2/5/62

Line 114.5 feet long, Parallel wires 7 inches apart

Capacity		Low Mode Frequency	Low Mode Reactance	High Mode Frequency	High Mode Reactance
pf		MC	Ohms.	MC	Ohms.
27		3.99	−2950	7.80	−1510
37		3.88	2220	7.63	1130
56		3.72	1530	7.43	766
99		3.42	940	7.15	450
199		3.04	526	6.80	236
490		2.70	241	6.50	100
1100		2.36	−123	6.40	−45
∞		2.21	0	6.30	0

Two series capacitors in each

Inductance					
uh					
5.7	Dial	1.96	+70	5.90	+211
11.0	Disc.	1.85	128	5.58	385
21.2	2.57C	1.66	221	5.16	687
37.5	1.12C	1.43	337	4.83	1140
84	6.60B	1.095	578	4.50	2380
178	2.95B	0.805	900	4.33	4840

21/4/64

Down lead Design

Choose frequency bands

1.95 to 2.35 mc, 2.15 mc center, 18.6% wide
6.20 to 6.80 mc, 6.50 mc center, 9.2% wide
Geometric mean 3.74 mc, Ratio 6.50/2.15 = 3.02

$Z = 276 \log_{10} \frac{D}{r}$; wire = 0.080" diameter; r = 0.040"
When D = 2", Z = 469 ohms; D = 7", Z = 619 ohms;
D = 38", Z = 822 ohms; D = 72", Z = 898 ohms

Required 90° = λ/4 length; 2.15 mc = 114.5 ft; 6.50 mc = 37.8 ft

Line Length Z = 469 ohms,							Each Series		Trap
Actual	Cancel at 6.50 mc			Add at 2.15 mc			Capacity	Inductance	Resonance
Feet	feet	degrees	ohms	feet	degrees	ohms	pf.	μh	MC
65.7	27.9	66.4	1075	48.8	38.4	372	45.7	13.8	6.34
57	19.2	45.7	482	57.5	45.2	472	102	17.5	3.77
55	17.2	41.0	407	59.5	46.7	498	121	18.4	3.37
52	14.2	33.8	314	62.5	49.1	541	157	20.1	2.84
50	12.2	29.0	260	64.5	50.7	573	189	21.2	2.52
48	10.2	24.3	212	66.5	52.3	606	232	22.5	2.20

Too long down lead causes trap to resonate in high band
Too short down lead causes trap to resonate in low band.
Optimum causes trap to resonate near geometric mean frequency
The electrical length to be cancelled at higher frequency equals the electrical length to be added at lower frequency.
Both are near 45° when frequency ratio is near 3.0 This will hold for all line impedances. Raising Z will cause C to decrease and L to increase proportionately. Thus LC will remain fixed.

(over)

Construct prototype down lead 51 feet long 8/5/64.
49 ft from pulley to bottom insulator; 2 ft to tuner box.
Make 7" apart at bottom and 16" apart at top.
Two 3 μh inductance at bottom to represent the primary of coupler transformer.
Adjust traps to resonate system at 2.15 mc and 6.50 mc
Measure the reactance characteristic.
Mount line vertically and repeat.

Actual coils 23 turns 1.5" long 0.685" diameter
$\ell/d = 1.5/.685 = 2.19$, $n = 23$, $L/d = 5$, $L = 3.4$ μh
Actual 3.0 μh by measurement on 18/5/64

29/4/04

Sample down lead 57 ft long
Spacing 2" at rear end, 38" at fore end.

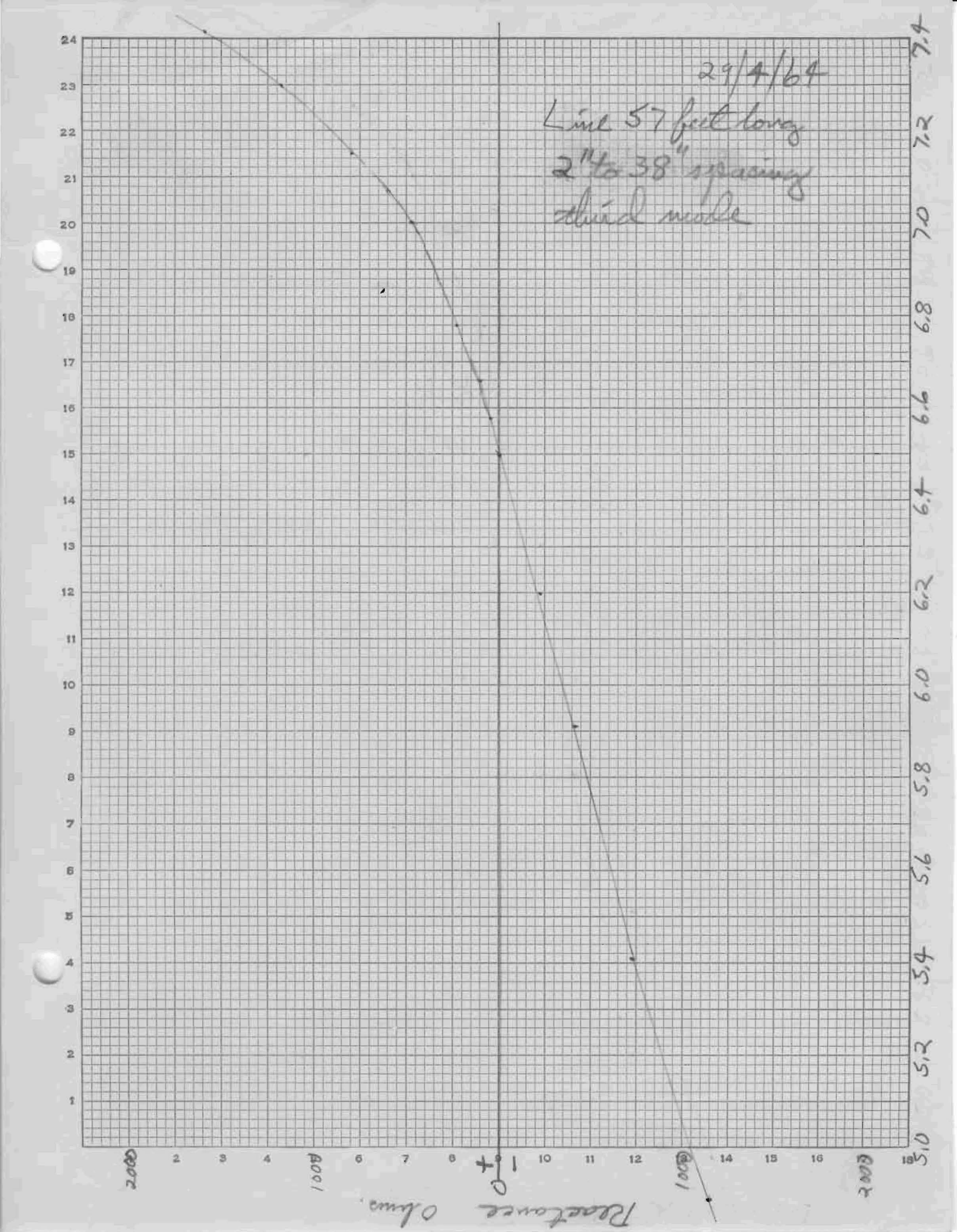
Mode.	Low		High	
Capacity pf.	Freq MC	X_c ohms.	Freq MC	X_c ohms.
27	3·38	3490	7·42	1590
37	3·16	2740	7·30	1180
56	3·03	1880	7·15	796
99	2·82	1140	7·00	460
199	2·59	618	6·78	236
490	2·37	274	6·66	98
1100	2·26	128	6·58	44
2600	2·19	56	6·53	19
∞	2·15	0	6·50	0

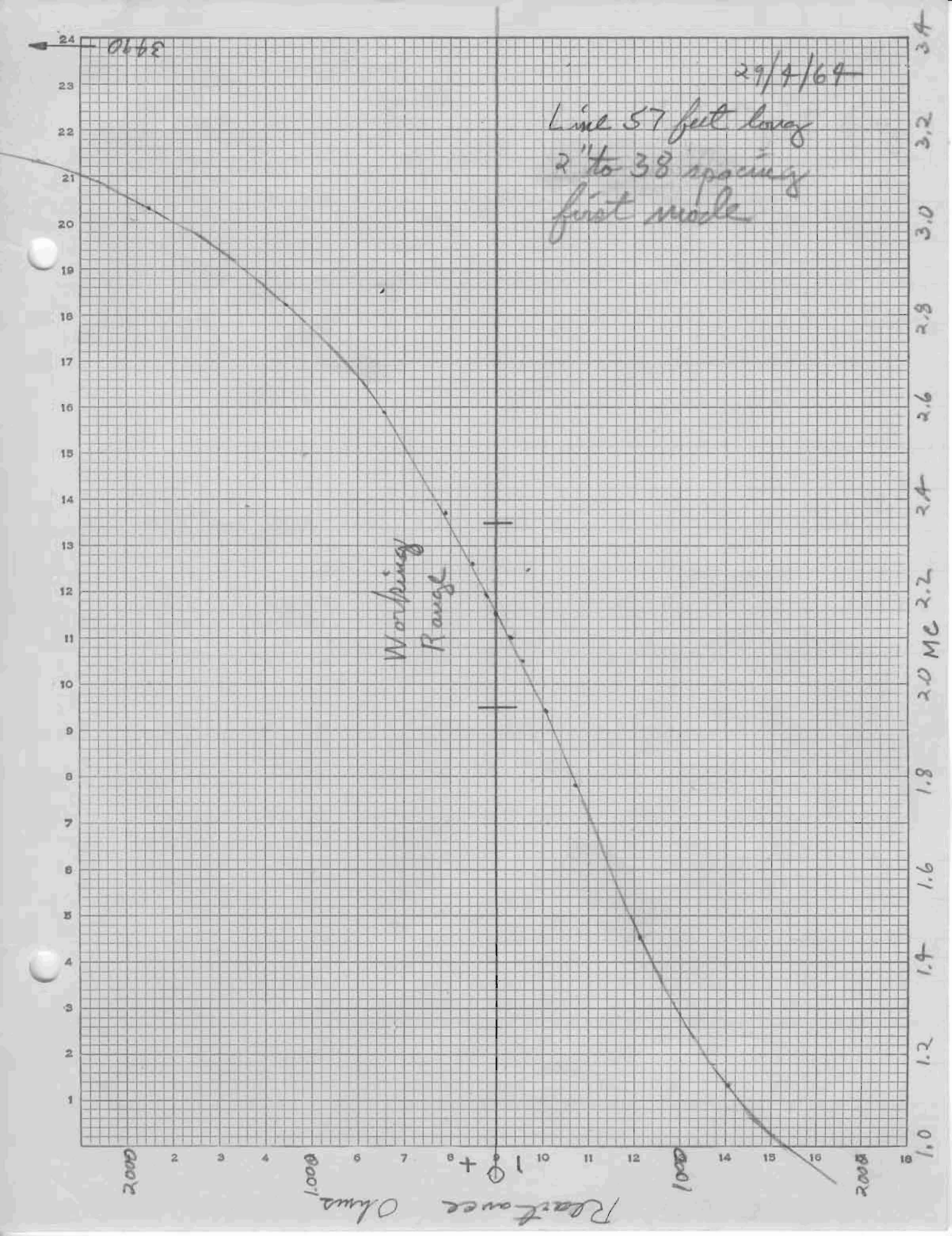
Inductance uh	Dial Divs	Freqn MC.	X_L ohms	Dial Divs.	Freqn MC	X_L ohms
5.7		2.10	75		6·20	222
11.0		2.05	141		5·91	408
21.2		1.94	258		5·41	720
37.5		1.78	420		4·88	1150
84.	1.25 C.	1.45	764		4·22	2230
178	6.98 B.	1.13	1265		4·20? 3,85 probable	4700

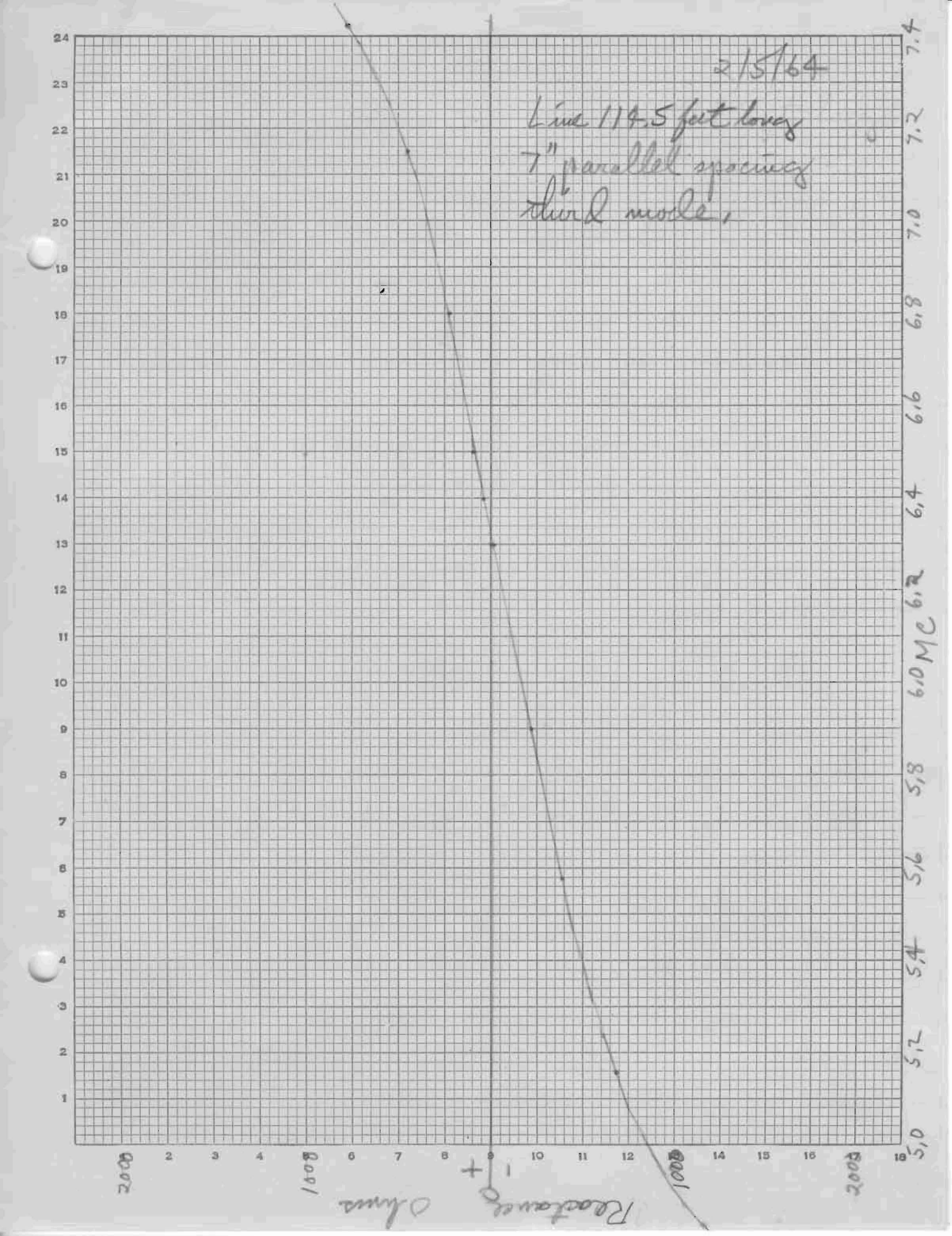
Coils are 21 turns 11" dia 16 = long on right, 2 1/2" = long on left, 3/4" diameter
Coils are 3" long, 1/8" diameter

Looking at assembly from back

Trap circuit on:	Right	Left.
Capacity	107 pf	110 pf.
Coil in air	L = 1.78 uh, C_o = 2 pf	L = 1.92 uh, C_o = 2 pf
Coil with core	L = 16.8 uh, C_o = 2 pf	L = 18.1 uh, C_o = 2 pf
2.15 mc	μ = 9.44, Q = 215	μ = 9.43, Q = 233
Resonant Frequency	3.72 mc computed 3.82 mc observed	3.53 mc computed 3.65 mc observed


29/4/64
Line 57 feet long
2" to 38" spacing
third mode
Resistance Ohms.


29/4/64
Line 57 feet long
2" to 38 spacing
first mode
3990
Working Range
Resistance Ohms
2000
1000
1000
2000
2.0 MC


2/5/64
Line 114.5 feet long
7" parallel spacing
third mode,
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0 MC
5.8
5.6
5.4
5.2
5.0
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
2000
1000
+
-
1000
2000
Roadway
Shoulder

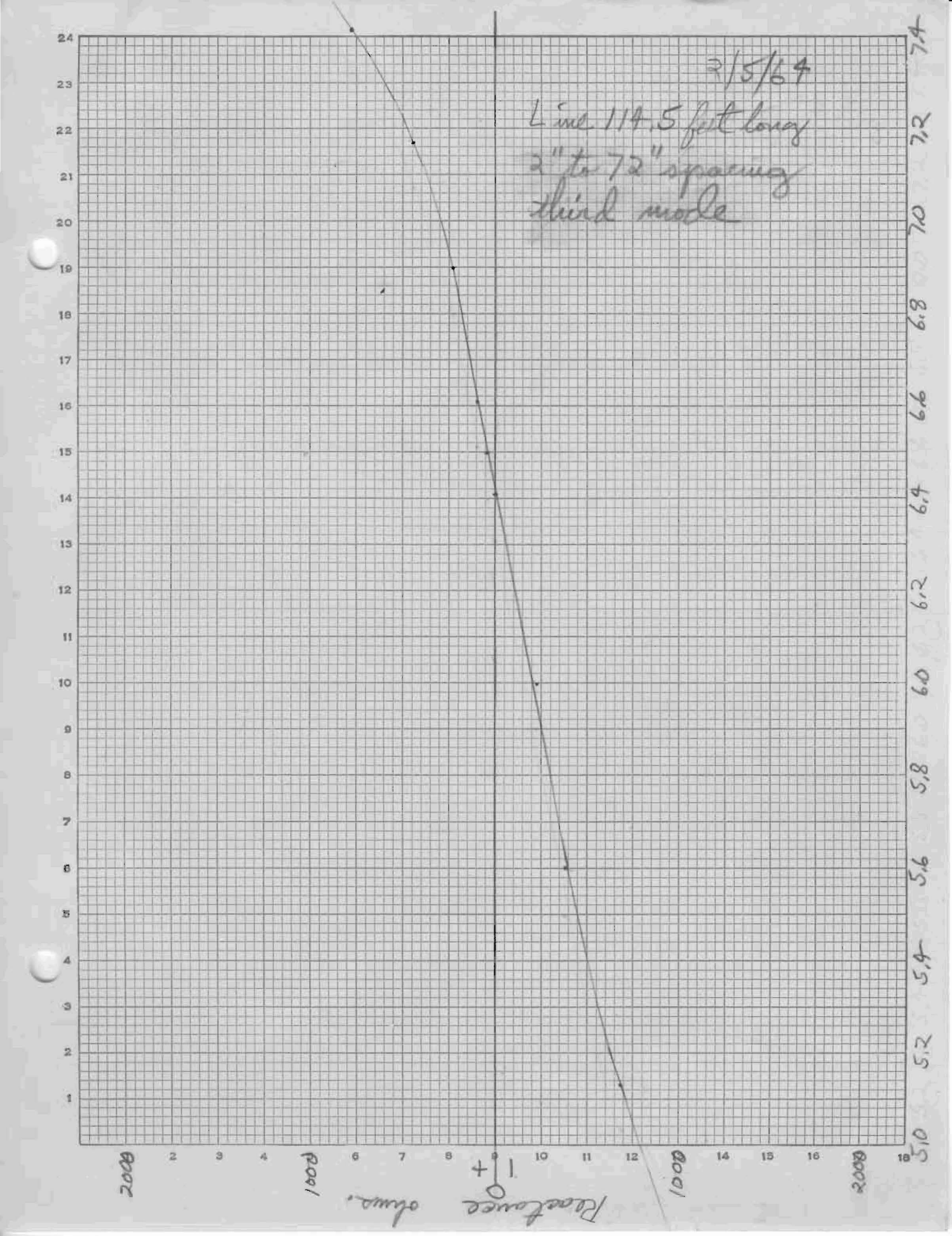
2/5/64

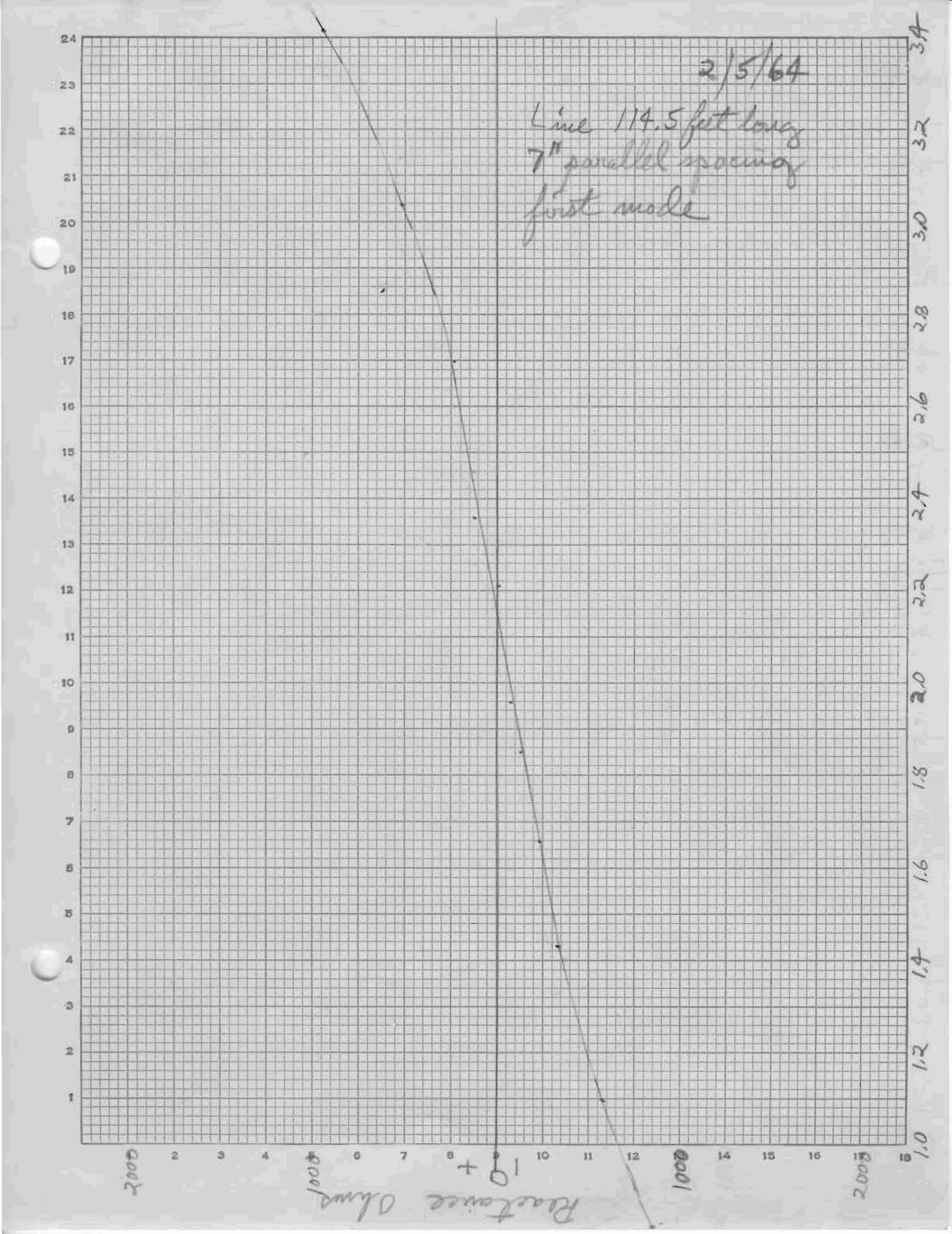
Line 6 feet apart at far end; 2 inches apart at near end.
Line 116 feet long, resonances at 2.22 mc & 6.38 mc
" 114.5 " " " 2.25 & 6.41

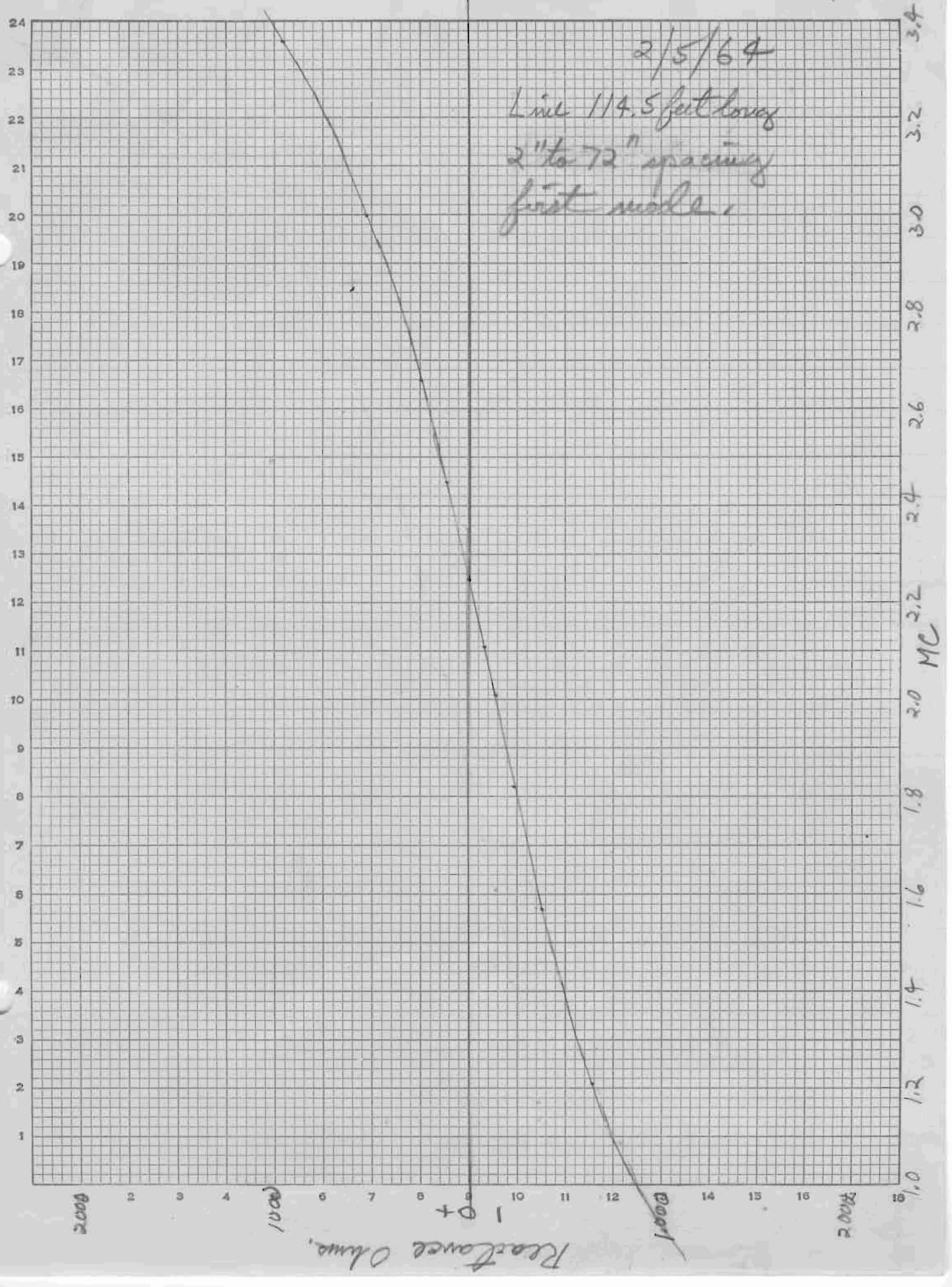
Two Series Capacitors Each

Capacity pf	Low Mode Frequency Mc	Low Mode Reactance Ohms.	High Mode Frequency Mc	High Mode Reactance Ohms.
27	3.79	3120	7.75	1524
37	3.75	2300	7.60	1133
56	3.60	1580	7.42	767
99	3.36	958	7.17	499
199	3.00	533	6.90	232
490	2.66	250	6.61	100
1100	2.45	118	6.50	45
∞	2.25	0	6.41	0

Inductance uh					
5.7		2.11	75	6.00	220
11.0		2.01	139	5.60	388
21.2	Dalbir.	1.82	242	5.15	683
37.5	2.10 C	1.57	370	4.77?	1125
84.0	7.90 B	1.21	638	4.38	2310
178	4.20 B	0.90	1010	4.20	4700


2/5/64
Line 114.5 feet long
2" to 72" spacing
third mode
Resistance ohms
2000
1000
1000
2000
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0
5.8
5.6
5.4
5.2
5.0


2/5/64
Line 114.5 feet long
7" parallel spacing
first mode
Reactance ohms
2000
1000
0
1000
2000
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4


2/5/64
Line 114.5 feet long
2" to 72" spacing
first mode.
MC
Reactance Ohms.

6/5/64

Line 57 feet long, Parallel wires 7 inches apart

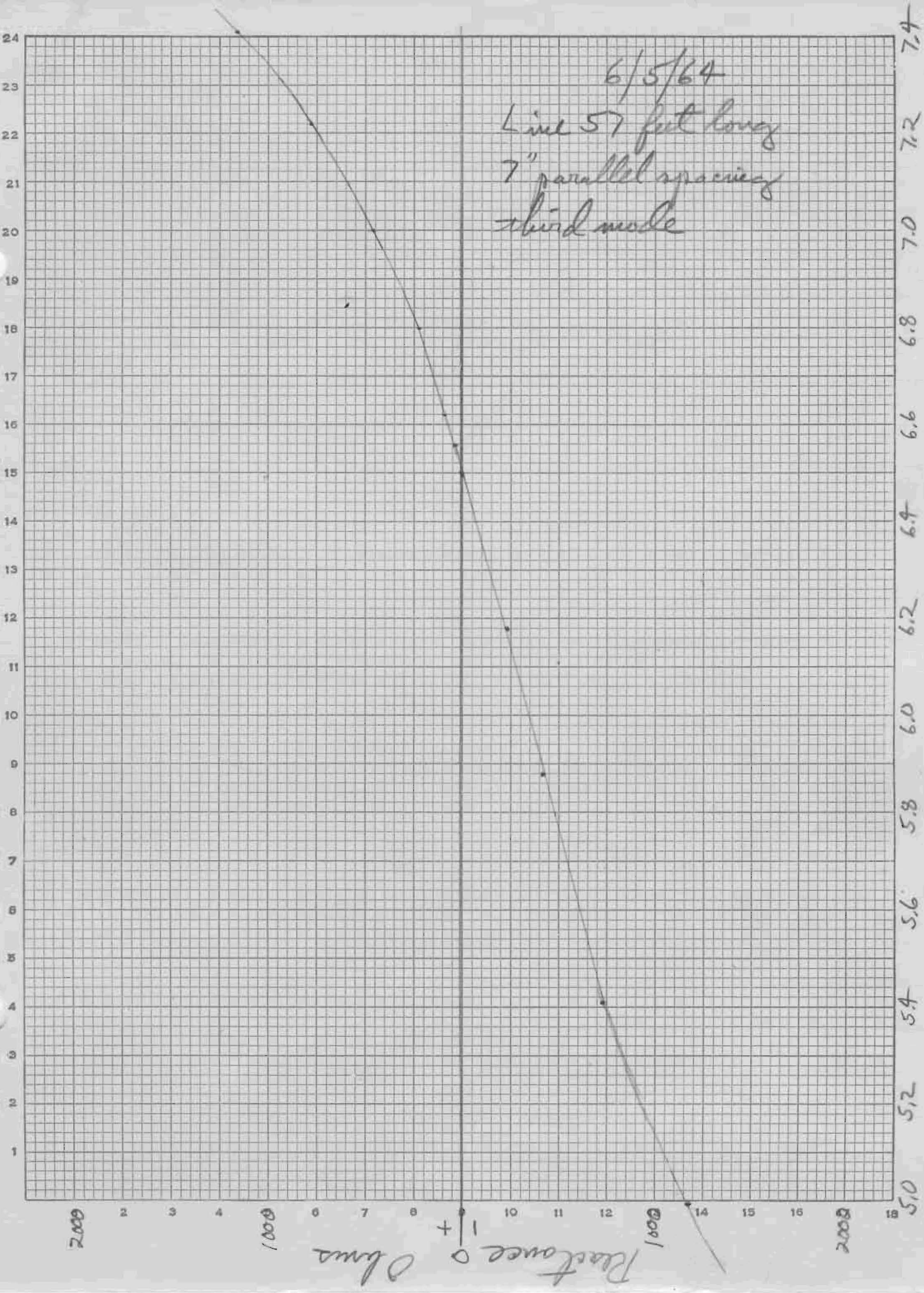
Capacity pf		Low Mode Frequency MC.	Low Mode Reactance Ohms	Hugle Mode. Frequency MC	Hugle Mode. Reactance Ohms.
Two variable capacities each	27	3.42	-4500	7.58	-1560
	37	3.33	2580	7.41	1160
	56	3.19	1780	7.22	787
	99	2.95	1090	7.00	459
	199	2.68	597	6.80	235
	490	2.41	270	6.62	98
	1100	2.29	-126	6.56	44
	∞	2.16	0	6.50	0

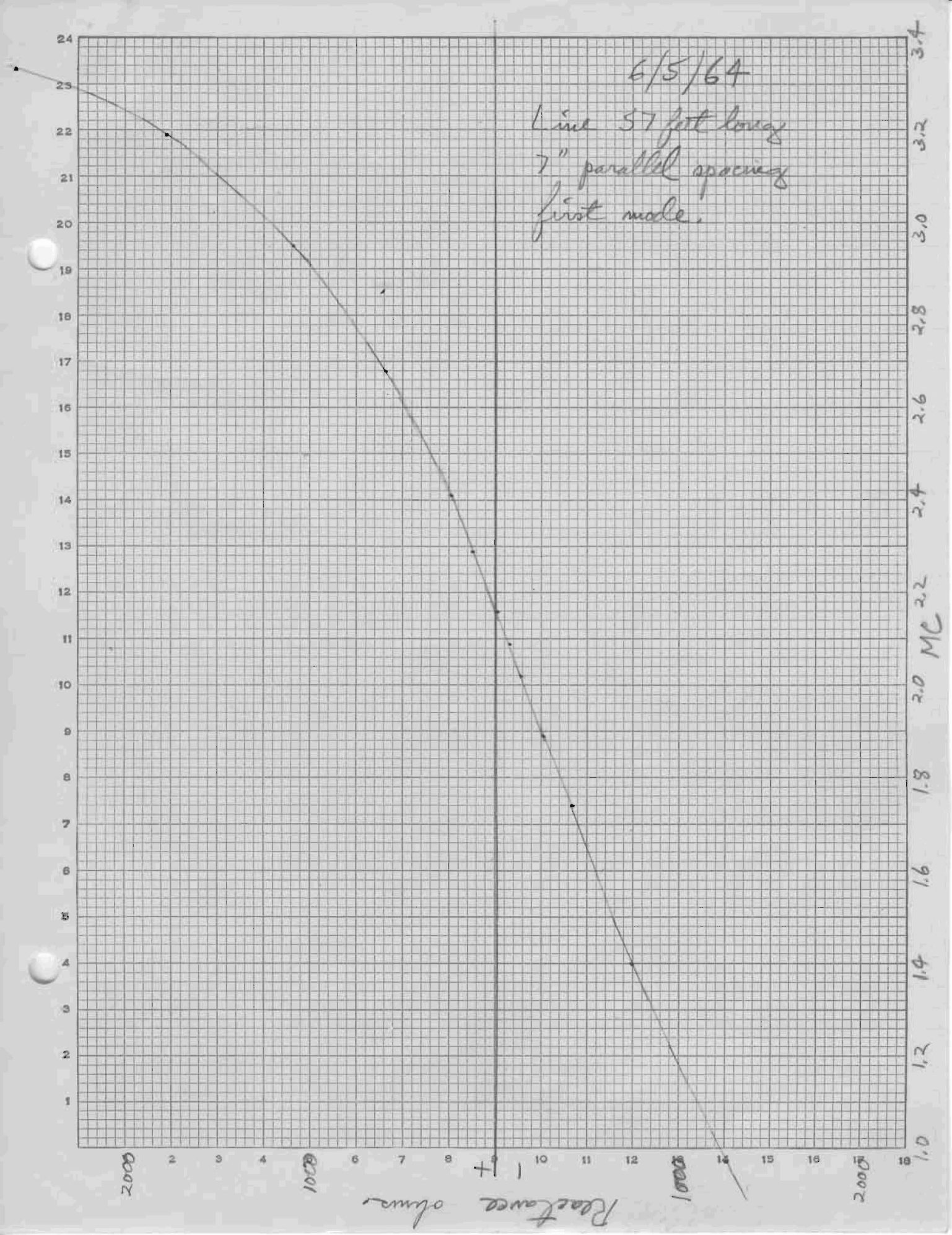
Inductance uh					
5.7		2.09	+75	6.18	221
11.0	Dial Div.	2.02	140	5.88	406
21.2		1.89	252	5.41	722
37.5		1.74	410	4.95	1166
84	0.88 c	1.40	740	4.35	2300
178	6.40 b	1.08	1240	4.00	4470

Trap.

Viewed from rear:	Right	Left.
Observed resonance	3.83 mc	3.82 mc
Capacity	108 pf.	112 pf.
C_o of coil with core	2 pf	2 pf.
L " " " "	15.6	15.0
Q " " " " at 2.15 mc	292	278
Computed resonant frequency	3.84 mc	3.85 mc

Coils are 18 turns 11/16" dia, 2 1/4" long, #14 Cores are 3" long


6/5/64
Line 57 feet long
7" parallel spacing
third mode
Reactance Ohms
2000
1000
+
0
-
1000
2000
5.0
5.2
5.4
5.6
5.8
6.0
6.2
6.4
6.6
6.8
7.0
7.2
7.4


6/5/64
Line 57 feet long
7" parallel spacing
first mode.
Resistance ohms
MC

8/5/64

Synopsis

A. When line is shortened physically and lengthened electrically, the rate of reactance change is about doubled; first mode.

B. When line is lengthened physically and shortened electrically, the rate of reactance change is increased about one third; third mode

C. When line is gently fanned out at far end, the rate of reactance change is increased about one fifth; first mode. No perceptable change on third mode.

D. When both A and C are done the rate of reactance change is increased additional one sixth; first mode.

E. When both B and C are done, no perceptable additional change on third mode.

Changing physical length of line and correcting electrically, increases rate of reactance change in both first and third modes, A and B.

Fanning out end of line increases rate of reactance change in first mode but not third mode C.

24/5/64

Shortening the line from 57 to 51 feet flattened the reactance of third mode but made no appreciable effect on first mode.

Fanning wires 7" to 15" produces a first mode reactance characteristic between a parallel wire line and one fanned 2" to 38".

(over)

31/5/64

The 51 ft line was setup vertically along a pole. The fittings consisting of pulleys etc at top added some capacity across open end of line. This had effect of increasing line length when viewed from bottom. Consequently the resonant frequencies were a bit low when same circuit constants were used as on 23/5/64. These values are given in parenthesis for reference. A simple correction was made by reducing capacity of traps. No alteration of inductance was necessary.

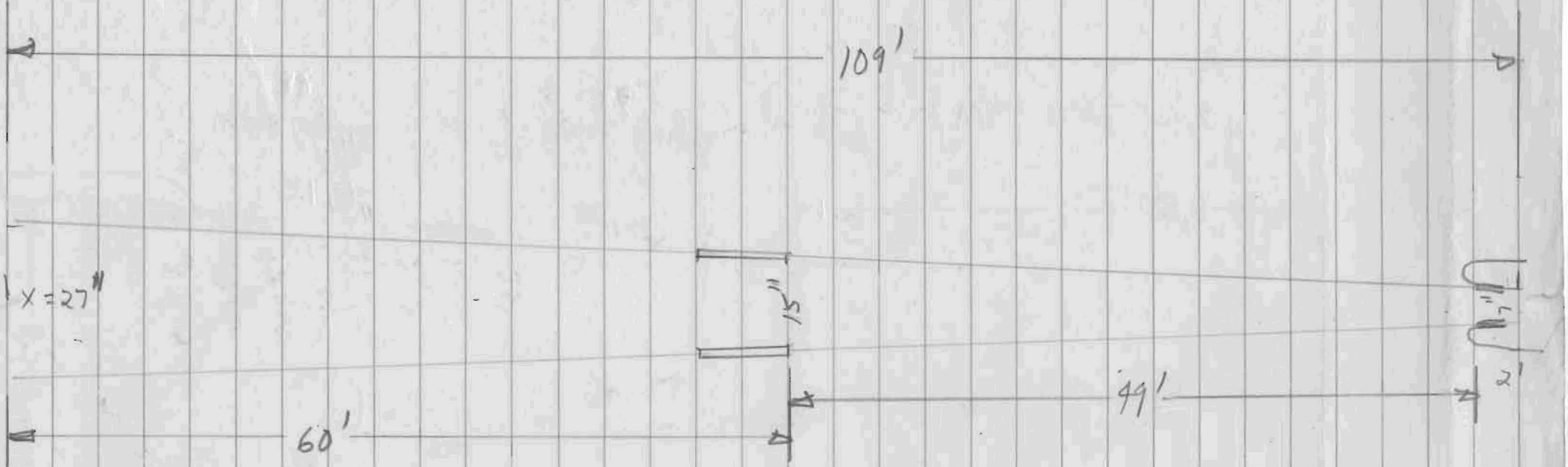
The effect of these changes was not significant at first mode. The rate of reactance change increased about thirty percent on third mode.

12/7/64

All the above is rather unimportant because the rate of change of reactance of complete system is very much faster than down leads only. Consequently the exact length, spacing and fanning of down leads may be neglected in the entire system.

T	MC
23	1,74
21	1,84
19	1,95
17	

20/5/64

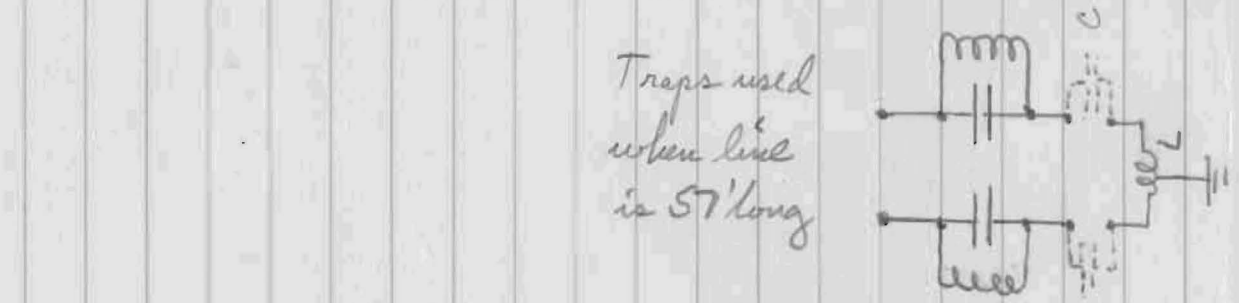


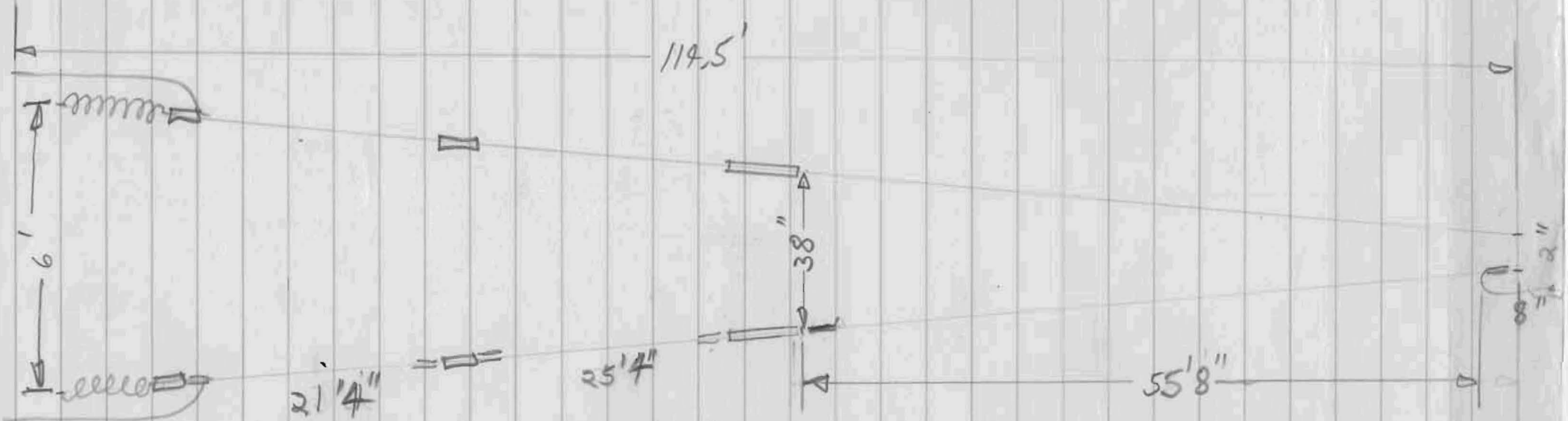
$X = 7'' + \frac{109}{49} \times 9'' = 7'' + 20'' = 27''$

line = 99'
tape = 2'
sleeves = 1' 3"
Wire 52' 3"

55' 8"
49' 0"
6' 8"
1. 4)
8'-

2/4/64





Wire length
22'

Wire length
26'

Wire length 57'6"

55' 8"	57' 6"
8"	56' 9"
56' 4"	3 1' 2"

5" per sleeve.

18/5/64

Freq MC	Cap pf	Q	R ohms
Coil A			
5	340	168	0,55
10	84	225	0,82

$C_0 = \frac{340 - 4 \cdot 84}{3} = \frac{4}{3} = 1.3\,pf$

$L_0 = 1/(6.28 \cdot 5 \cdot 10^6)^2 \cdot 341 \cdot 10^{-12}$

$= 1/988 \cdot 341 = 2,97\,\mu h$

$R = \omega L/Q = 18.6\,MC/Q$

Coil B			
5	341	169	0,55
10	84	227	0,82

$C_0 = \frac{341 - 4 \cdot 84}{3} = \frac{5}{3} = 1.6\,pf.$

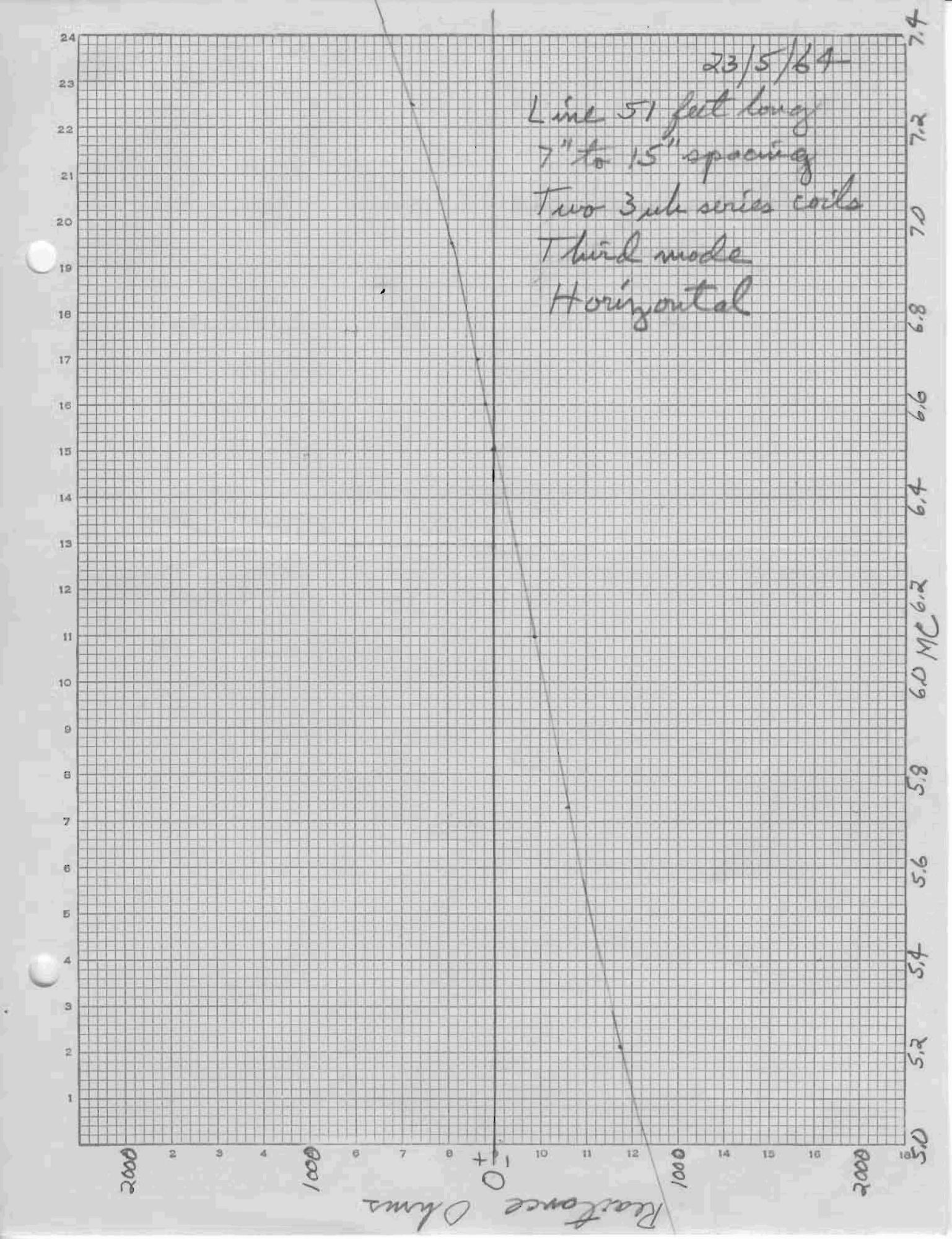
$L_0 = 2.96\,\mu h$

Series coils to represent primary of coupler transformer.

at 6.5 MC R ∞ 0.65 ohm

at 2.15 MC R ∞ 0.3 ohm

Coils 23 turns 1.5" long, 0.81" diameter


23/5/64
Line 51 feet long
7" to 15" spacing
Two 3 ele series coils
Third mode
Horizontal
Reference Ohms
2000
1000
0
1000
2000
6.0 MC

23/5/64.

Horizontal

Lines 49' long 7" to 15" plus 2' tabs. Total 51 ft long
Plus two 2.96 μh coils to represent primary of antenna coupler.

capacity pf	Low Mode Frequency MC	Reactance Ohms	High Mode Frequency MC.	Reactance Ohms
27	3.41	− 3460	8.10	− 1460
37	3.21	2680	7.90	1090
56	3.09	1840	7.61	748
99	2.88	1115	7.25	443
199	2.61	613	6.95	230
490	2.39	276	6.70	81
1100	2.27	− 128	6.60	− 44
∞	2.15	0	6.50	0

Inductance μh.	dial div.				
5.7		2.10	+ 75	6.10	+ 218
11.0		2.04	141	5.73	396
21.2	4.67 02	1.92	256	5.21	693
84.0	5.00	1.44	760	4.14	2190
178.0	2.22	1.11	+ 1240	3.82	+ 4280

Trap

Viewed from rear	Right	Left
Observed resonance	3.67 mc	3.62 mc
Capacity	115 pf	114 pf
Cd of coil with core	2 pf	2 pf
L " " " "	16.2 μh	15.8 μh
Q " " " " at 2.15 mc	266	257
Computed resonant frequency	3.66 mc	3.72 mc

Coils are 17 turns, 11/16" dia, 1 7/16" long. = 11 tpi
Cores are 1/2" diameter, 3" long

Vertical

30/5/64

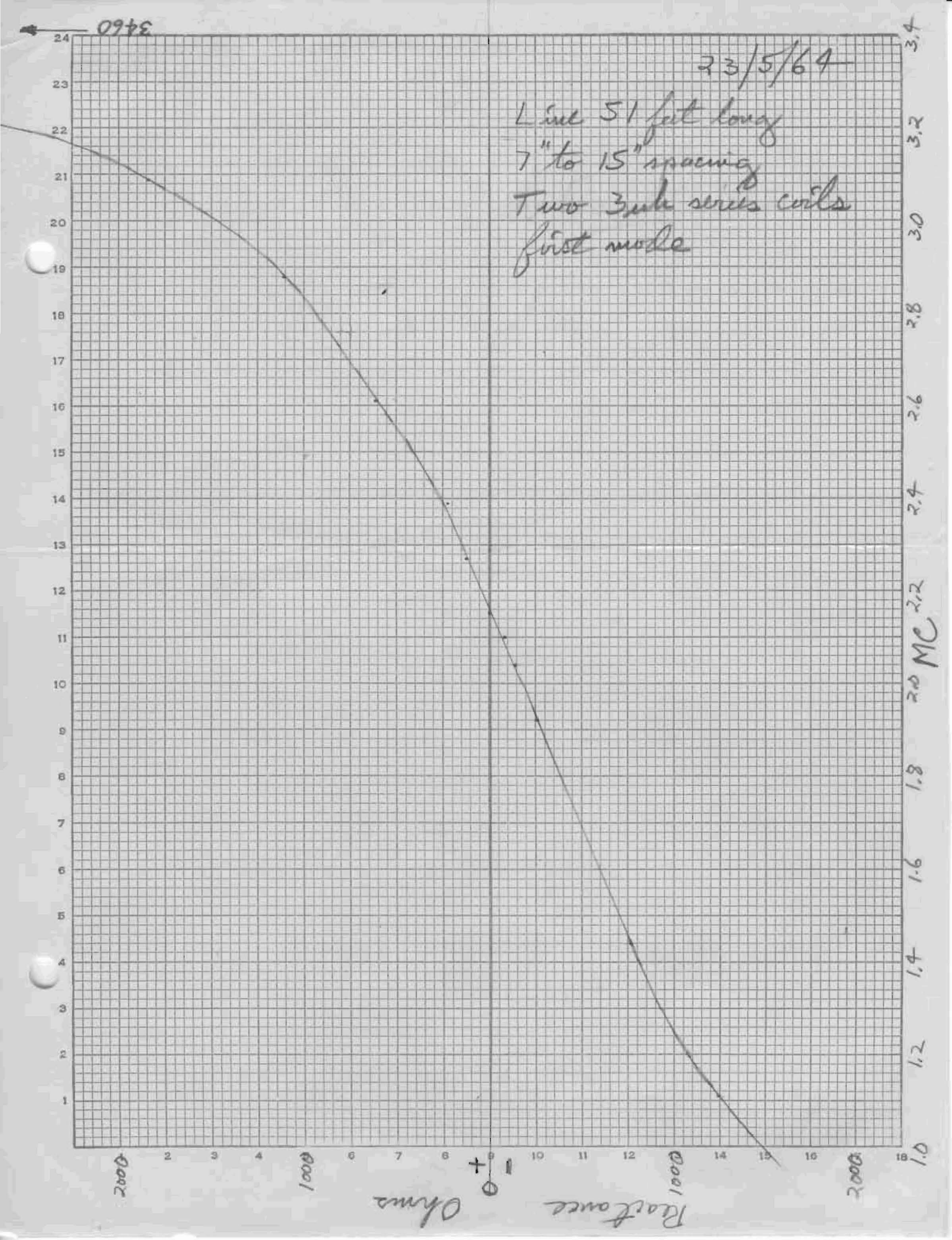
Same arrangement as 23/5/64

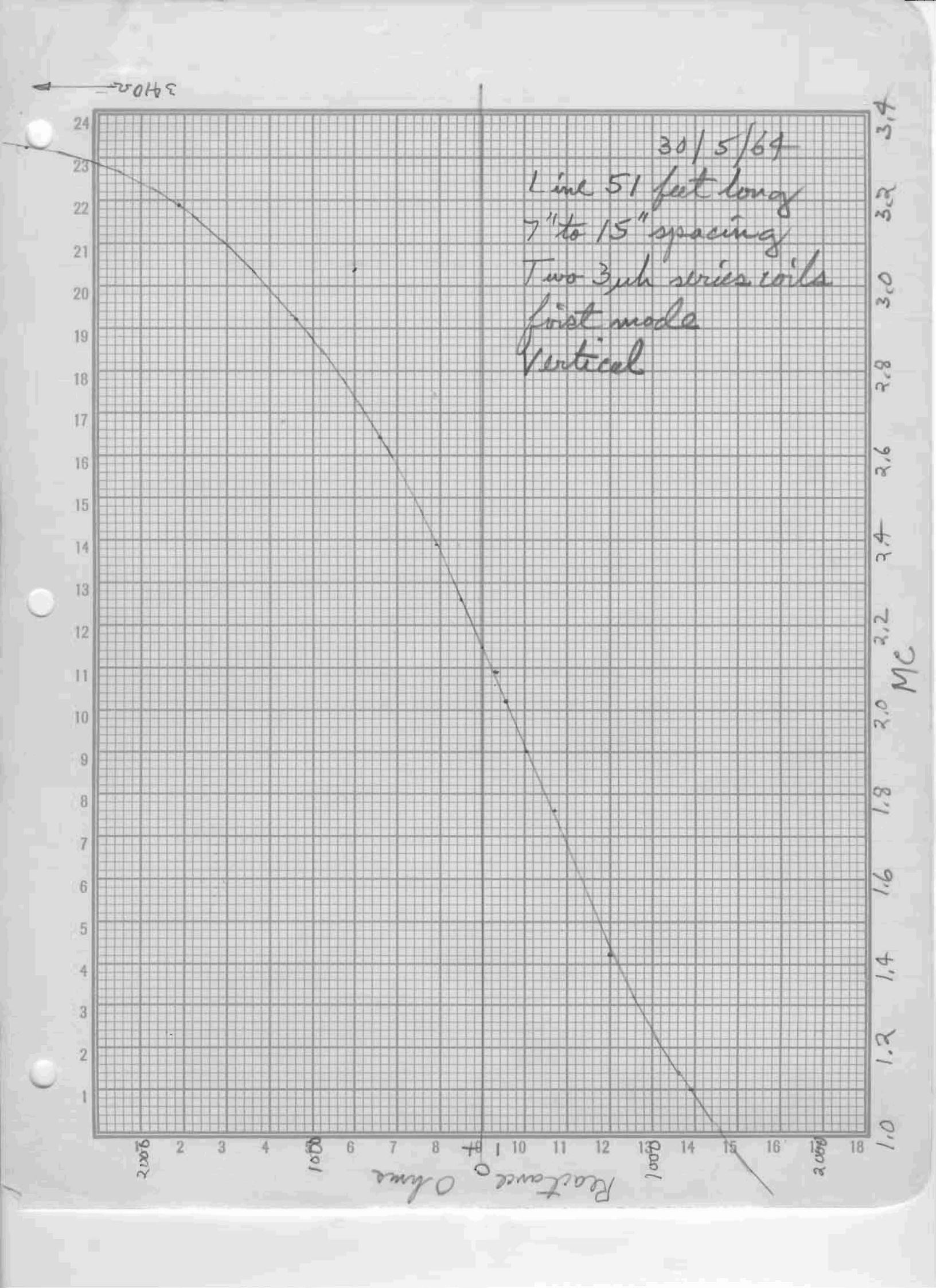
Capacity pf.	Low Mode Frequency Mc	Low Mode Reactance Ohms.	High Mode Frequency Mc	High Mode Reactance Ohms.
27	3.46	-3410	7.86	-1500
37	3.32	2590	7.64	1125
56	3.19	1780	7.40	770
99	2.92	1100	7.15	458
199	2.64	606	6.85	234
490	2.39	272	6.63	98
1100	2.26	-135	6.58	-44
∞	2.15	0	6.50	0
∞	(2.18)	0	(6.28)	0

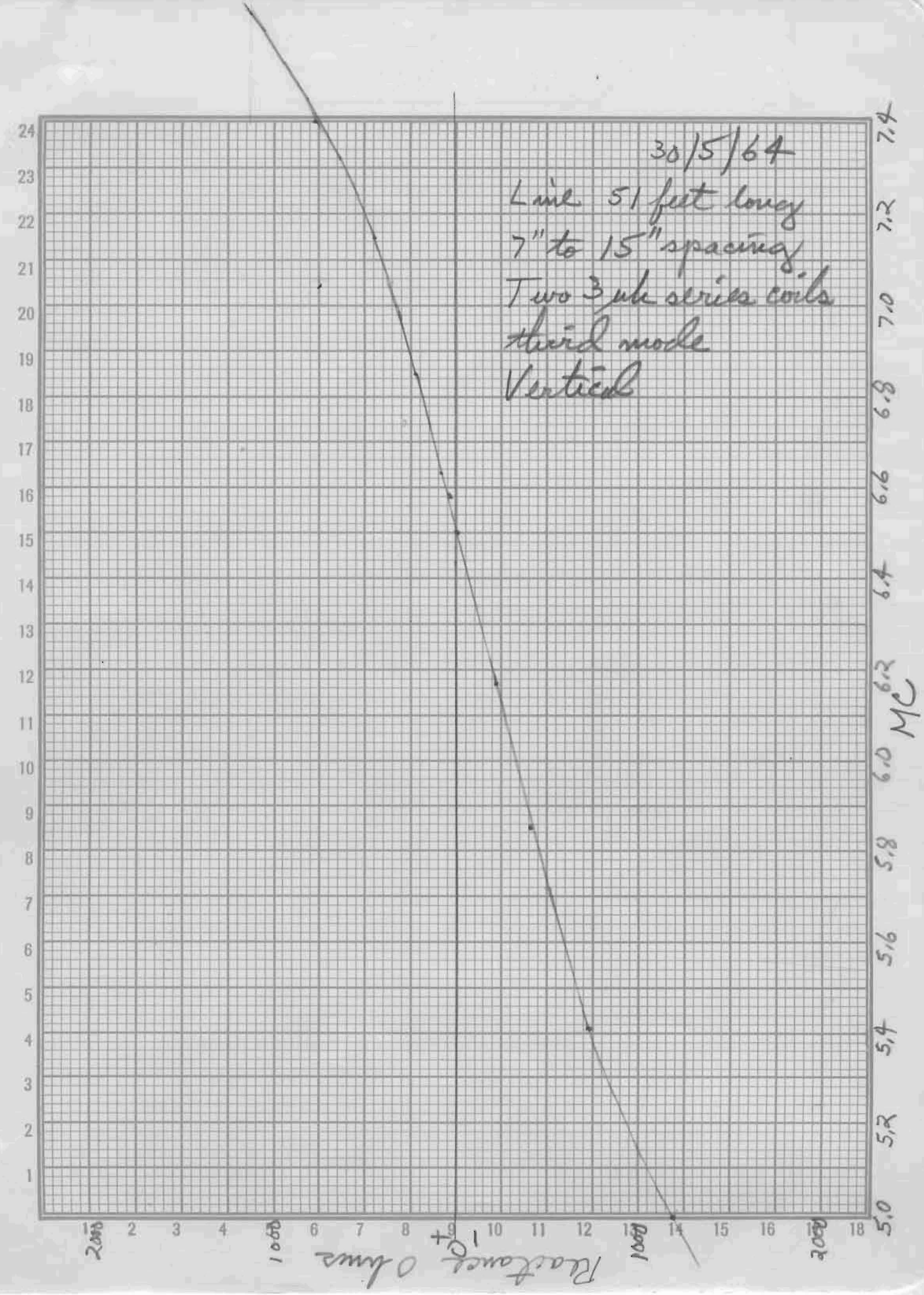
Resonances with trap capacity 115pf as 23/5/64

Inductance uh					
5.7	Dial Drive #46702	2.09	+ 75	6.17	+221
11.0		2.02	140	5.85	404
21.2		1.90	253	5.41	720
37.5		1.76	414	4.99	1175
84	4.83	1.42	750	4.40	2320
178	2.10	1.10	1230	4.05	4530

Viewed from rear	Trap Right	Trap Left
Observed resonance	3.96 mc	3.96 mc
Capacity	100 pf.	102 pf.
Coils	same as 23/5/64	
Computed resonance	3.92	3.93


3460
23/5/64
Line 51 feet long
7" to 15" spacing
Two 3 mh series coils
first mode
MC
Ohms
Reactance


30/5/64
Line 51 feet long
7" to 15" spacing
Two 3 pole series coils
first mode
Vertical
MC
Resistance Ohms


30/5/64
Line 51 feet long
7" to 15" spacing
Two 3 μh series coils
third mode
Vertical
Mc
Reactance Ohms
2000
1000
1000
2000
+ -
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0
5.8
5.6
5.4
5.2
5.0