CHAPTER IV

EXPERIMENT SET UP AND MEASUREMENTS

A. IMPEDANCE MEASUREMENT: The measurements of the cylindrical stub antenna consist of two parts:

1. Measurement of the impedance of the cylindrical stub antenna over a circular ground plane as shown in Fig. 4.1(a) (Ø 3 × stub length)
2. Measurement of the impedance of the cylindrical stub antenna over a circular ground plane with a concentric hole to reduce fringing capacitance and cap capacitance as shown in Fig. 4.1 (b) and Fig. 4.2 (a). In this experiment, the diameter of the concentric hole is two and a half times larger than the diameter of the cylinder.

The instruments,used in this experment, are as follow:

1. A hollow cylindrical antenna made of aluminium,50 cm long and 3" in diameter. It is tightened by a wooden stick to hold vertically above the circular ground plane as shown in Fig. 4.2(a)
2. The antenna, which was described in 1 is installed on the desk 2.5 m high as shown in Fig. 4.2(a)
3. A unit voltmeter, Philips type PM 2440 (see Fig. 4.2 (b)

4. A unit oscillator, General Radio Co. type 1208-B (see Fig. 4.2(c))

5. A unit power supply, General Radio Co., type 1269-A (see Fig. 4.2(c))

6. A unit slotted line, General Radio Co., type 847 (see Fig. 4.2(c))

7. Variable voltage tranformer, Tokoyama Electric Work, type B15 (see Fig. 4.2(c))

8. Co-axial line RG-8/U, 4.00 metre long , as a feeder.

The measurement is done by keeping the physical length constant and the frequency is changed (between 150-480 MHz) to attain the required antenna length. The whole measurement is made at the top floor of the five story building at the Department of Electrical engineering, Chulalongkorn University. The datas, obtained from the measurement , are recorded in the table 4.1 and 4.2, that follows

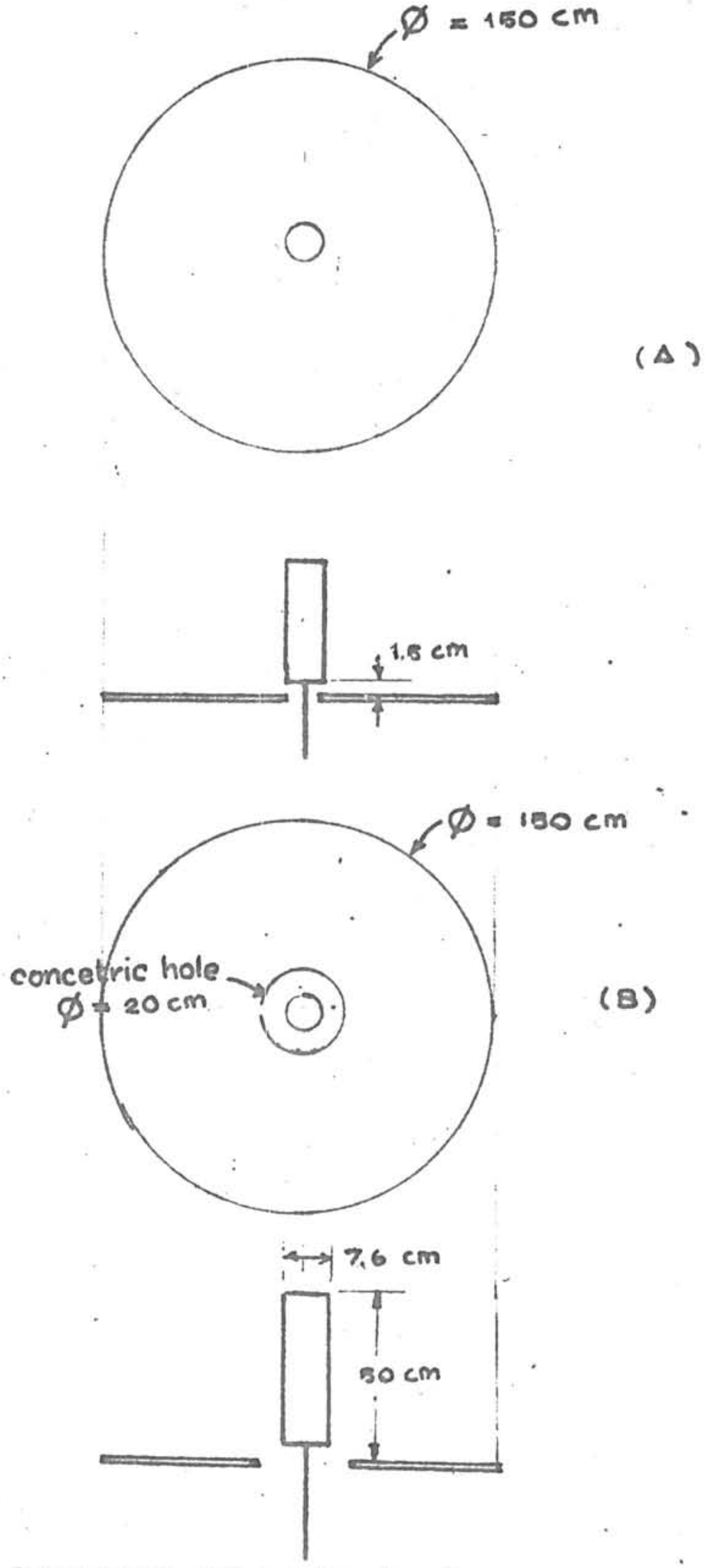

Fig.4.1 Experiment set up for impedance measurement
(A) without concentric hole on ground plane and
(B) with concentric hole on ground plane.

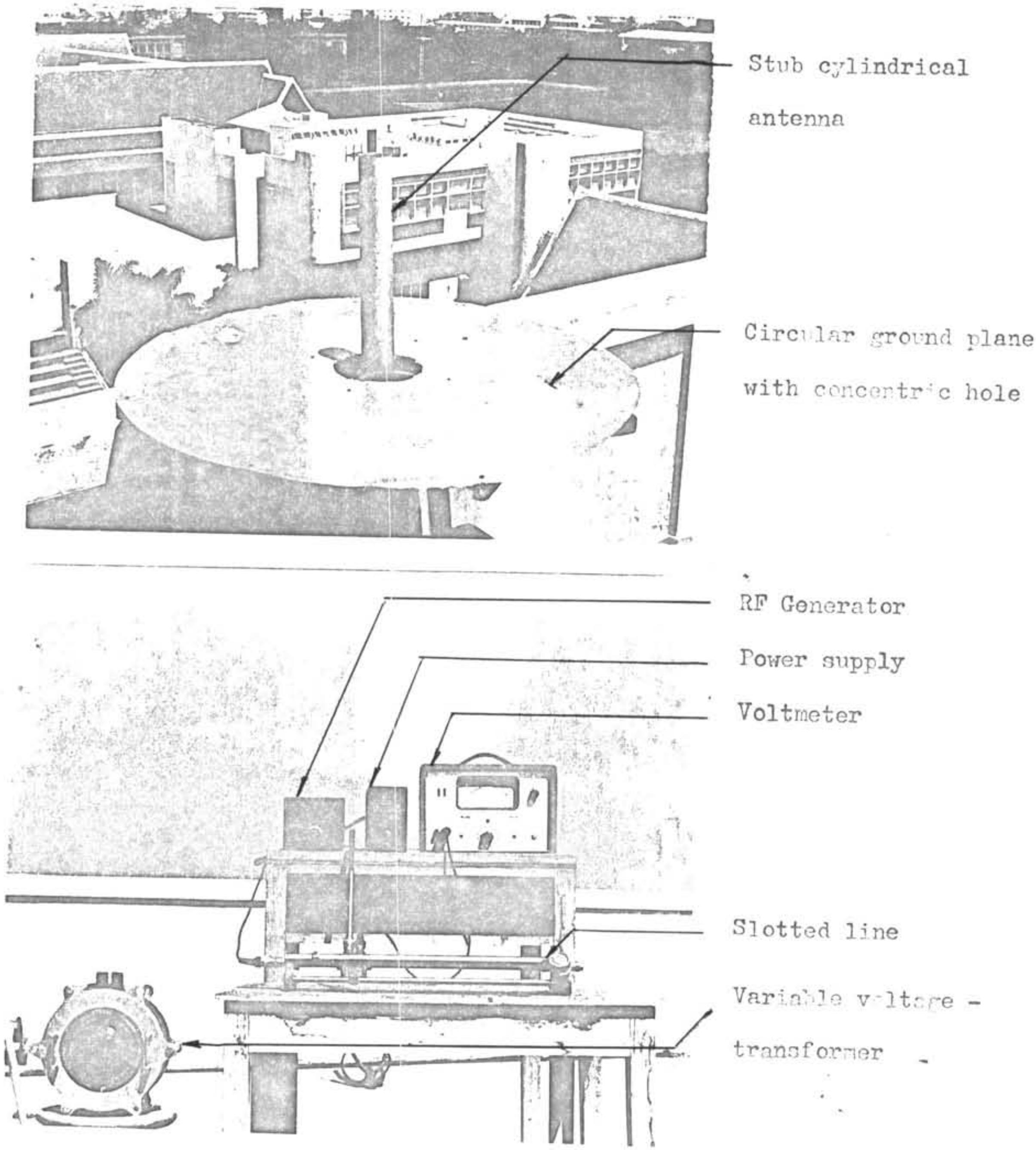

Fig 4.2 (A) The stub cylindrical antenna over a cricular ground plane with concentric hole.

(B) The equipment for impedance measurement.

TABLE 4.1

Data from the impedance measurement (without concentric hole on the circular ground plane)

L (λ)	F (MHz)	E_{min} (mv)	E_{max} (mv)	d_{min} (cm)	$d_{s/c}$ (cm)	Air line (cm)
0.25	150	1.7	3.2	1.5	20.4	-
0.3	180	1.4	2.9	2.2	44.5	20
0.4	240	.8	4.9	31.8	21.8	-
0.5	300	.6	4.3	0.6	37.6	-
0.6	360	.3	2.6	11.3	2.3	10
0.7	420	1.1	3.0	15.1	10.5	-
0.8	480	.8	6.2	13.2	12.2	-

Remark

d_{min} = position of the minimum voltage on the slotted line, on load condition

$d_{s/c}$ = position of the minimum voltage on the slotted line with the load terminal short circuit

TABLE 4.2

Data from the impedance measurement (with concentric hole on the circular ground plane)

L (λ)	F (MHz)	E_{min} (mv)	E_{max} (mv)	d_{min} (cm)	$d_{s/c}$ (cm)	Air line (cm)
0.25	150	1.9	3.3	3.0	37.4	-
0.3	180	1.3	2.8	7.7	41.3	10
0.4	240	1.1	3.0	12.4	45.3	20
0.5	300	1.3	4.7	7.2	37.6	-
0.6	360	1.4	4.1	12.5	25.2	20
0.7	420	2.8	3.1	1.0	5.9	-
0.8	480	3.0	3.4	2.3	14.3	-

Remark

d_{min} = position of the minimum voltage on the slotted line, on load condition

$d_{s/c}$ = position of the minimum voltage on the slotted line with the load terminal short circuit

TABLE 4.3

Detail computation from table 4.1

L (λ)	S	loss (dB)	S'	Δd_{min} (λ)	R (ohms)	X (ohms)
0.25	1.88	.33	2.0	.095	35	22
0.3	2.07	.37	2.20	.26	85	40
0.4	6.13	1.06	18.4	−.160	8	- 74
0.5	7.17	1.45	30	.37	2	- 5
0.6	8.67	1.58	$\approx \infty$	−.108	0	- 40
0.7	2.73	.70	4.6	−.065	12	- 20
0.8	7.75	1.70	$\approx \infty$	−.016	0	- 5

Remark

Positive sign of Δd_{min} = toward generator

Minus sign of Δd_{min} = toward load.

TABLE 4.4

Detail computation from table 4.2

L (λ)	S	loss (dB)	S'	Δd_{min} (λ)	R (ohms)	X (ohms)
0.25	1.74	.325	1.9	.172	60	32.5
0.3	2.15	.500	2.4	.262	85	47.5
0.4	2.73	.616	3.10	.203	142	- 30
0.5	3.62	.776	4.7	.304	70	- 96
0.6	2.93	.802	3.8	.152	35	- 58
0.7	1.11	.600	1.1	.068	45	- 5
0.8	1.13	.650	1.1	.192	55	6

Remark

Positive sign of Δd_{min} = toward generator

Minus sign of Δd_{min} = toward load.

The computation of the datas from table 4.1 and 4.2 are carried out by using the Smith's chart with the consideration of cable loss. A sample calculation is as follow:

From table 4.2 $L = 0.5\lambda, f = 300$ MHz

Hence, the voltage standing wave ratio becomes

$$S = \frac{4.7}{1.3}$$

$$= 3.62$$

From Fig. 4.3(a), cable length $= 4.00$ metre (13.33 ft.)

cable loss $= \frac{3.5}{100} \cdot 13.33$ dB

$= 0.466$ dB

From Fig. 4.3(b), the additional loss due to the standing wave equals to 0.31 dB

Therefore, total loss $= 0.466 + 0.31$ dB

$= 0.776$ dB

$S = 3.62$ is the standing wave at the slotted line, but the true standing wave at the load terminal is required. From Fig. 4.3(c) the additional distance ΔS in the Smith's chart is obtained

Let S_1 = the voltage standing wave ratio at the load terminal

$$S_1 = S + \Delta S$$

$$= 4.7$$

The difference between d_{min} and $d_{s/c}$ $= \Delta d_{min}$

$d_{min} = 37.6 - 7.2$

$= 30.4$ cm

$$d_{min} = .304\lambda \text{ toward generator}$$

Starting from the minimum point on S = 4.7 and moving toward the generator for a distance = 0.304λ, The normalized value of the antenna impedance is obtained.

Therefore $$Z_{nor} = 1.4 - j1.92$$

The characteristic impedance of the coaxial cable, type RG-8/U equals to 50 ohms.

Hence, the input impedance of the cylindrical stub antenna is

$$Z = 50(1.4 - j1.92) \quad \text{ohms}$$

$$Z = 70 - j96 \quad \text{ohms}$$

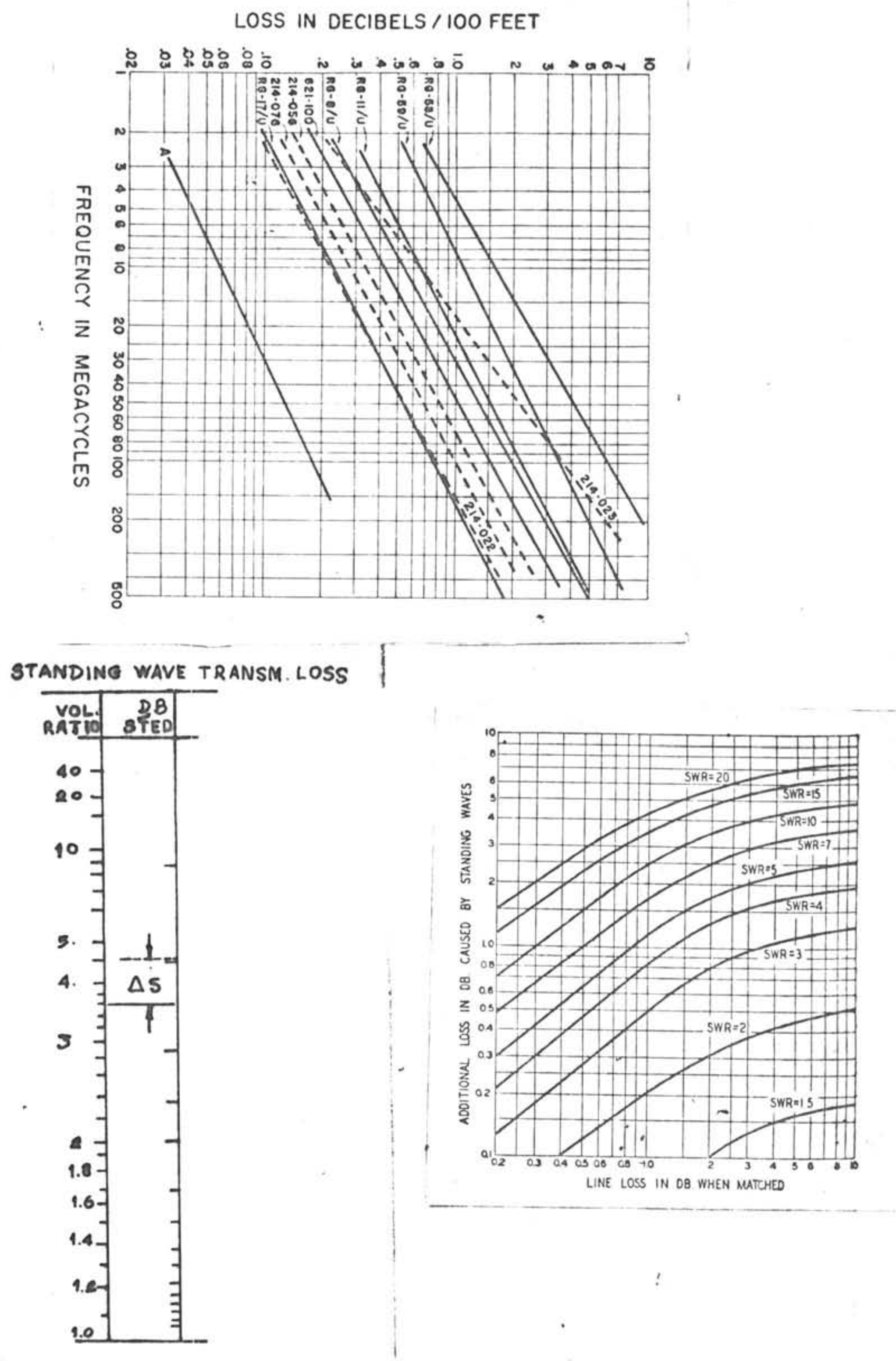

Fig 4.3 line loss and standing wave transformation loss coppied right from The Radio Amateur's Handbook by the Headquarters Staff of the American Radio Relay league, 1969, P 348

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IMPEDANCE OR ADMITTANCE COORDINATES

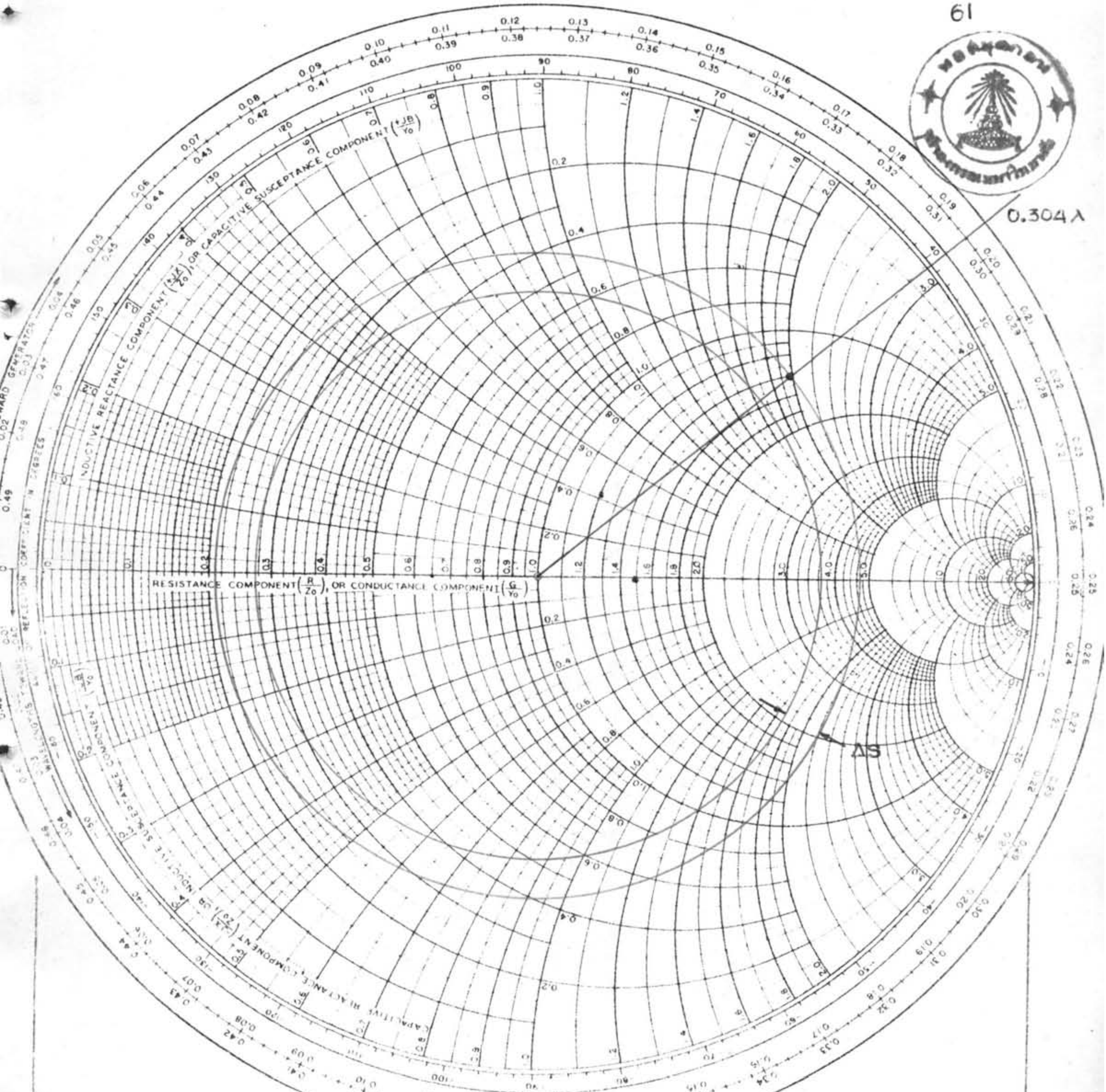
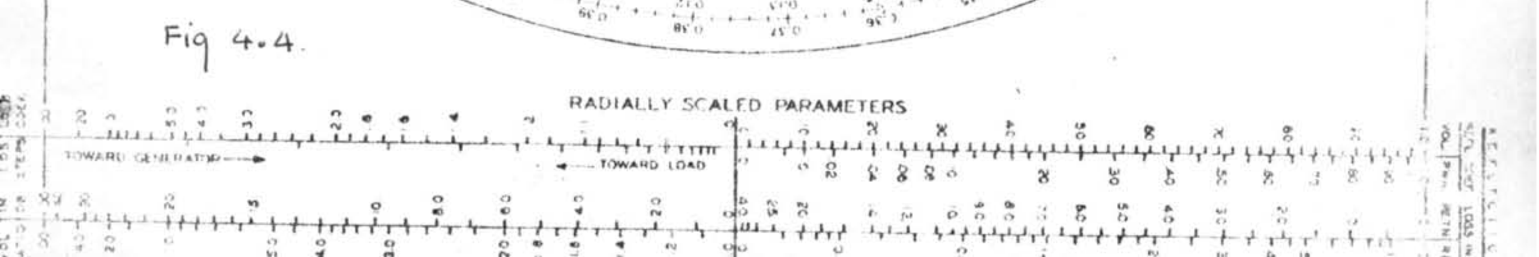


Fig 4.4.



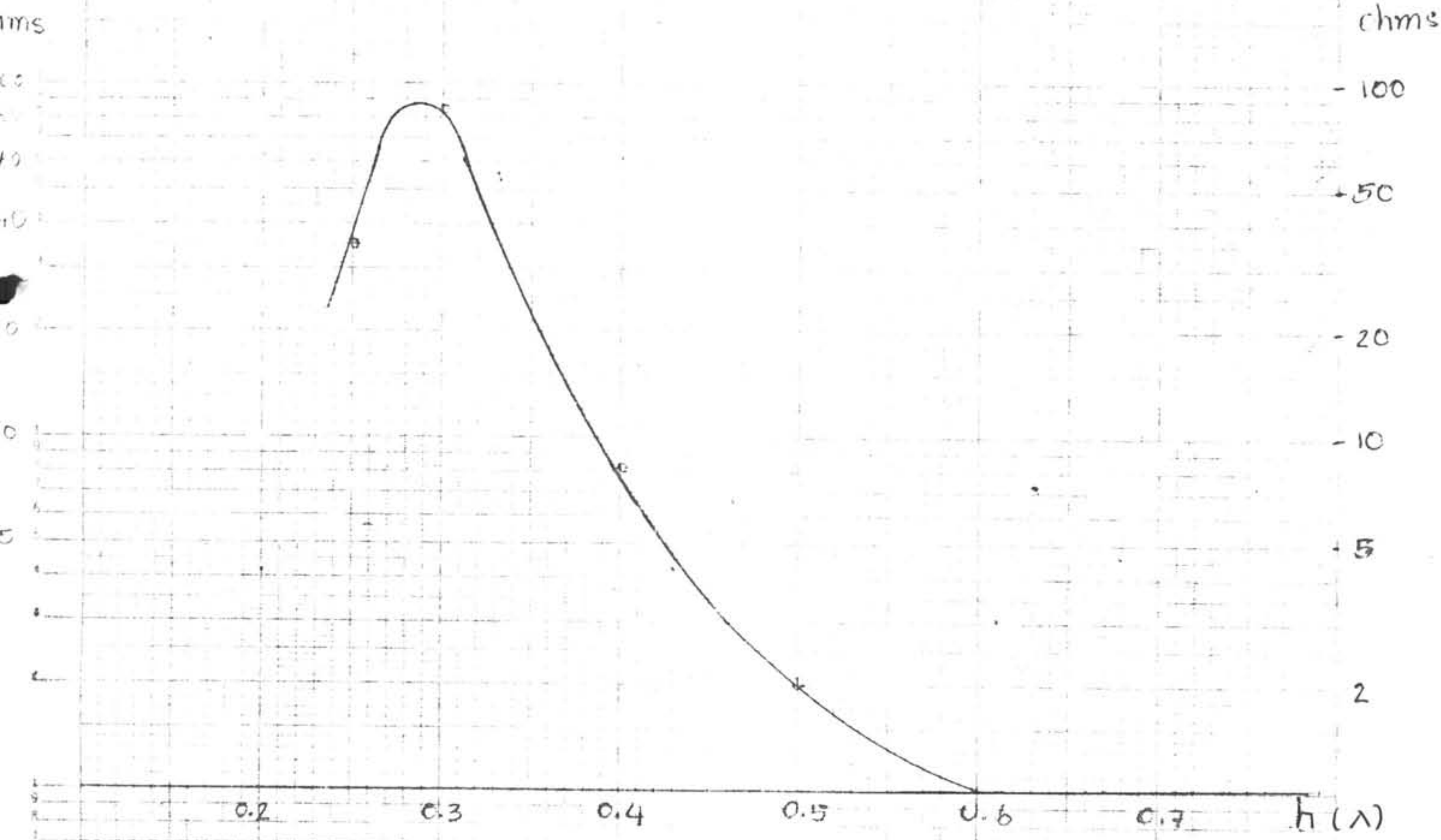


Fig4.5Resistance of stub cylindrical antenna with out centric hole on ground plane and length to radius ratio = 13.1 (experimental)

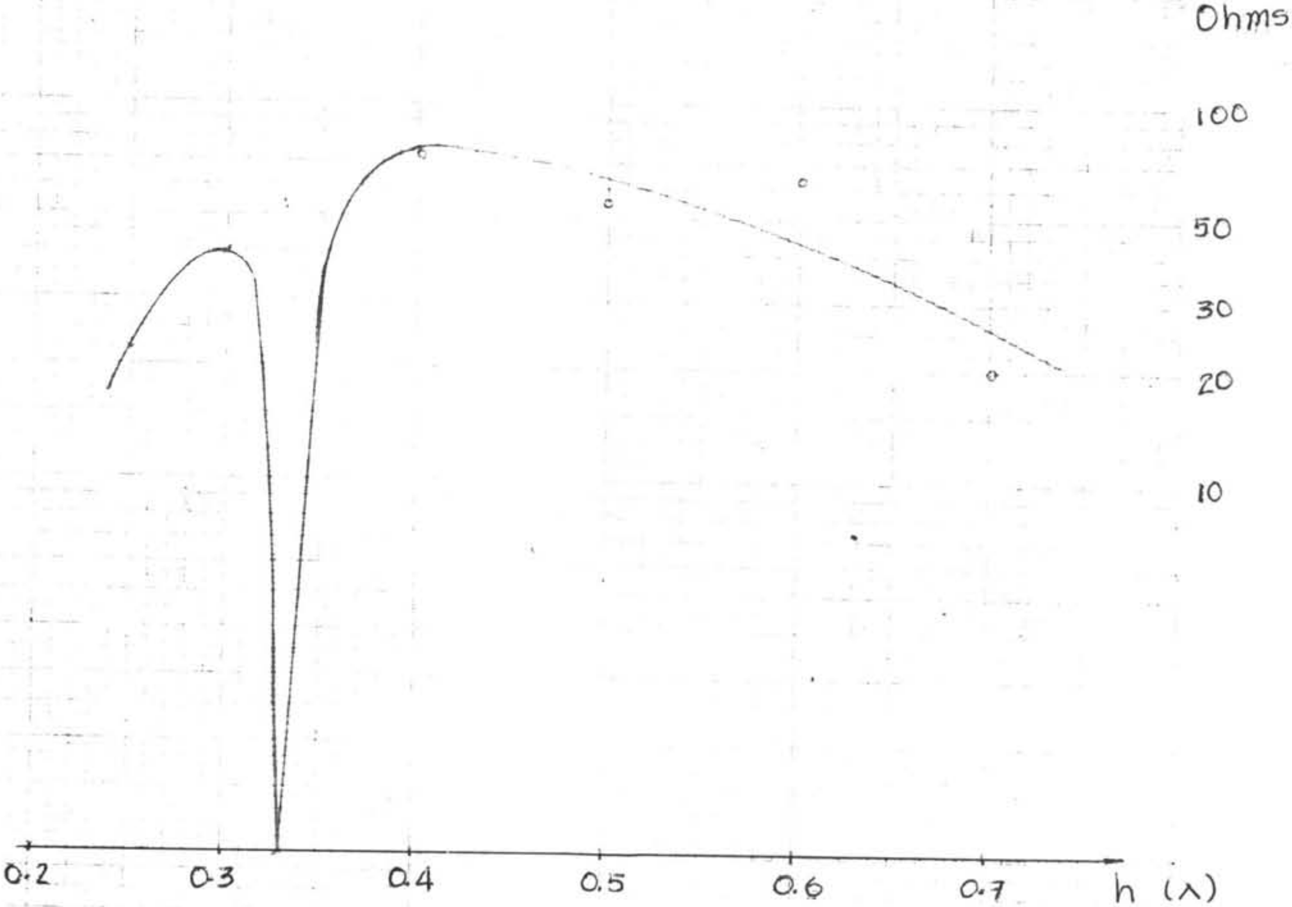


Fig. 4.6 Reactance of stack cylindrical entenna without concentric hole on ground plane and with length to radius ratio = 13.1 (experimental)

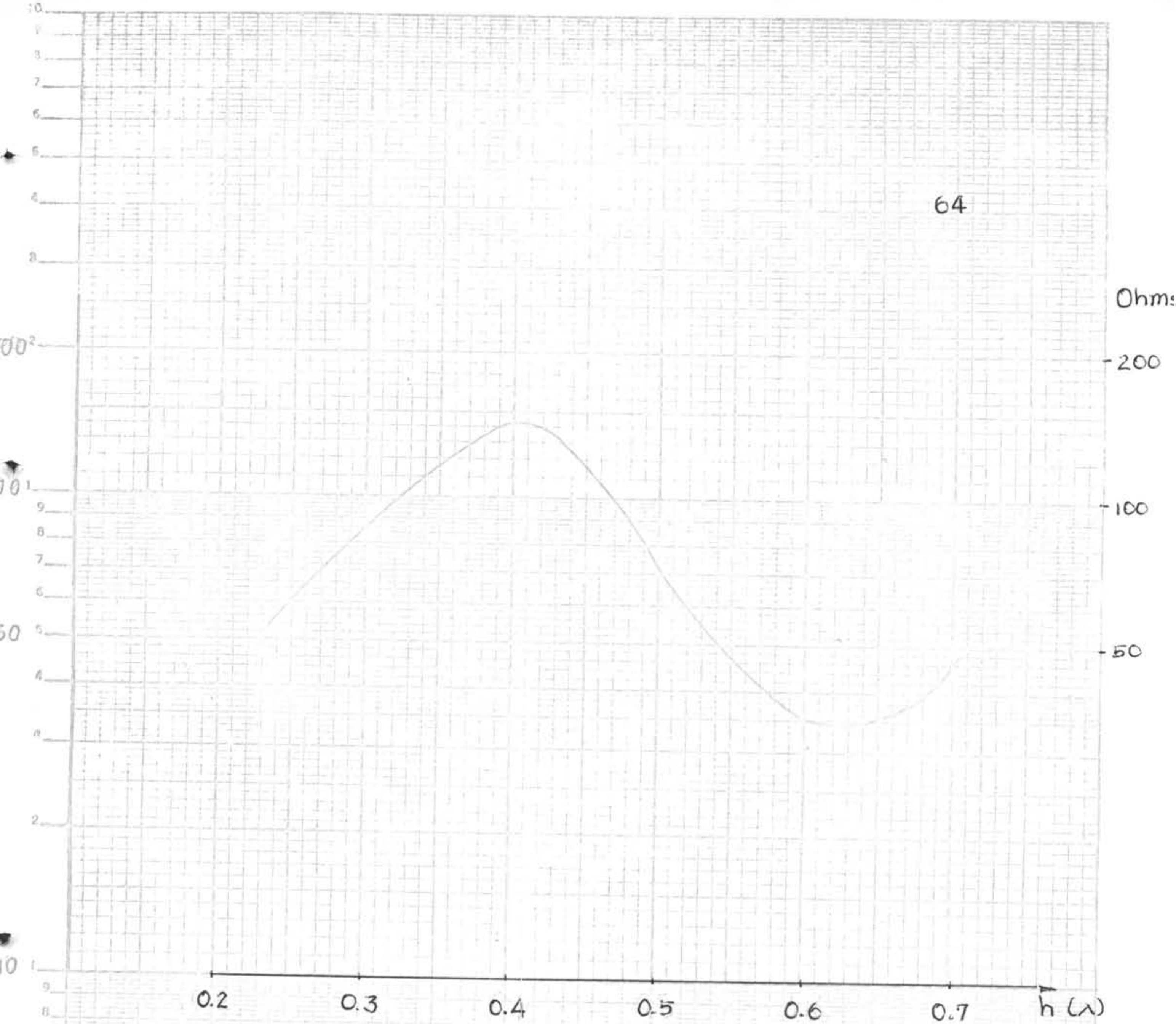


Fig 4.7 Resistance of stub cylindrical antenna with concentric circle on ground plane and length to radius ratio = 15.1 ([illegible])

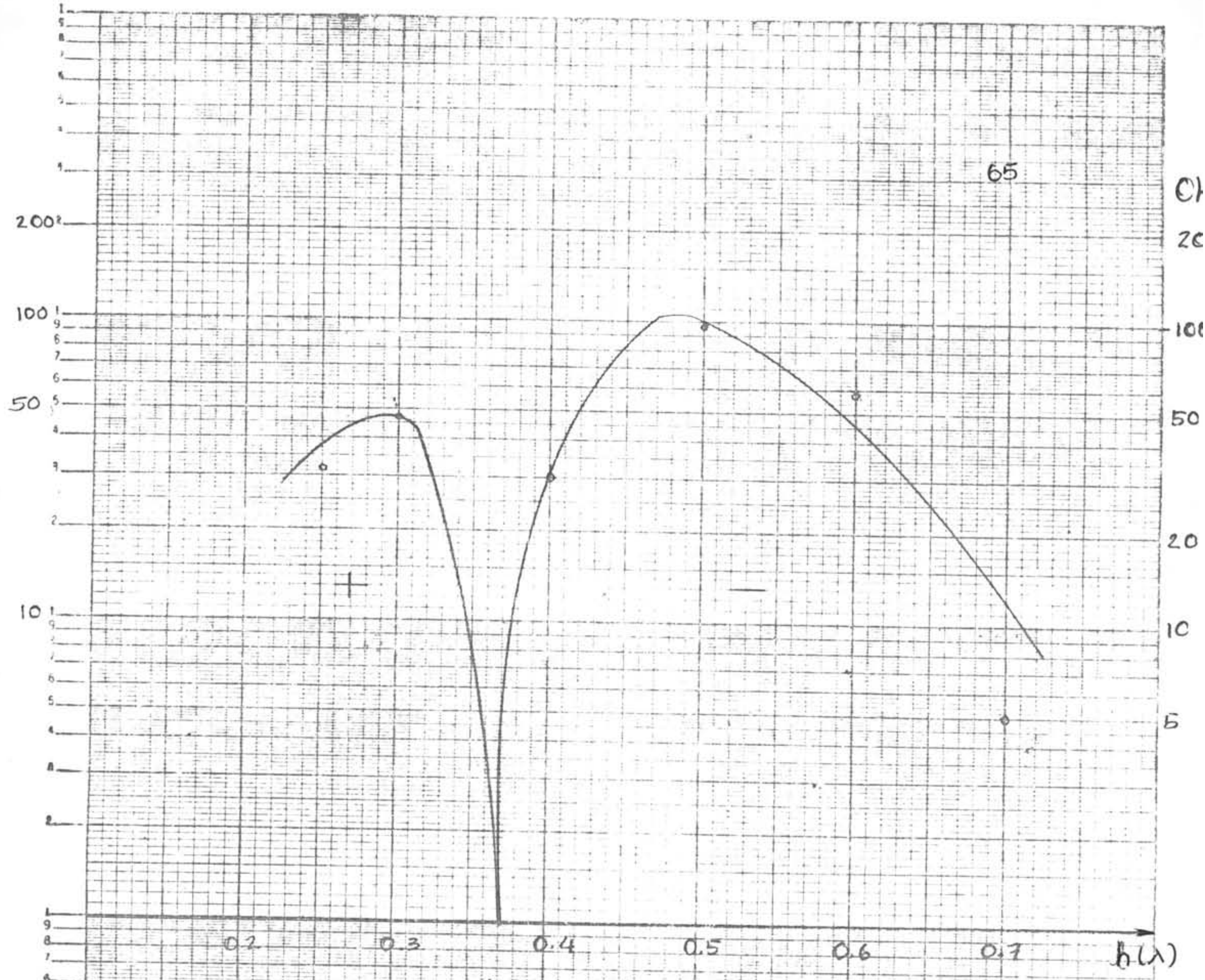


Fig 48 Reactance of stub cylindrical antenna with concentric hole on ground plane and length to radius ratio = 13.1 (experimental)

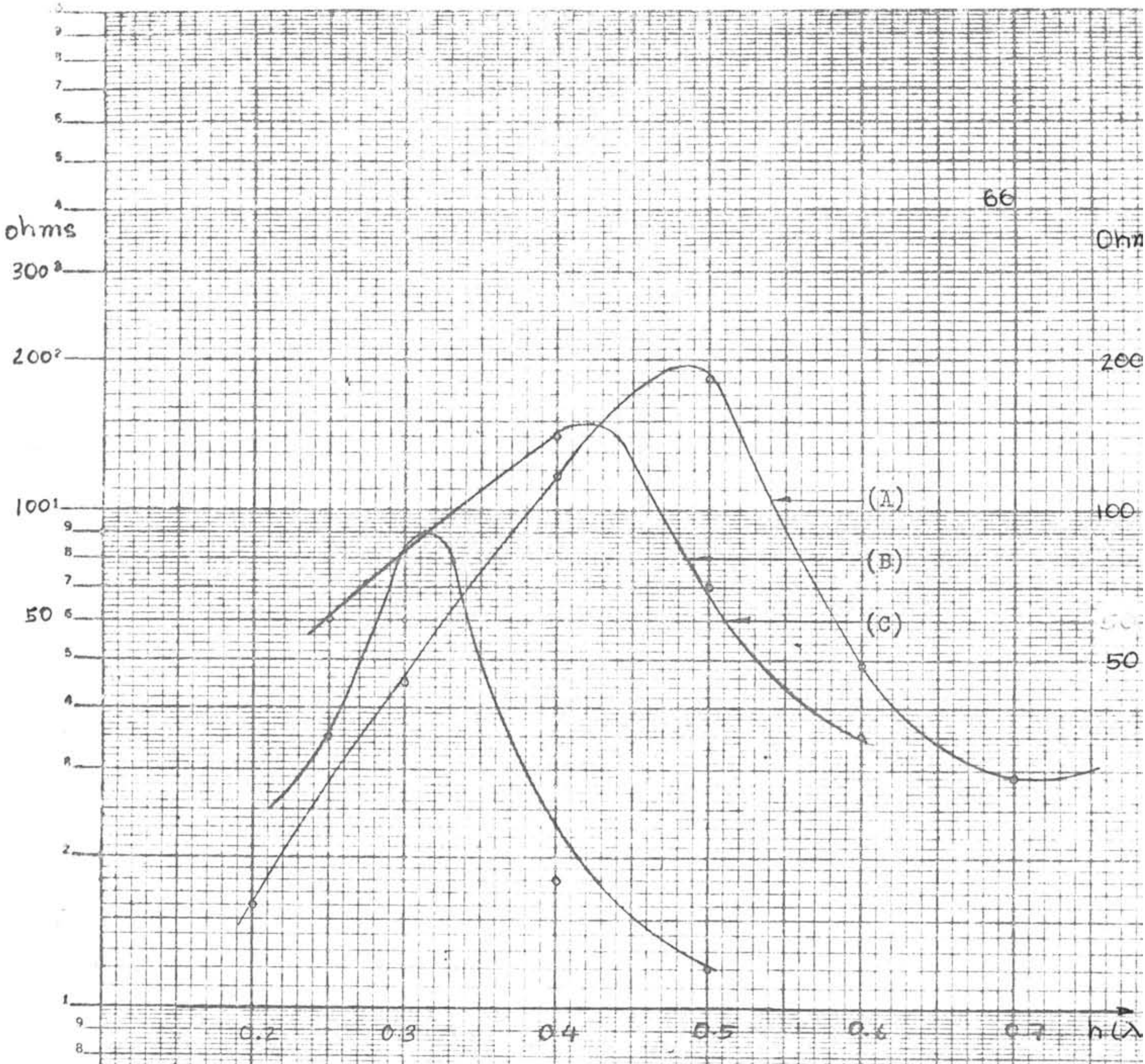


Fig 4.9 Resistance of stub cylindrical antenna with
length to radius ratio = 13.1
comparision between (A) theoritical (B) experimental
with concentric circle on ground plane
(C) experimental without concentric circle on ground
plane.

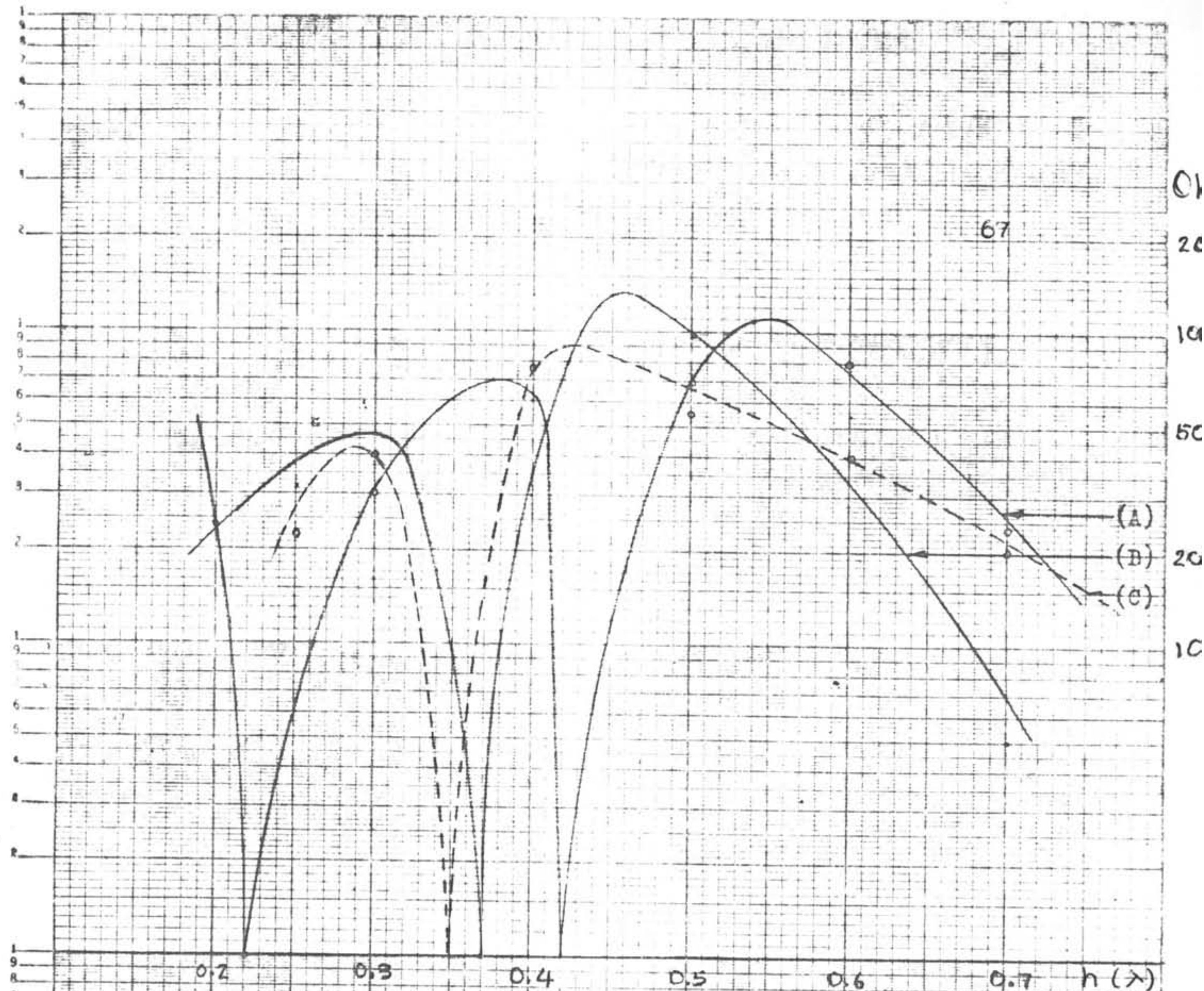


Fig4.10Reactance of stub cylindrical antenna, length to radius Ratio = 13.1, comparision between (A) Theoritical,(B) experimental with concentric hole and (C) experimental without concentric hole one ground plane

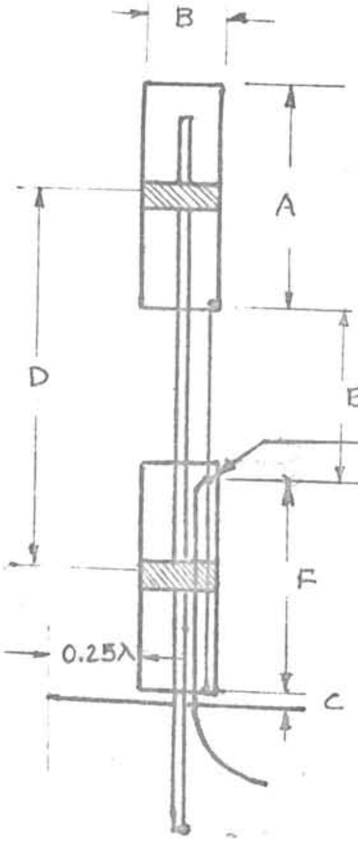
THE IMPEDANCE MEASUREMENT OF STACKED CYLINDRICAL ANTENNAS

The impedance measurement of two-element, inphase, stacked cylindrical antennas with four radial ground rods as shown in Fig. 4.11 and 4.12 is handling in the region of second resonant. In this experiment, the value between 0.33λ to 0.50λ will used by keeping the physical length of the antenna constant while the frequencies vary between 200 to 300 MHz.

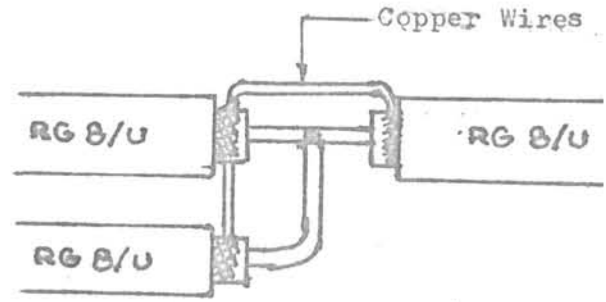
The instruments, used in this experiment, are as follow:

1. Two hollow cylindrical antennas made of aluminium, 50 cm long and 3" in diameter, which the arrangements are as shown in Fig. 4.11 and 4.12.
2. Four radial ground rods, each element made of aluminium, (0.25λ + 3.8 cm) long and 0.65 cm in diameter.
3. The measuring equipments are exactly the same as stated in item 3-7 of the former experiment (the impedance measurement of the cylindrical stub antenna).

This experiment is made at the same place as the former experiment. The datas obtained from this measurements are recorded in table 4.5 that follows :



(A)



(B)

Fig. 4.11 The experiment sets up for impedance measurement of stacked cylindrical antenna with four radial ground rods. The dimensions as shown in (A) are as follow: A = 50 cm, B = 7.6 cm, C = 1.5 cm, D = 0.5λ, E = F = 0.5λ (B) Detail of the input terminal.

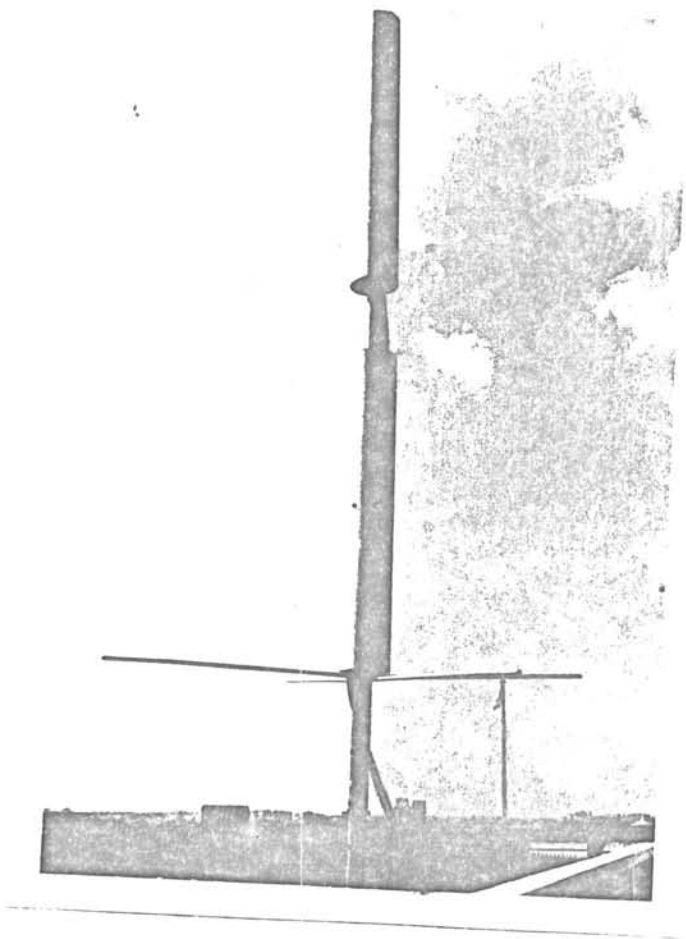


Fig 4.12 The stacked cylindrical antenna with four radial ground rods.

Table 4.5

Data from the impedance measurement of stacked cylindrical antenna at various stub lengths.

L (λ)	F (MHz)	E_{min} (mv)	E_{max} (mv)	d_{min} (cm)	$d_{s/c}$ (cm)	Air line (cm)
0.33	200	1.71	3.2	23.4	47.5	20
0.37	220	1.23	3.8	47.5	4.4	10
0.40	240	2.25	2.7	26.0	16.8	20
0.45	270	.73	4.3	40.1	38.3	-
0.50	300	.59	4.1	3.5	38.4	-

Remark

d_{min} = position of the minimum voltage on the slotted line, on load condition.

$d_{s/c}$ = position of the minimum voltage on the slotted line with the load terminal short circuit.

Table 4.6

Details computed from table 4.5

L (λ)	s	Loss (dB)	s'	Δd_{min} (λ)	R (ohms)	X (ohms)
0.33	1.9	.36	2	.17	57	38
0.37	3.2	.48	3.7	−.19	68	77
0.40	1.2	.32	1.2	−.08	45	7.2
0.45	6.0	.95	20	−.02	2.5	-5
0.50	7.3	1.17	30	.35	1.0	-70

Remark

Positive sign of Δd_{min} = toward generator

Minus sign of Δd_{min} = toward load

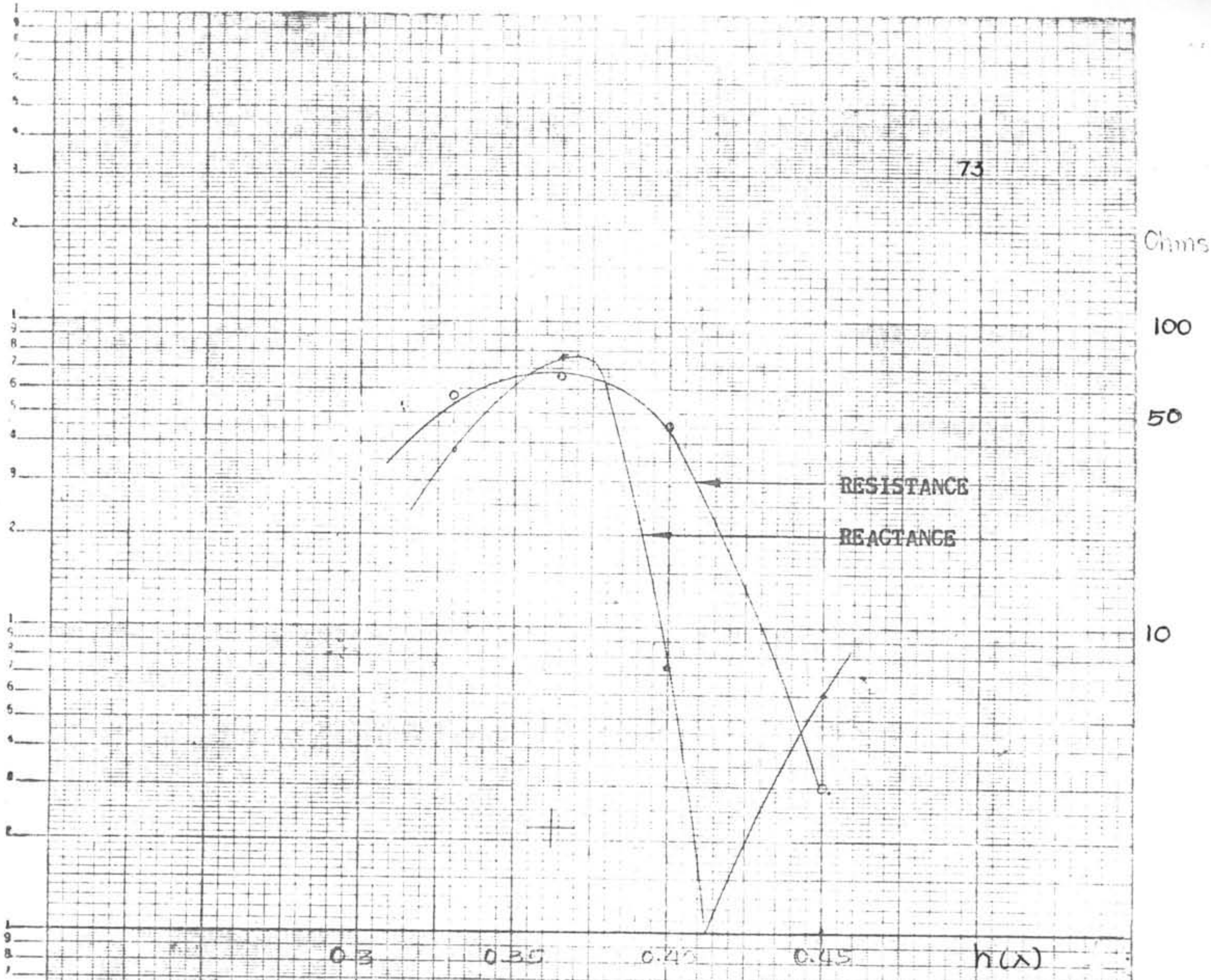


Fig. 4.13 Resistance and reactance of stacked cylindrical antenna against stub lengths (the experimental values, given from table 4.5)

B. FIELD STRENGTH MEASUREMENT. The measurement consists of 3 parts:

1. Measurement of the vertical field pattern of the cylindrical stub antenna 0.4λ long [as shown in Fig. 4.14(a) and Fig. 4.15(a)]
2. Measurement of the vertical field pattern of two-element stacked cylindrical antennas. The element's length equals to 0.4 λ and the distance between elements = 0.5λ and 0.6λ [as shown in Fig. 4.14 (b) and 4.15(b)]
3. Measurement of the vertical field pattern of two-element stacked cylindrical antennas. With four radial ground rods. The element's length equals to 0.4λ and the distance between elements equal to 0.5λ and 0.6λ [as shown in Fig. 4.14 (c) and Fig. 4.15(c)]

The instruments used in these experiments are as follow:

1. Hollow cylindrical antenna, made of aluminium, 50 cm long and 3" in diameter.
2. For part 2 and 3, two elements are the same as stated in 1 except for part 3 with four radial ground rods 37 cm (≈ 0.25λ) long and 3" (≈ 0.005λ) in diameter (distance in wave-length based on frequency 230 MHz)
3. The antennas as stated in 1,2 are fixed firmly on a turning wooden pole to which the pointer attached, at the lower end.
4. A unit oscillator, General Radio Co., type 1208-B [see Fig. 4.15(d)]

5. Aunit power supply, General Radio Co., type 1269-A [see Fig. 4.17(d)]
6. A unit R.F. amplifier, R,F. Comunication, type RF 815 [see Fig. 4.17(d)]
7. A unit field strength meter, Prestel, type MC 16 [see Fig. 4.17(d)]
8. Regulator, ToKoyama Electric Work, type B 15 [see Fig. 4.16(d)]
9. Co-axial line RG-8/U, 4.00 meter as a feeder.

The measurements are made at a frequency of 230 MHz and the vertical field patterns are measured by rotating the antennas in horizontal plane. The experiments arė perfomed on the top floor of the five-story building at the Department of Electrical Engineering Chulalongkorn University and are made after midnight for which there are very little disturbing signals. The datas obtained from the experiments and their normalized values are recorded in table 4.7 to 4.14, that follows:

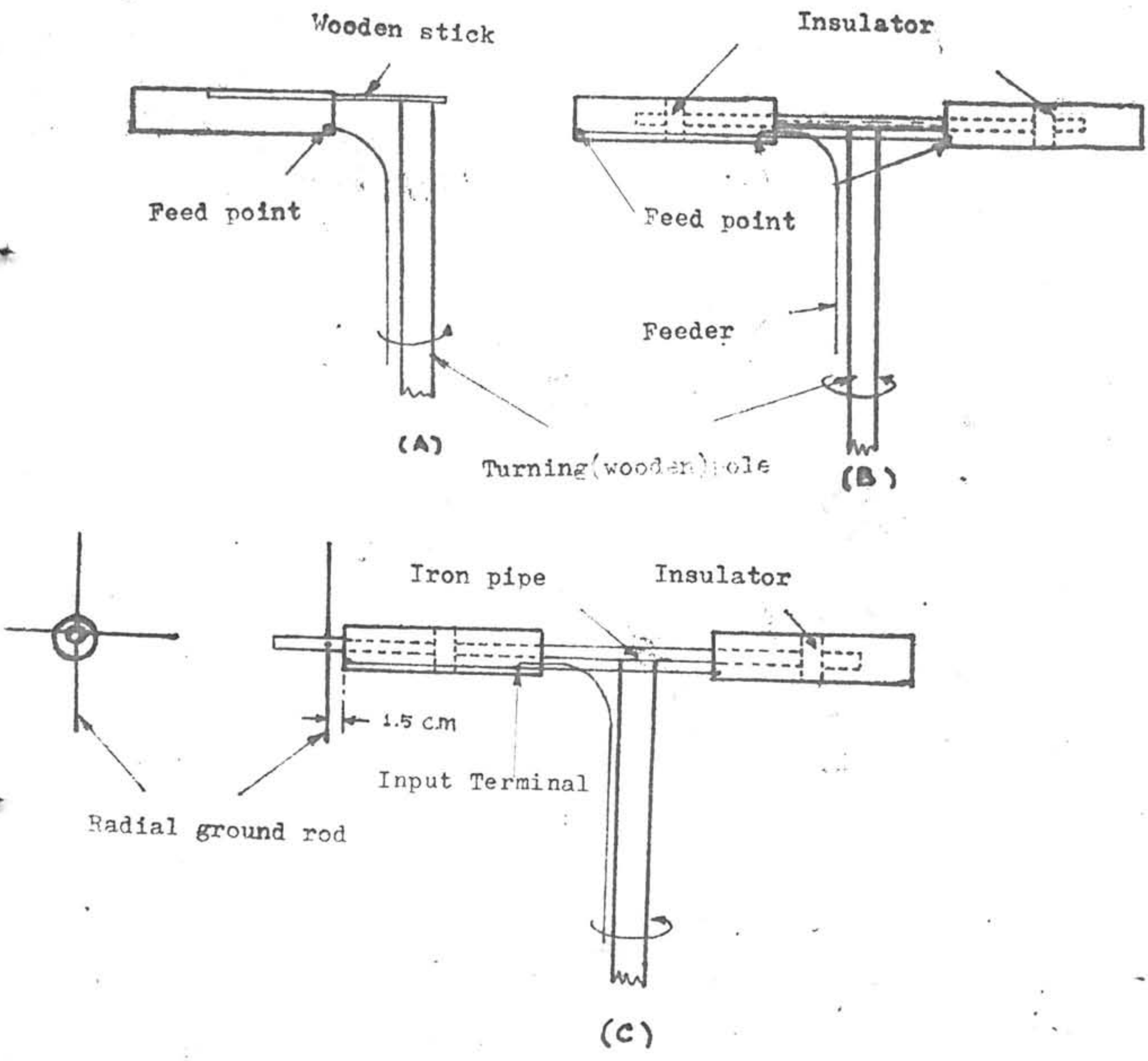
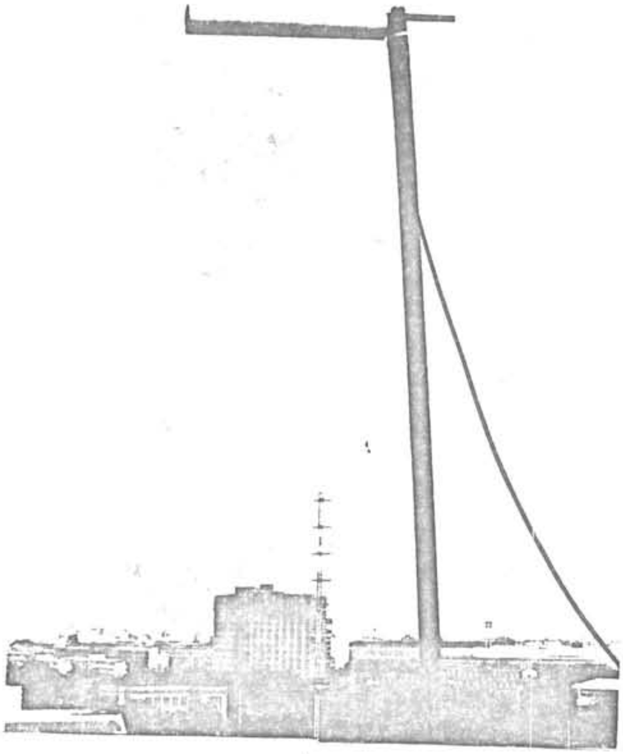
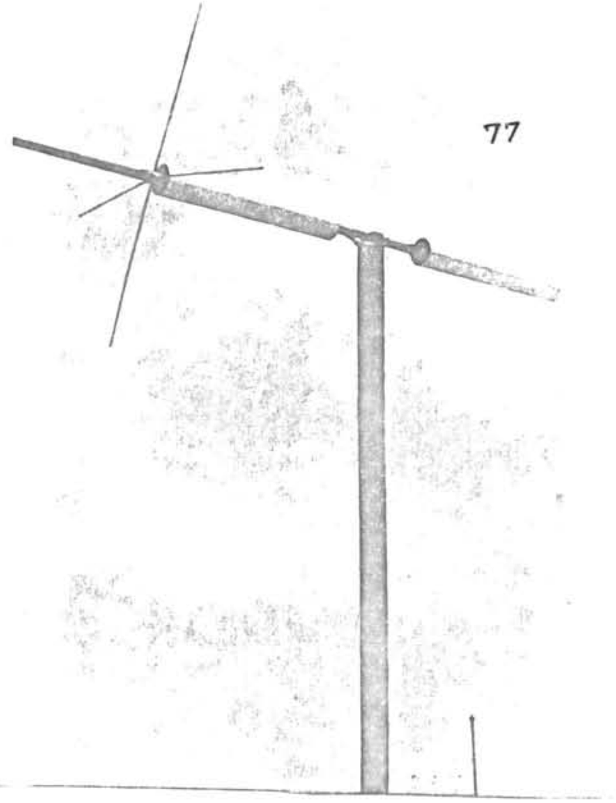


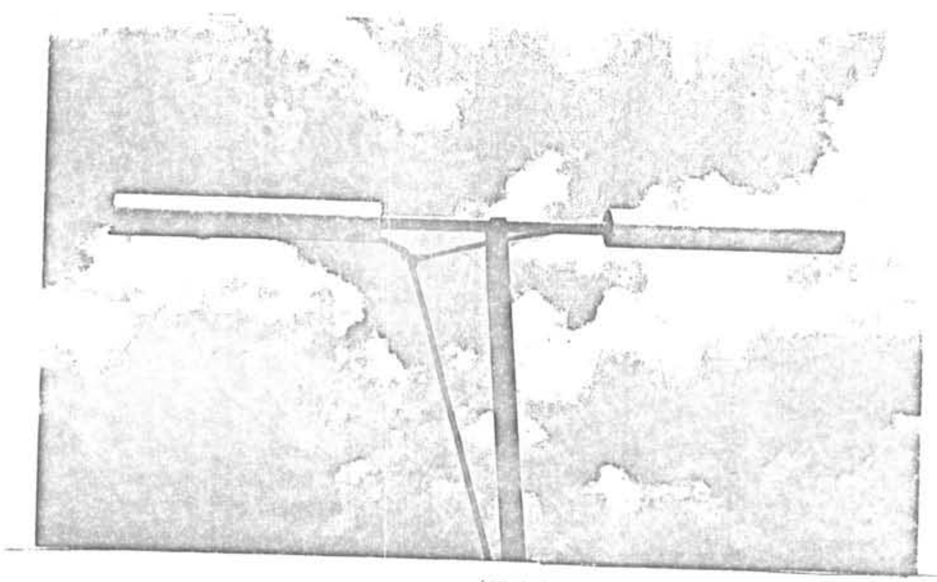
Fig. 4.14 Experiment set up for field patten measurments.



(A)



(C)



(B)

Fig 4.15 (A) The antennas on the top of the turning (wooden) pole (A) stub cylindrical antenna (B) and (C) stacked cylindrical antennas without and with four radial ground rods respectively

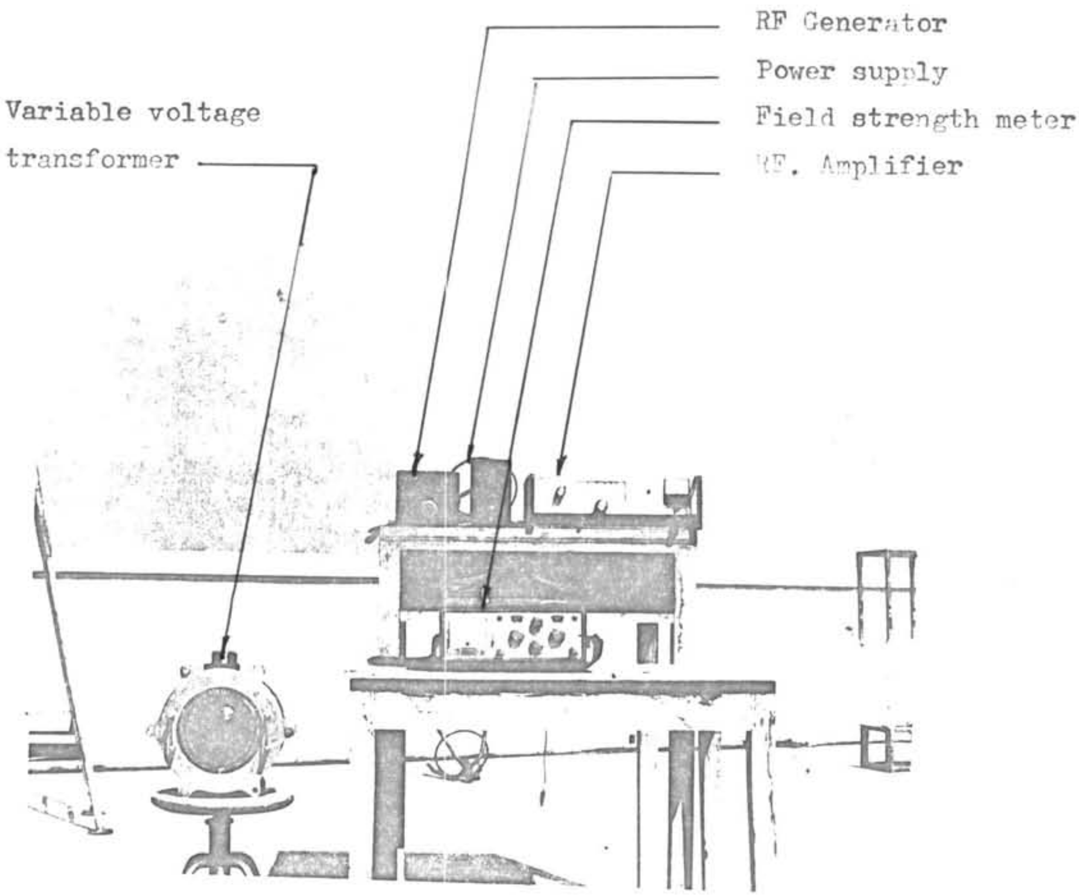


Fig 4.15 (D) The equipment for field strength measurement

TABLE 4.7

Field strength of 0.4 λ cylindrical antenna

Degree	Field Strength (x10 μV)			Average	Normalized
	E_1	E_2	E_3	(x10 μV)	(x10 μV)
0	18	16	14	16	.94
10	19	17	15	17	1
20	18	15	14	15.66	.92
30	16	14	13	14.33	.84
40	14	13	12	13	.76
50	13	12	11	12	.70
60	10	9	7	8.66	.50
70	9	7	6	7.33	.43
80	8	6	5	6.33	.37
90	6	5	4	5	.29
100	5	4	4	4.33	.25
110	8	7	6	7	.41
120	11	9	7	9	.52
130	13	12	9	11.33	.66
140	15	13	11	13	.76
150	17	14	12	14.33	.84
160	18	16	14	16	.94
170	19	17	15	17	1
180	18	16	15	16.33	.96

TABLE 4.8

Field strength of 0.4 λ ,cylindrical antenna

Degree	Field Strength (x10 μV)			Average (x10 μV)	Normalized
	E_1	E_2	E_3		
190	16	15	13	14.66	.86
200	14	12	11	12.33	.72
210	11	12	10	11.66	.68
220	13	9	9	9.66	.56
230	9	8	7	8	.47
240	8	7	7	7.33	.43
250	7	5	6	6	.35
260	7	4	4	5	.29
270	6	3	3	4	.23
280	8	4	3	5	.29
290	9	5	4	6	.35
300	10	6	5	7	.41
310	12	9	9	10	.58
320	14	10	9	11	.64
330	15	13	10	13	.76
340	17	15	11	14.33	.84
350	18	16	13	15.66	.92

TABLE 4.9

Field strength of stack cylindrical antenna, 0.5 λ apart, without ground plane.

Degree	Field Strength (x10 µV)			Average (x10 µV)	Normalized
	E_1	E_2	E_3		
0	26	29	29	28	1
10	24	28	27	26.33	.94
20	20	24	24	22.66	.80
30	16	19	18	17.66	.63
40	12	15	13	13.33	.47
50	8	11	9	9.33	.33
60	7	9	8	8	.28
70	5	6	6	5.66	.20
80	6	5	6	5.66	.20
90	6	6	5	5.66	.20
100	5	4	6	5.00	.18
110	6	8	7	7.00	.26
120	8	9	7	8.00	.29
130	11	13	12	12.33	.45
140	16	18	16	16.66	.60
150	20	23	21	21.33	.76
160	21	26	24	23.66	.84
170	25	29	27	27	.96
180	25	30	27	27.33	.97

TABLE 4.10

Field strength of stack cylindrical antenna, 0.5 λ apart, without ground plane.

Degree	Field Strength (x10 μV)			Average (x10 μV)	Normalized
	E_1	E_2	E_3		
190	24	28	26	26	.92
200	21	25	23	23	.82
210	17	21	19	19	.67
220	13	15	14	14	.50
230	7	9	7	7.66	.27
240	7	8	6	7	.25
250	5	7	5	5.66	.20
260	4	6	5	5	.17
270	4	5	4	4.33	.15
280	5	5	4	4.66	.16
290	4	4	7	5	.17
300	5	7	7	6.33	.22
310	7	10	8	8.33	.29
320	10	13	11	11.33	.40
330	16	20	17	5.66	.63
340	22	25	24	23.66	.84
350	25	31	28	28	1

TABLE 4.11

Field strength of stack cylindrical antenna, 0.6 λ apart, without ground plane.

Degree	Field Strength (x10 μV)			Average (x10 μV)	Normalized
	E_1	E_2	E_3		
0	33	35	31	33	1
10	32	33	30	31.66	.95
20	26	29	28	27.66	.84
30	18	20	18	21.66	.66
40	14	18	17	16.33	.49
50	9	12	11	10.66	.32
60	8	9	9	8.66	.26
70	6	6	5	5.66	.17
80	5	6	4	5	.15
90	6	5	5	5.33	.16
100	7	6	7	6.66	.20
110	10	8	9	9.33	.28
120	7	9	6	7.33	.22
130	10	12	10	10.66	.32
140	14	16	13	14.33	.43
150	20	22	19	20.33	.61
160	26	25	26	25.66	.71
170	30	32	28	30.00	.96
180	32	30	30	30.66	.92

TABLE 4.12

Field strength of stack cylindrical antenna, 0.6 λ apart, without ground plane.

Degree	Field Strength (x10 μV)			Average (x10 μV)	Normalized
	E_1	E_2	E_3		
190	32	34	31	32.33	.97
200	29	30	27	28.66	.86
210	20	22	18	20.00	.60
220	7	8	7	7.33	.23
230	6	1	3	3.3	.10
240	5	5	4	4.66	.14
250	6	4	5	5.00	.15
260	6	5	4	5.00	.15
270	7	9	6	7.33	.22
280	8	10	7	8.33	.25
290	5	6	5	5.33	.16
300	6	5	8	6.33	.19
310	9	8	11	9.33	.28
320	12	11	14	12.33	.37
330	20	17	21	19.33	.58
340	25	23	27	25.00	.75
350	33	30	31	31.33	.94

TABLE 4.13

Field strength of stack cylindrical antenna, 0.5 λ apart, with four radial ground rods.

Degree	Field Strength (x10 μV)			Average (x10 μV)	Normalized
	E_1	E_2	E_3		
0	51	47	46	48	1
10	40	42	44	42	.87
20	38	32	30	33.66	.70
30	23	18	17	19.33	.40
40	13	9	7	9.66	.20
50	11	10	8	9.66	.20
60	12	11	9	10.66	.22
70	8	10	11	9.66	.20
80	4	3	4	3.66	.07
90	3	2	2	2.33	.05
100	1	8	1	.97	.02
110	3	3	2	2.66	.06
120	4	3	3	3.33	.06
130	4	3	3	3.33	.06
140	11	8	9	9.33	.19
150	17	14	17	16	.33
160	33	28	29	30	.62
170	45	42	41	42.66	.88
180	48	44	46	46	.95

TABLE 4.14

Field strength of stack cylindrical antenna, 0.6 λ apart, with four radial ground rods.

Degree	Field Strength (x10 μV)			Average (x10 μV)	Normalized
	E_1	E_2	E_3		
0	56	52	54	54.00	0.95
10	50	45	46	47.00	0.83
20	37	33	34	34.66	0.60
30	21	17	18	18.66	0.32
40	17	14	14	15.0	0.26
50	15	13	11	13.00	0.23
60	18	15	13	15.39	0.27
70	15	13	10	12.66	0.22
80	11	9	8	9.33	0.16
90	11	10	8	9.66	0.165
100	13	11	9	11.00	0.19
110	15	12	11	12.56	0.22
120	17	14	12	14.33	0.25
130	14	12	11	12.33	0.22
140	13	11	10	11.33	0.20
150	18	15	13	15.33	0.26
160	35	29	24	29.33	0.52
170	59	56	52	55.66	0.97
180	62	58	54	57	1

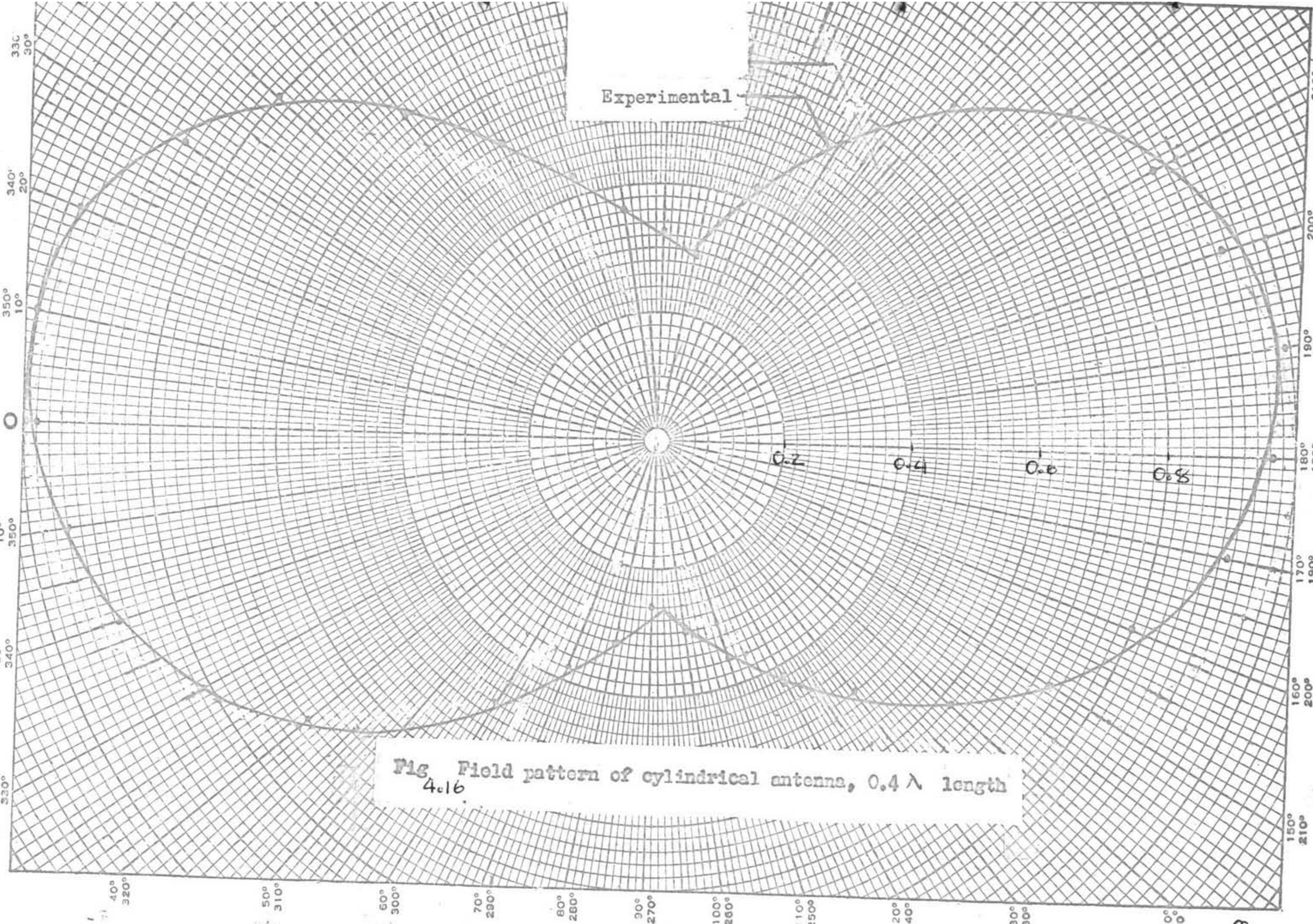


Fig 4.16 Field pattern of cylindrical antenna, 0.4 λ length

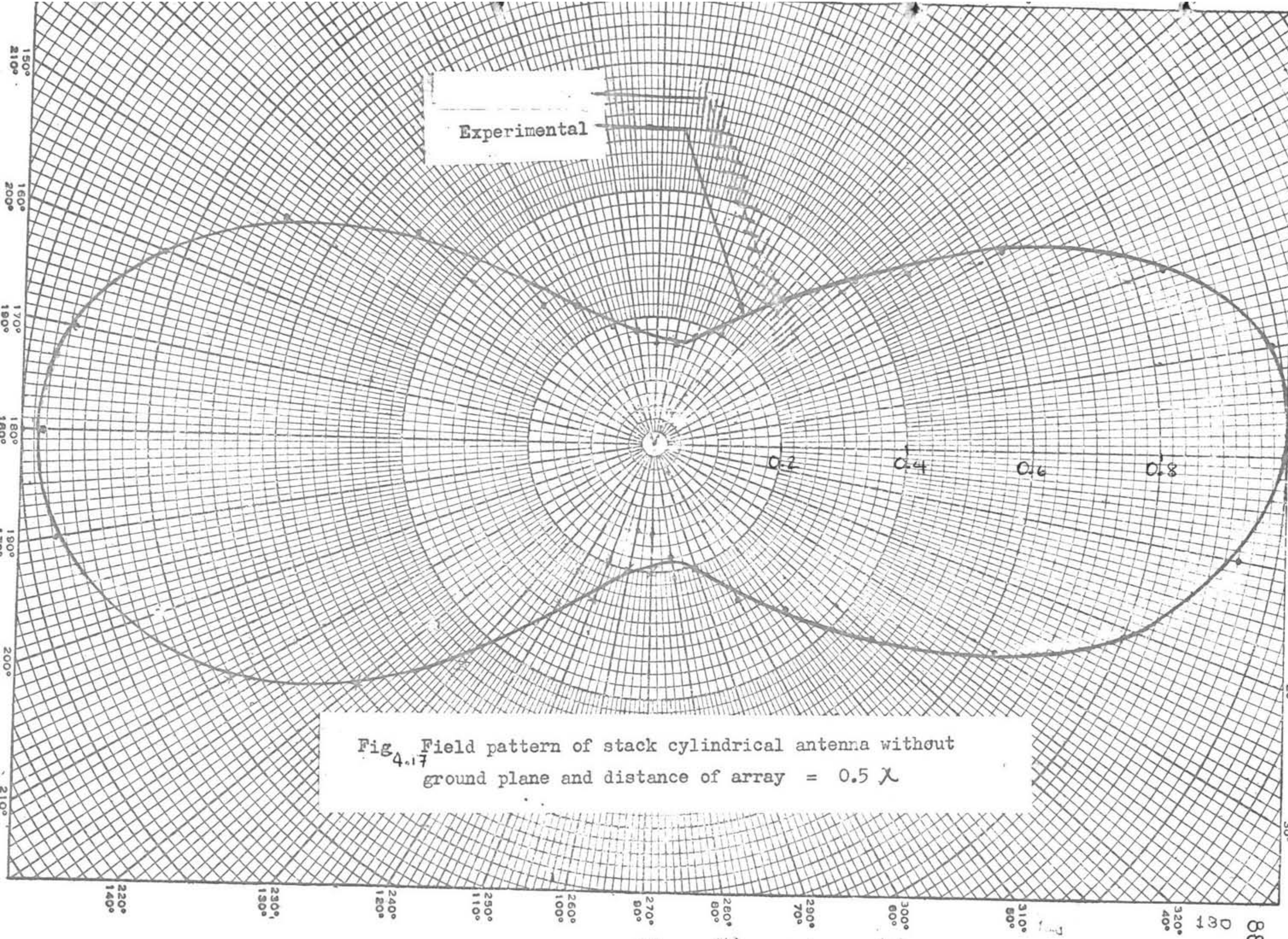


Fig 4.17 Field pattern of stack cylindrical antenna without ground plane and distance of array = 0.5 λ

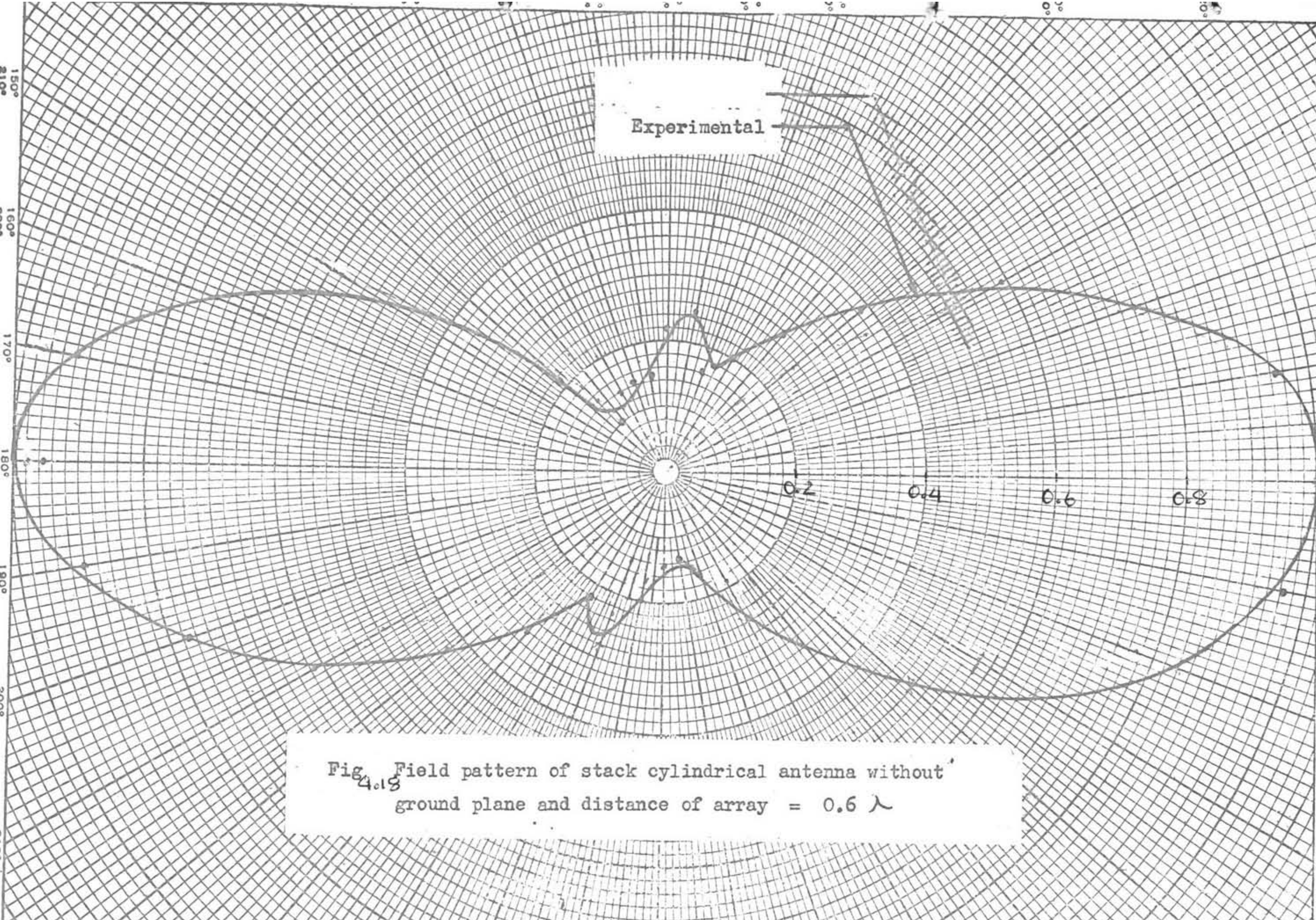


Fig. 4.18 Field pattern of stack cylindrical antenna without ground plane and distance of array = 0.6 λ

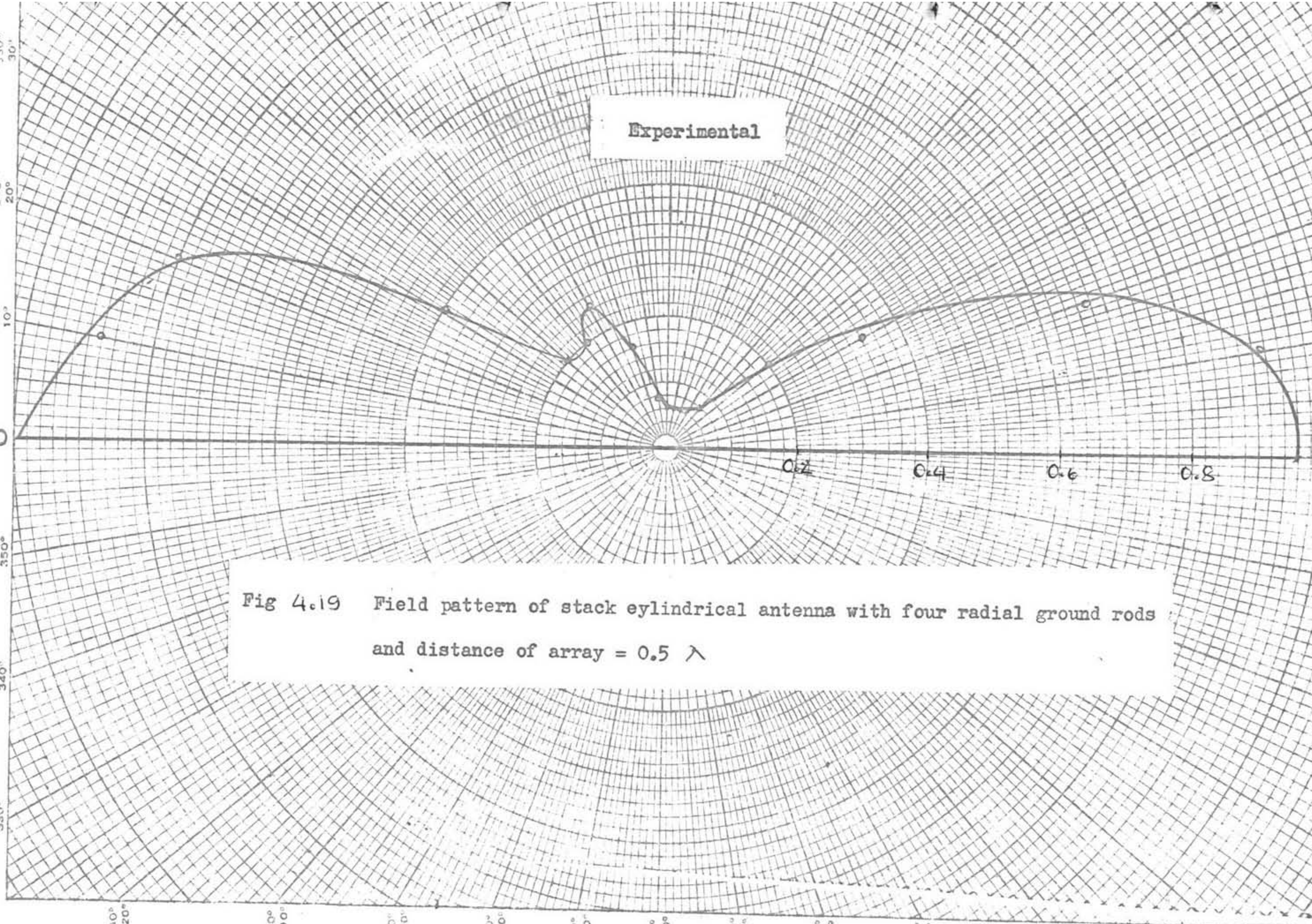


Fig 4.19 Field pattern of stack cylindrical antenna with four radial ground rods and distance of array = 0.5 λ

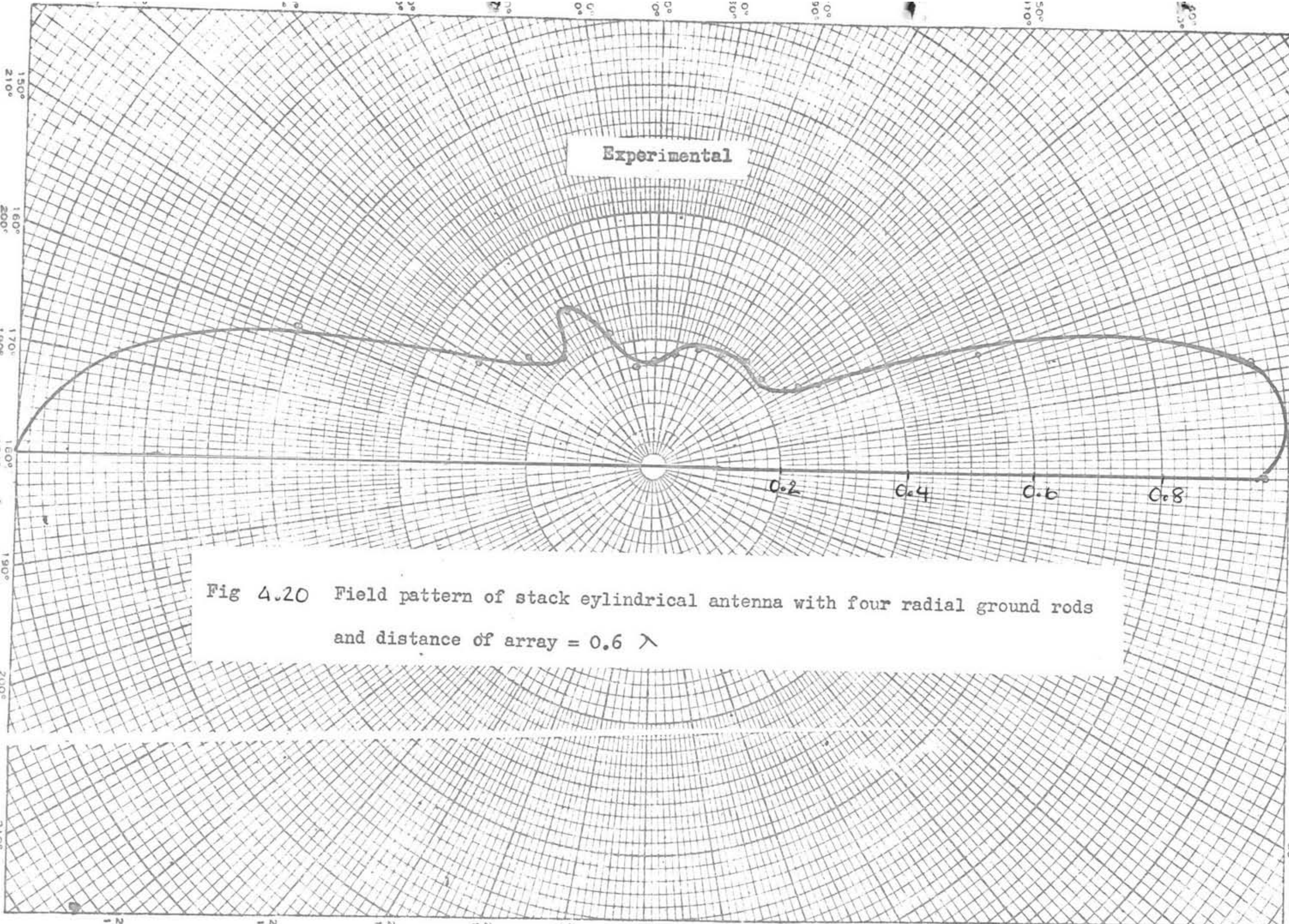


Fig 4.20 Field pattern of stack cylindrical antenna with four radial ground rods and distance of array = 0.6 λ

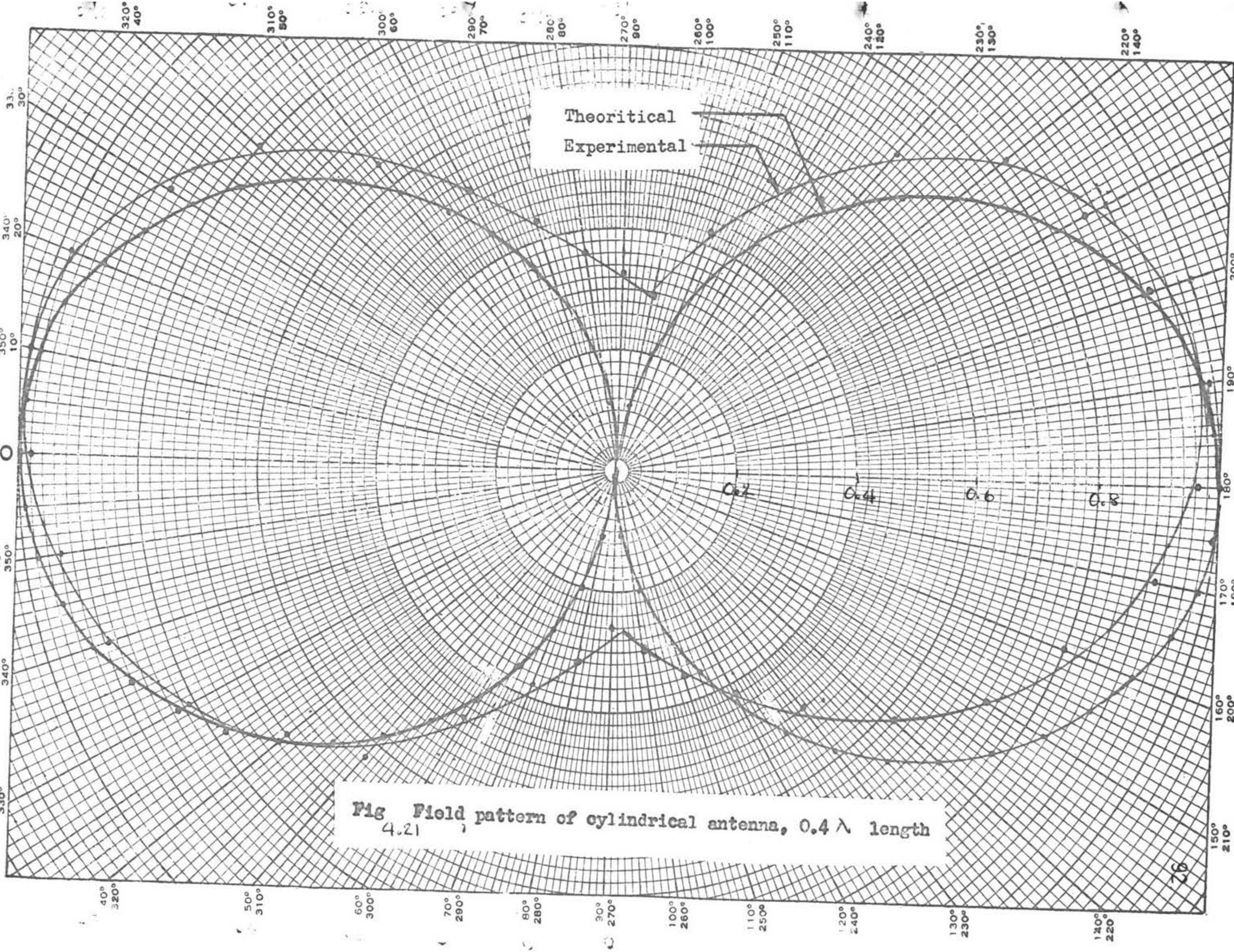


Fig 4.21 Field pattern of cylindrical antenna, 0.4 λ length

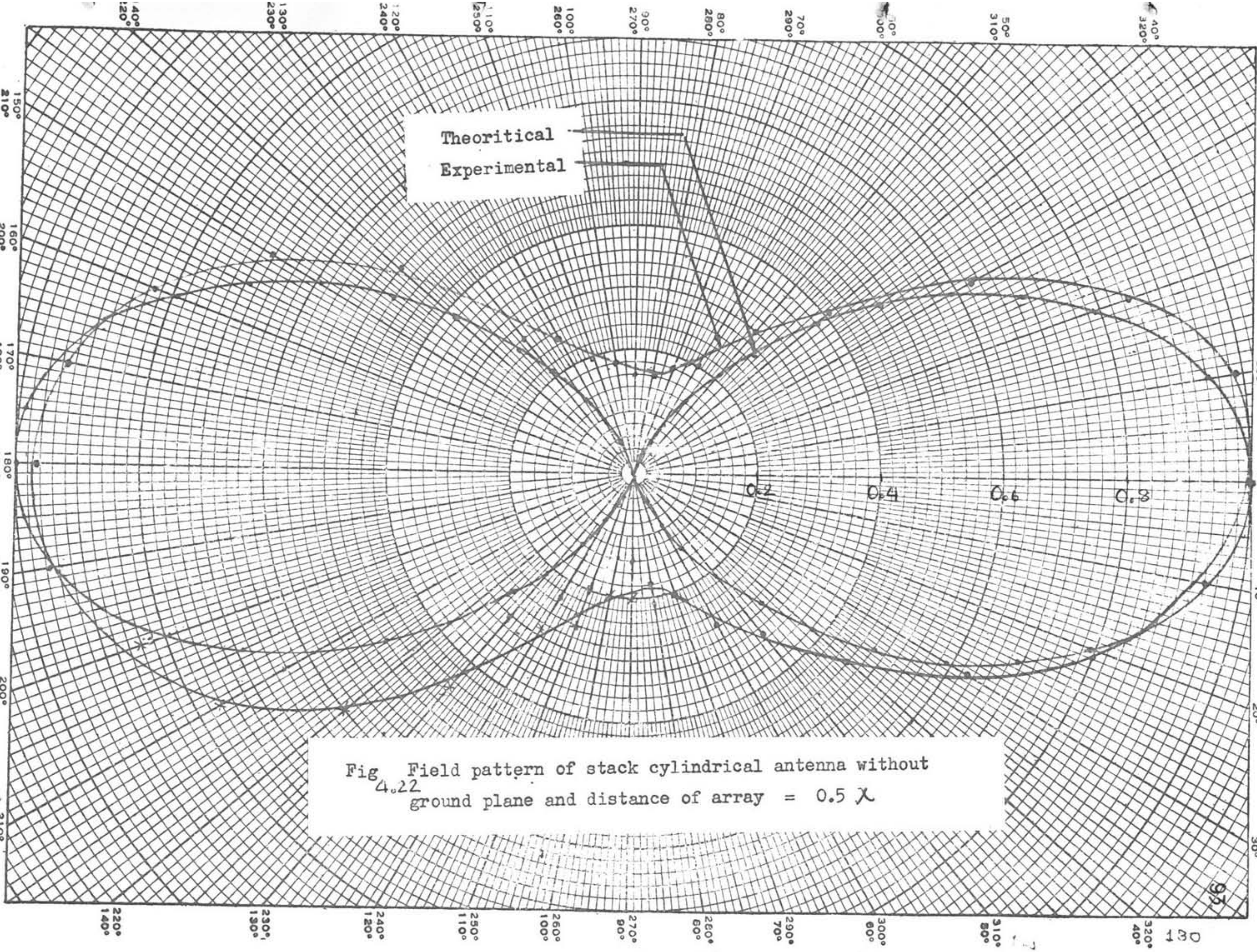


Fig 4.22 Field pattern of stack cylindrical antenna without ground plane and distance of array = 0.5 λ

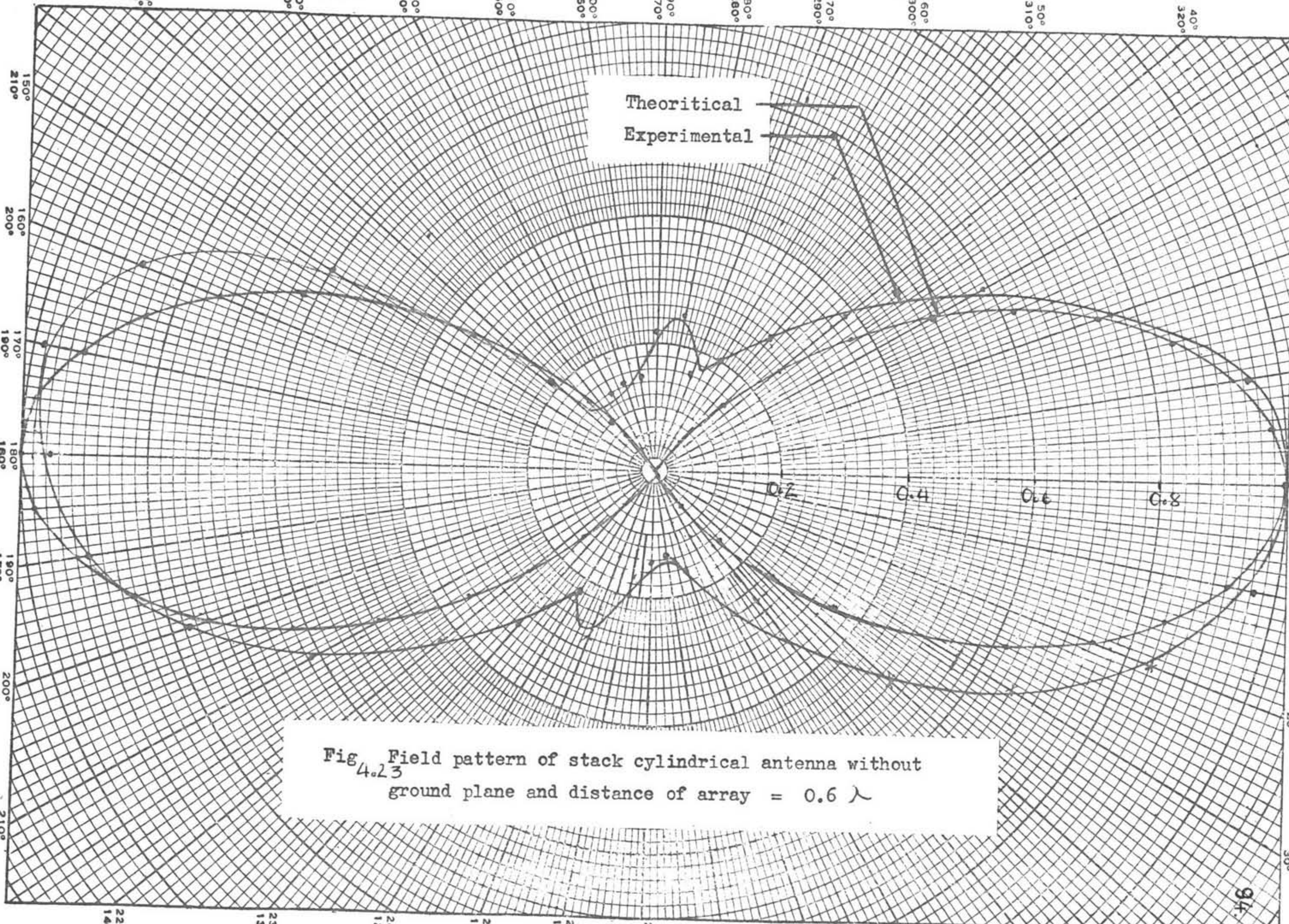


Fig 4.23 Field pattern of stack cylindrical antenna without ground plane and distance of array = 0.6 λ

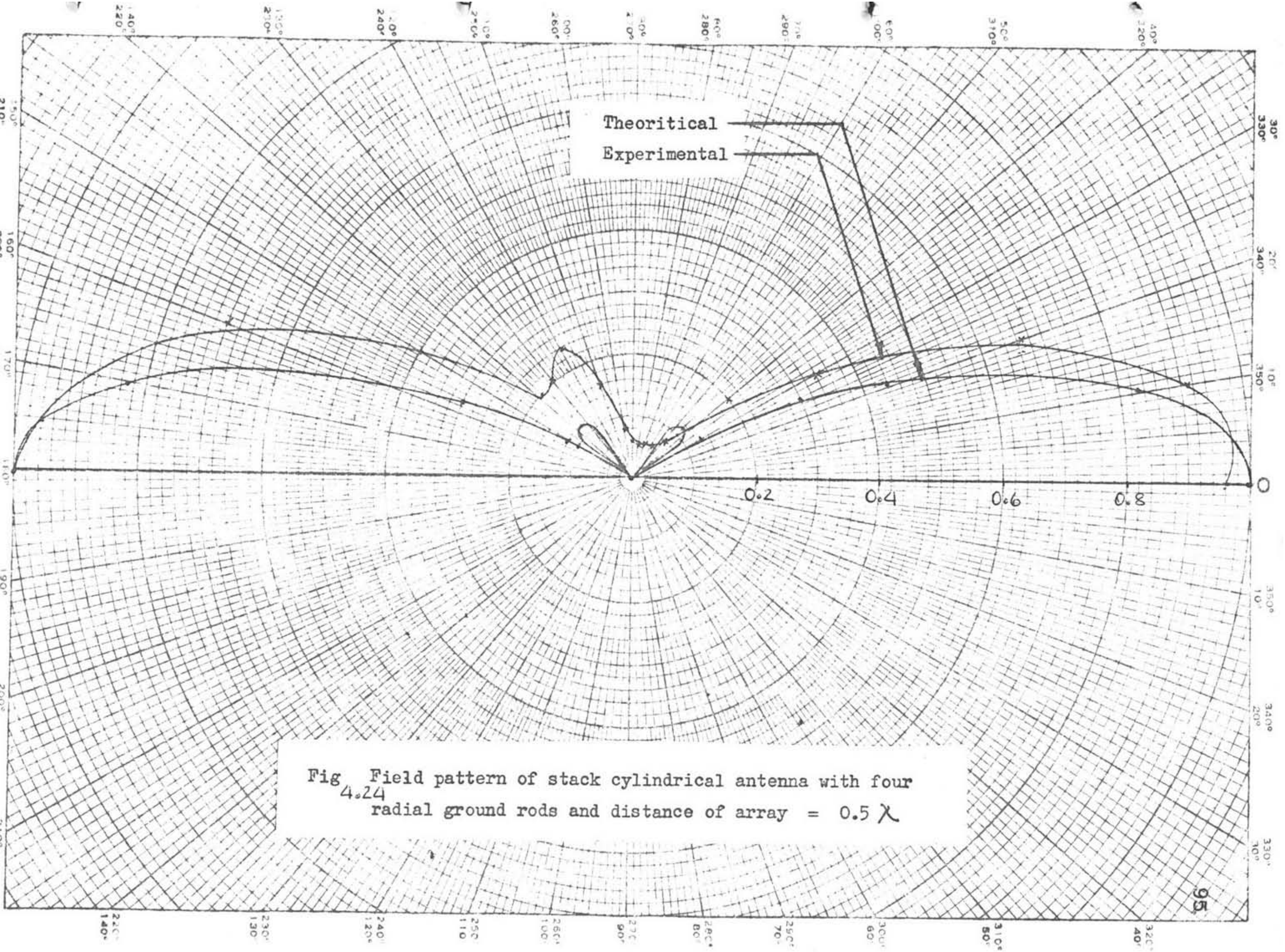


Fig 4.24 Field pattern of stack cylindrical antenna with four radial ground rods and distance of array = 0.5 λ

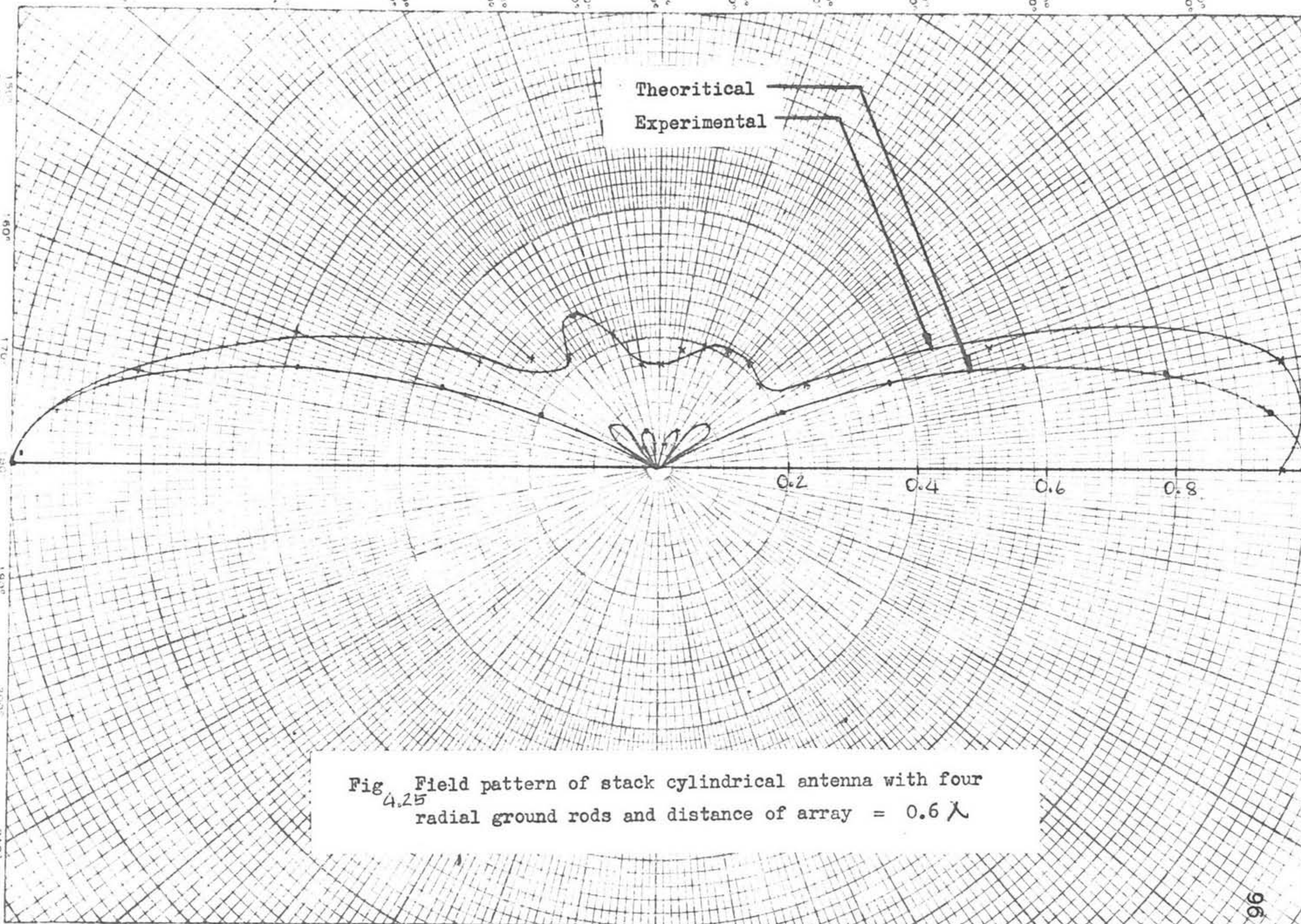


Fig 4.25 Field pattern of stack cylindrical antenna with four radial ground rods and distance of array = 0.6 λ