering the medium is modulated by the information contained in the original electrical signal. Since the modulated light has a spatial variation equivalent to the time variation of the signal parallel processing of the information is possible. The result of the acousto optical interaction is the production of two significant beam outside the Bragg cell, the undiffracted main beam and the diffracted beam. The diffraction angle is $\propto$ to the sound frequency and hence the radio frequency. When a range of radio frequencies are present each radio frequency deflects the light at its characteristic angle producing a band of light in the output plane. Light intensity in the bands indicate the distribution of energy across the radio spectrum of the incoming signal.

The Gauribidanur Acousto-optic spectrometer

The Gauribidanur AOS system is shown in Fig 1. The laser source is a Helium Neon laser operating at 633 nm with an output power of 2mw. To illuminate the whole width of the acousto-optic deflector the beam of the laser is expanded in one dimension using prisms. The Bragg cell is made of TeO_2 material. Its center frequency is 45 MHz and bandwidth is 30 MHz. The acoustic velocity in this Bragg cell is 621.7 m/sec. The time bandwidth product is 1760 . Table 1. shows the characteristics of the Bragg cell used in our system . The diffracted beam of light is passed through a fourier transform lens and recorded on a CCD placed at one focal length away from the lens. The CCD consists of 1760 pixels. The analog output signal from the CCD is digitised using a 12 bit A/D converter operating at a conversion speed of 25 micro seconds . The output of A/D is read by DR11C of VAX comptuer and the data is stored in digital format. The control and timing unit derives all the necessary timing and control signals from the computer clock. The minimum sampling rate is 64 msec. Table 2. shows the characteristics of the Gauribidanur AOS system.

The AOS system is used along with a Broadband array for the study of fine structures in the radio emission of the sun. Fig 2a. shows typical example of narrow band short duration bursts. One can see bursts with positive and negative drifts. Fig 2b. shows a typical example of type III radio bursts.

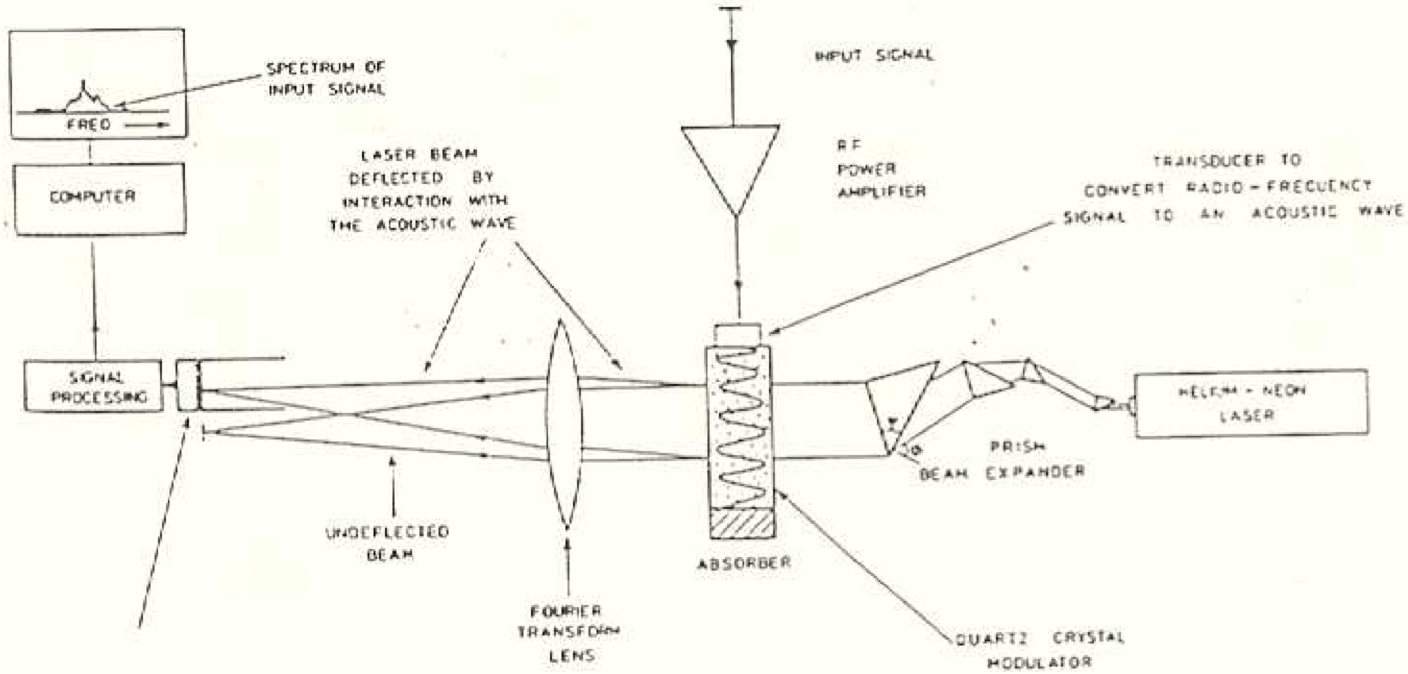


Figure 1: Schematic diagram of the acousto-optical spectrograph.

Fig 1.

AOS BRAGG CELL

OPERATING PARAMETERS:

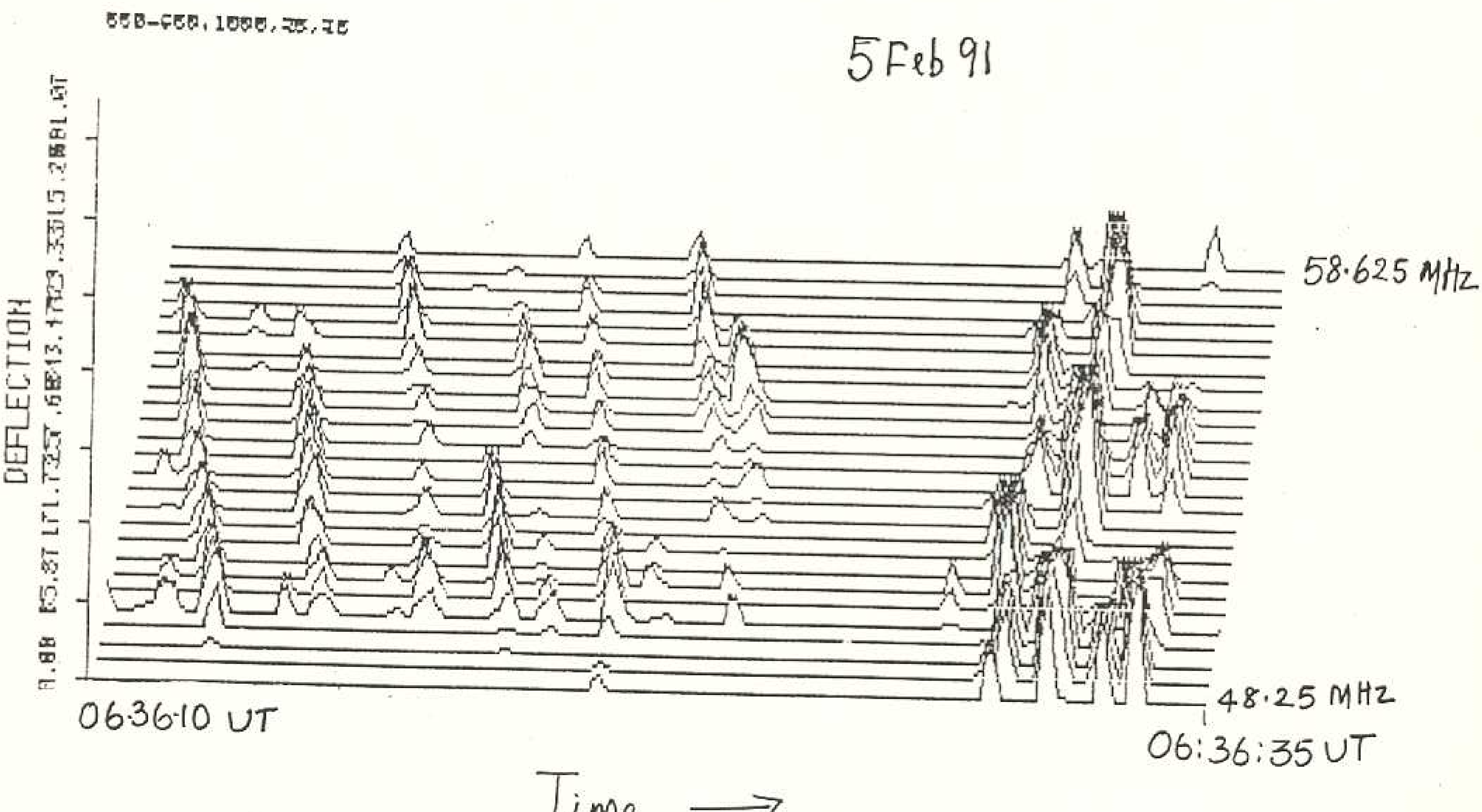
OPERATING WAVELENGTH	: 633nm.
CENTRE FREQUENCY	; 45 Mhz.
3 DB BANDWIDTH	: 30 Mhz.
ACTIVE APERTURE	: 4mm *31mm.
INTERACTION MEDIUM	: TeO_2 .
PHASE	:single . xstal(110).
ACOUSTIC VELOCITY	: .617mm/µSEC.
INPUT IMPEDENCE	: 50 ohm.
OPTICAL REFLECTIVITY	: < .5%/surface.
OPTICAL SURFACE FLATNESS	: $\lambda/10$ better
RF POWER (MAXIMUM)	: 1.2 watts.

Taba 1.

AOS CHARACTERISTICS

▪ Total Bandwidth	: 30 MHz
▪ Number of Channels	: 1760.
▪ Centre Frequency	: 45 MHz
▪ Channel Spacing	: 17 KHz
▪ Stabilization Time after turn on	: 6 Hrs.
▪ Temp. Stabilization	: + 1 deg.
▪ Dynamic Range	: > 30 dB.

Table 2.


5 Feb 91
DEFLECTION
58.625 MHz
48.25 MHz
06:36:10 UT
06:36:35 UT
Time →
Fig 2a.

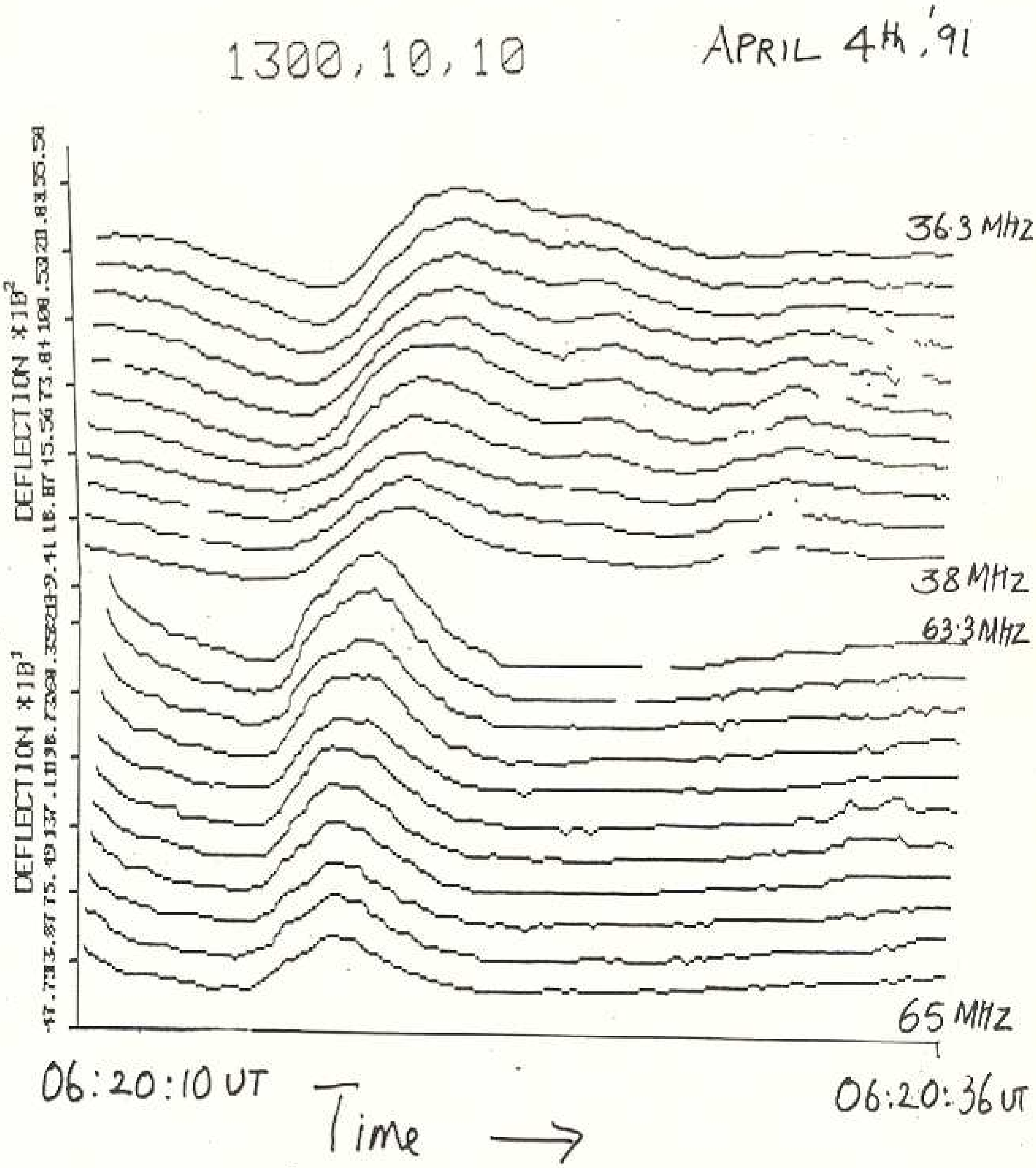
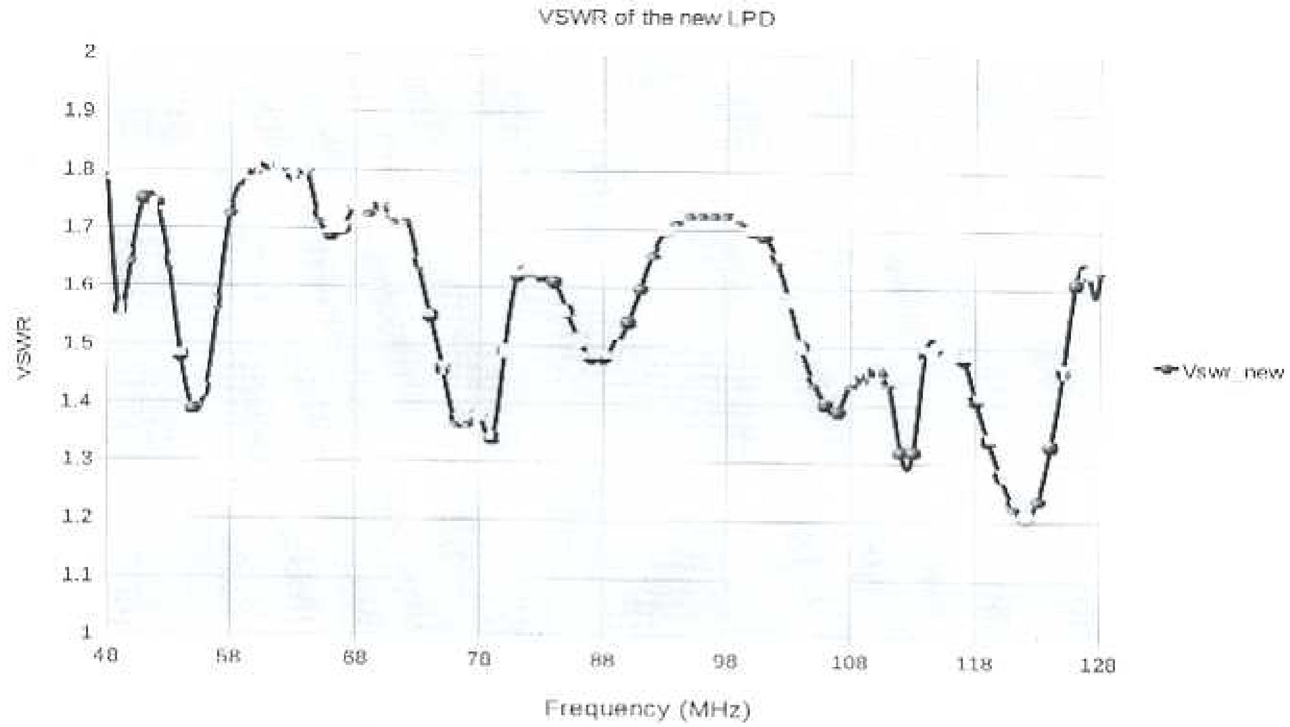

1300,10,10
APRIL 4th,'91
DEFLECTION *10^2
DEFLECTION *10^3
36.3 MHz
38 MHz
63.3 MHz
65 MHz
06:20:10 UT
06:20:36 UT
Time →

Fig 2b.

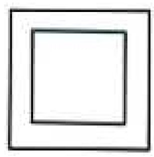
From Kathiravan, GBD



Dimension specification (approx.)

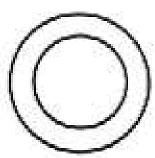
Arm	Length (mm)	spacing (mm)
Top edge (close to feed point)		
		90
1	509	
		150
2	582	
		210
3	678	
		280
4	793	
		290
5	914	
		340
6	1061	
		390
7	1231	
		490
8	1437	
		530
9	1667	
		270
bottom edge (close to shorting point)		

Total boom length = 3000 mm (approx.)



Boom cross-section

outer boundary = 25.3 mm
Thickness = 3.12 mm



Tube cross-section

diameter (outer) = 12.7 mm
Thickness = 2.7 mm