JOHN H. MULLANEY, P.E.
JOHN J. MULLANEY

MULLANEY ENGINEERING, INC.
9049 SHADY GROVE COURT
GAITHERSBURG, MD 20877

301 921-0115

June 7, 1989

Bill Fawcett
Mountain Valley Broadcast Services, Inc.
Route 3, Box 308
Harrisonburg, VA 22801

RE: WNLR Folded Unipole Design

Dear Bill:

We have completed our design on the WNLR Folded Unipole System per our discussions. In addition we also checked out the series-fed bandwidth vs the folded unipole.

For ease of reading we will treat each design separately.

FOLDED UNIPOLE DESIGN

We have designed assuming the three folds come off the **side** of the tower. Spacing of the folds from the side is 36 inches. The width of your tower is 18 inches, the radius of the fold wire is approximately 0.102 inches and the folds would be bonded to the tower at the approximate 90° point.

Using these assumptions the **stub point** on the tower is approximately 112 feet. This obtains a base impedance of:

50.1 j 336.4

The following is a tabulation of the base impedance vs frequency with a stub 112 feet from the top of the tower.:

FREQUENCY (kHz)	RESISTANCE (R)	REACTANCE (jX)
1120.	47.623	304.952
1125.	47.974	309.984
1130.	48.349	315.091
1135.	48.747	320.279
1140.	49.169	325.550
1145.	49.616	330.908
1150.*	50.088	336.357
1155.	50.585	341.901
1160.	51.109	347.545
1165.	51.659	353.292
1170.	52.237	359.147
1175.	52.843	365.115
1180.	53.479	371.201

* = Operating Frequency

Figure 1 attached is a Schematic Diagram of A -86.2^{o} T-Network which we recommend for your design. The following tabulation furnishes the resulting impedances and VSWR at the input of this network:

FREQUENCY (kHz)	RESISTANCE (R)	REACTANCE (jX)	VSWR
1165	42.29	-16.83	1.49
1160	46.00	-12.92	1.32
1155	48.97	- 6.91	1.15
1150	50.00	0.0	1.00
1145	49.22	+ 5.99	1.15
1140	46.90	+11.38	1.28
1135	42.77	+16.30	1.47

Your attention is called to the fact that this network is actually a T-Net and Series-Net in series. The series portion is C1 plus a portion of L1.

When we consider the effect of this series network it further reduces the side band reactances as follows:

FREQUENCY (kHz)	RESISTANCE (R)	REACTANCE (jX)	VSWR
1165	42.29	- 2.49	1.19
1160	46.00	- 3.34	1.11
1155	48.97	- 2.11	1.05
1150	50.00	0.0	1.00
1145	49.22	+ 1.16	1.03
1140	46.90	+ 1.17	1.08
1135	42.77	+ 1.76	1.17

We next look at the output of your transmitter or transmission line to antenna coupling unit. Inasmuch as your line is 180 feet or -95.8° in length this further reduces the side band reactance which will give you good overall bandwidth. The results are:

FREQUENCY (kHz)	RESISTANCE (R)	REACTANCE (jX)	VSWR
1165	59.570	+ 0.98	1.19
1160	54.925	+ 2.86	1.11
1155	51.429	+ 1.94	1.05
1150	50.00	0.0	1.00
1145	50.520	- 1.32	1.03
1140	52.832	- 2.48	1.08
1135	57.780	- 3.77	1.17

Table I attached is the T-Network printout without the series portion of C1 and part of L1.

The following tabulation is a list of the network components:

ITEM	QUANTITY	DESCRIPTION
J-1	1	J-Plug
J-2	1	J-Plug
C-1	1	Vacuum Capacitor JCS 250-15$ Pfd (15 kV, 70A)
C-2	1	Mica Capacitor Type 292-152, 1500 Pfd (10 kV, 12A)
C-3	1	Vacuum Capacitor JCS 250-10$ 483.00 Pfd (10 kV, 65A) 15-16 weeks
C-4	1	Variable Vacuum Capacitor UCS 25-500 Pfd (7.5 kV, 60A)
L-1	1	Fixed Inductance 200-105, 120 UH, 10A
L-2	1	Fixed Inductance L10-20A
M-1	1	10 Amp Delta Meter
T-1	1	Delta TTT-4 Torodial

You asked if we recommended using a straight variable vacuum capacitor in series with the antenna and no T-Net. This will work but you will have poor bandwidth. Using your 120 microhenry coil along with vacuum would improve the net results, but it would not be as good as the Series-T or present series-fed.

SERIES-FED DESIGN

As we discussed, based on the information you have furnished us we believe the best course WNLR could follow would be to replace their broken base insulator and re-design their T-Network.

Figure 2 attached, is a schematic diagram of a -57.24^{o} T-Network using the following base impedances:

FREQUENCY (kHz)	RESISTANCE (R)	REACTANCE (jX)
1165	162	246
1160	156	238
1155	152	236
1150	146	233
1145	141	231
1140	136	229
1135	133	225

At the input of the T-Network the resulting impedances and VSWR are:

FREQUENCY (kHz)	RESISTANCE (R)	REACTANCE (jX)	VSWR
1165	50.698	-5.94	1.126
1160	49.835	-3.18	1.066
1155	49.979	-1.99	1.041
1150	50.00	0.0	1.00
1145	50.006	+ 1.61	1.033
1140	49.855	+ 3.28	1.068
1135	48.641	+ 4.44	1.099

At the transmitter output assuming a line length of -95.8^{o} we obtain:

FREQUENCY (kHz)	RESISTANCE (R)	REACTANCE (jX)	VSWR
1165	48.541	+5.96	1.133
1160	49.655	+3.19	1.066
1155	49.849	+2.00	1.041
1150	50.00	0.0	1.000
1145	50.172	-1.63	1.033
1140	50.432	-3.37	1.070
1135	51.859	-4.98	1.110

Table II attached is the T-Network data sheet.

The following tabulation furnishes a list of the T-Network components:

ITEM	QUANTITY	DESCRIPTION
J-1	1	J-Plug
J-2	1	J-Plug
C-1	1	Mica Capacitor Type 292-152, 1000 Pfd (10 kV, 12A)
C-2	1	Fixed Vacuum Capacitor JCS 250-7.55 7.5 kV, 60A)
C-3	1	Variable Vacuum Capacitor Type UCS 500.755, 25-500 Pfd (7.5 kV, 60A)
L-1	1	Fixed Inductor Type L16-15 UH
L-2	1	Fixed Inductor Type L16-15 UH
M-1	1	10 Amp. Delta Meter
T-1	1	Delta Torrodial

Bill, that is it. what else can we send you?

Sincerely,

John H. Mullaney, P.E.

JHM/mfm

Enclosures - 5

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:WORK:

INPUT  RA,XA,RS,XS,DEGREES ?   146,233,50,0,-57.23


                PHASE SHIFT (DEGREES) = -57.230

        ********    X1    ****************  X2    ********
RS + J XS          69.426        *       -225.371        RA + J XA
(SOURCE)                         *                         (LOAD)
                                 *
RS=  50.00                       *                       RA= 146.00
XS=   0.00                       *                       XA= 233.00
                                 *
                                 *
                                X3
                             -101.611
                                 *
                                 *
                                GRD


 NPUT  FREQ.(MHZ.), POWER(WATTS) ? 1.150,2500

                 BRANCH 1          BRANCH 3          BRANCH 2
                 [INPUT]           [SHUNT]           [OUTPUT]

REACTANCE          69.426          -101.611          -225.371
PFD OR MICRO-H      9.608          1362.007           614.079
RMS AMPS            7.071             5.954             4.138
MODULATED AMPS      8.660             7.292             5.068
RMS  VOLTS        490.914           604.977           932.592
PEAK  VOLTS      1388.515          1711.132          2637.767


      TOTAL VOLT-AMPERE PRODUCT   10932.301

                          Q       4.373


                    NETWORK  SET-UP  INFORMATION

                      BRANCH 1          BRANCH 3          BRANCH 2

   COMPONENTS :

   MEASUREMENT:
   (REF. POINT)

   GR BRIDGE            79.84           -116.85           -259.18
   (DIAL X)

   DELTA BRIDGE         60.37            -88.36           -195.97
   (DIAL X)
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JUNE 1989

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GAITHERSBURG, MARYLAND

TABLE II
SERIES-FED
T-NETWORK DATA

RADIO STATION WNLR
CHURCHVILLE, VIRGINIA
1150 kHZ 2.5 kW DA-D

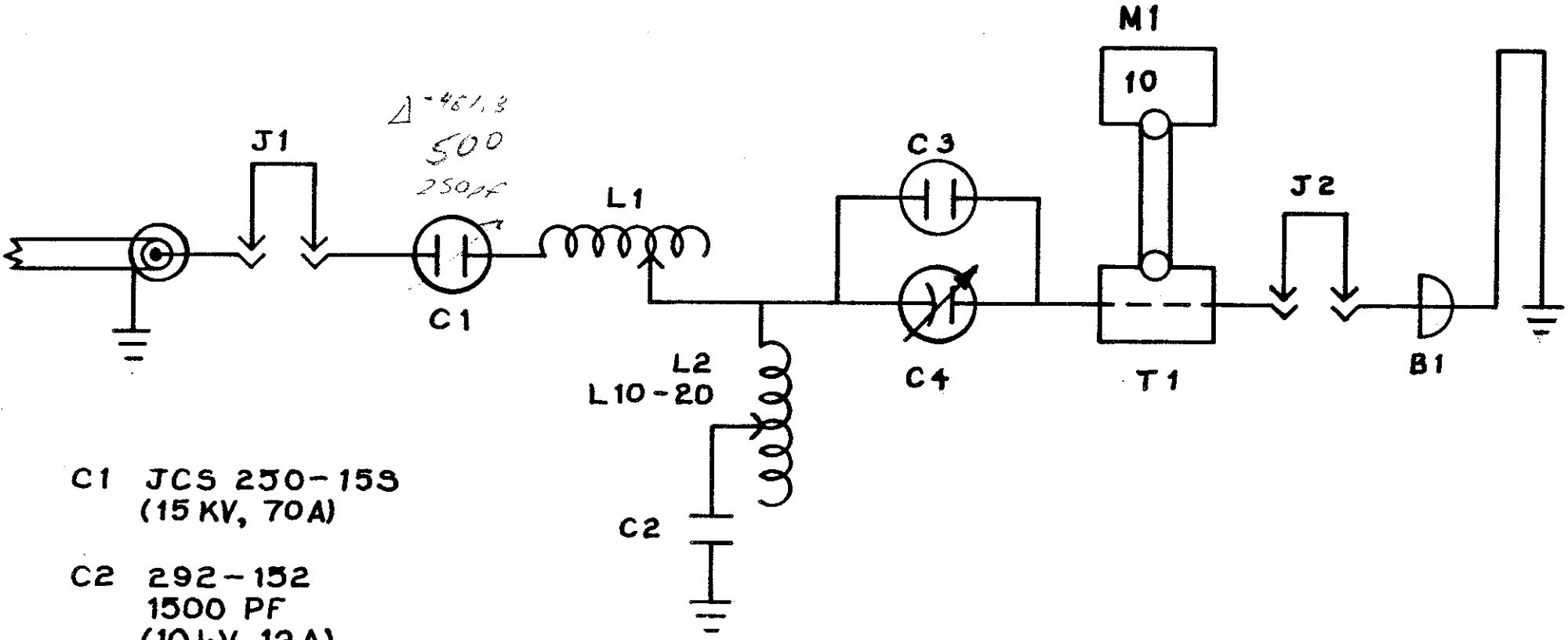
```
.TWORK:

INPUT  RA,XA,RS,XS,DEGREES ?   50.088,336,50,0,-86.22


                PHASE SHIFT (DEGREES) = -86.220

        ********    X1    ***************  X2    ********
RS + J XS          46.850        *       -289.156       RA + J XA
(SOURCE)                         *                        (LOAD)
                                 *
RS=  50.00                       *                      RA=  50.09
XS=   0.00                       *                      XA= 336.00
                                 *
                                 *
                                 *
                                X3
                             -50.153
                                 *
                                 *
                                GRD


!PUT  FREQ.(MHZ.), POWER(WATTS) ? 1.150,2500

                BRANCH 1          BRANCH 3          BRANCH 2
                [INPUT]           [SHUNT]           [OUTPUT]

REACTANCE         46.850            -50.153          -289.156
PFD OR MICRO-H     6.484           2759.463           478.619
RMS AMPS           7.071              9.661             7.065
MODULATED AMPS     8.660             11.832             8.653
RMS  VOLTS       331.277            484.504          2042.846
PEAK  VOLTS      936.992           1370.385          5778.042


     TOTAL VOLT-AMPERE PRODUCT   21455.447

                          Q        8.582


                    NETWORK  SET-UP  INFORMATION

                    BRANCH 1          BRANCH 3          BRANCH 2

COMPONENTS :

MEASUREMENT:
(REF. POINT)

GR BRIDGE             53.88             -57.68            -332.53
(DIAL X)

DELTA BRIDGE          40.74             -43.61            -251.44
(DIAL X)
```

JUNE 1989

MULLANEY ENGINEERING, INC.
GAITHERSBURG, MARYLAND

TABLE I
FOLDED UNIPOLE
T-NETWORK DATA

RADIO STATION WNLR
CHURCHVILLE, VIRGINIA
1150 kHZ 2.5 kW DA-D



C1 JCS 250-159
(15 KV, 70A)

C2 292-152
1500 PF
(10 kV, 12A)

C3 JCS 250-105
(10 kV, 65A)

C4 UCS 25-500 PF
(7.5 kV, 60A)

J2 50.1 + j 336
2500 W
7.065 A

L1 200-105
120 uh, 10 A

JUNE 1989

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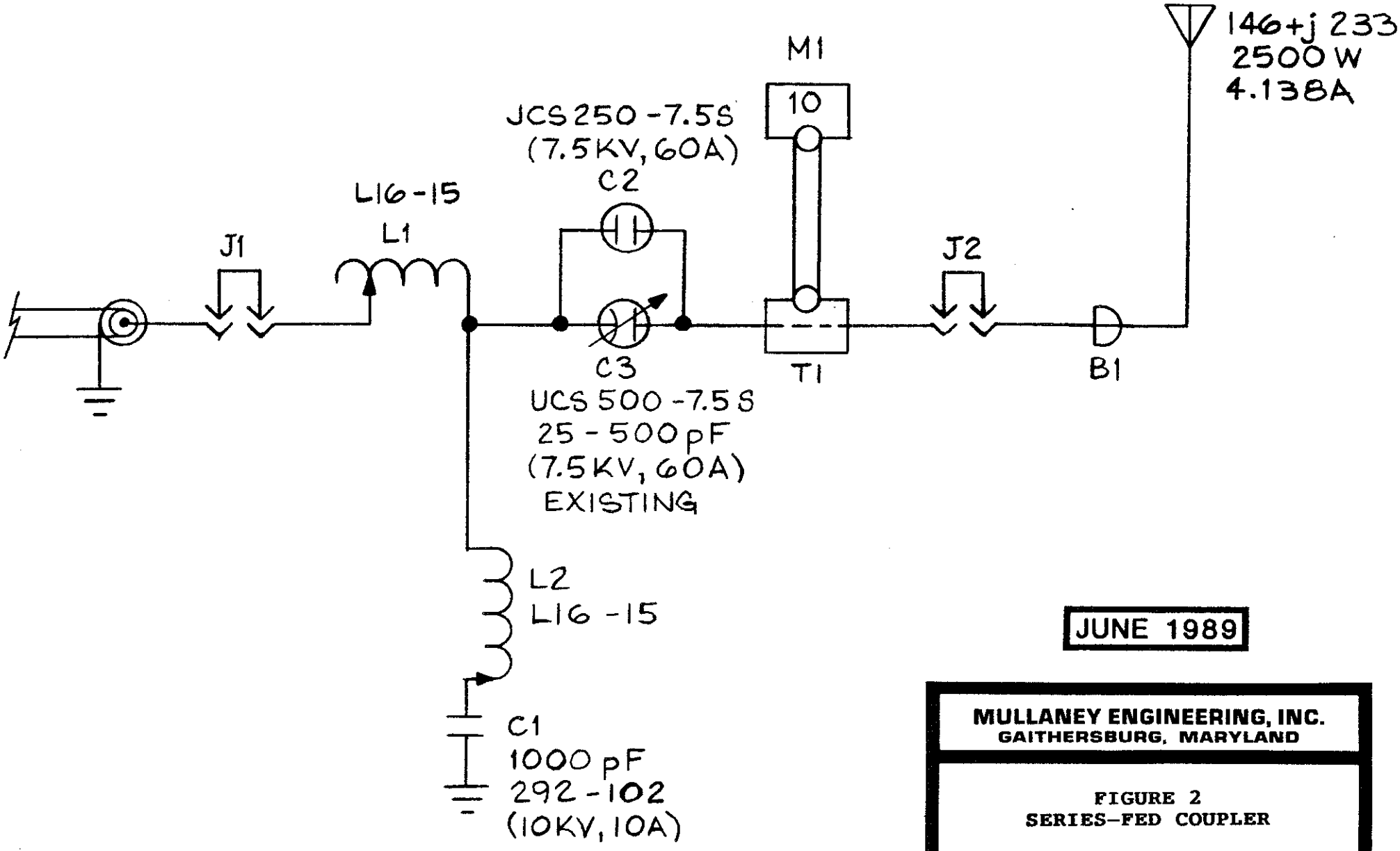
FIGURE 1
FOLDED UNIPOLE COUPLER

RADIO STATION WNLR
CHURCHVILLE, VIRGINIA
~~1120~~ 1150 kHz 2.5 kW-D



JUNE 1989

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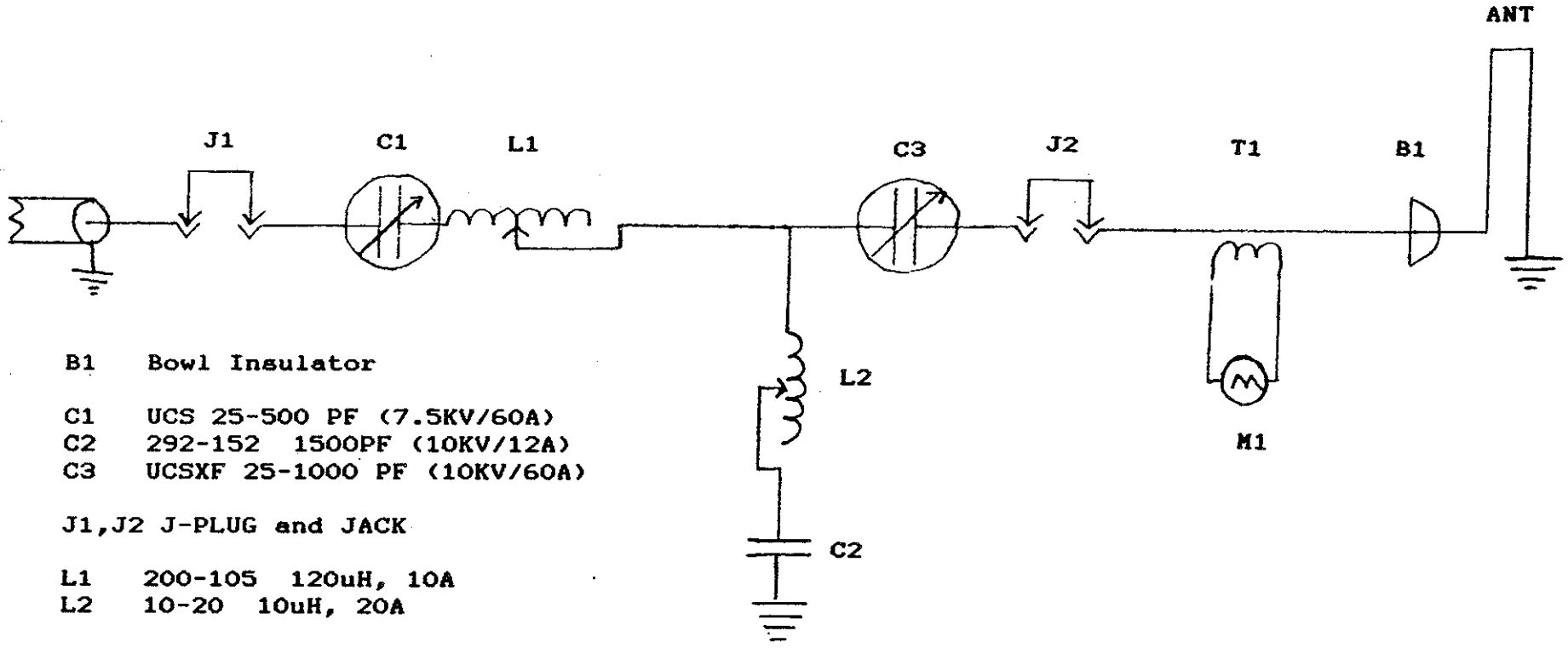
FIGURE 2
SERIES-FED COUPLER

RADIO STATION WNLR
CHURCHVILLE, VIRGINIA
1120 kHz 2.5 kW-D

MOUNTAIN VALLEY BROADCAST SERVICE, INC. HARRISONBURG, VIRGINIA

Blue Ridge Broadcasting, Inc.
AM BROADCAST STATION WNLR
Churchville, Virginia



B1 Bowl Insulator

C1 UCS 25-500 PF (7.5KV/60A)
C2 292-152 1500PF (10KV/12A)
C3 UCSXF 25-1000 PF (10KV/60A)

J1,J2 J-PLUG and JACK

L1 200-105 120uH, 10A
L2 10-20 10uH, 20A

T1/M1 Delta TCT-10EX

WDF 6/27/89

Figure 1.

ANTENNA TUNING UNIT SCHEMATIC

Figure 3.

WNLR CHURCHVILLE VIRGINIA
1150 kHz 6/24/89

UNIPOLE SWEEP AT FEEDPOINT

kHz	R	DIAL X	X
1120	47.2	220	246.4
1122	48.0	223	250.2
1125	47.5	224	252.0
1127	47.9	225	253.6
1130	48.0	226	255.4
1132	48.0	227	257.0
1135	48.5	228	258.8
1137	49.2	230	261.5
1140	49.8	231	263.3
1142	49.6	232	264.9
1145	49.9	232	265.6
1147	50.2	237	271.8
1150	50.0	234	269.1
1152	50.8	237	273.0
1155	51.1	237	273.7
1157	51.8	240	277.7
1160	51.9	240	278.4
1162	52.1	243	282.4
1165	52.3	243	283.1
1167	52.9	245	285.9
1170	53.9	246	287.8
1172	53.9	247	289.5
1175	54.9	250	293.8
1177	54.9	250	294.3
1180	56.4	252	297.4
1182	56.4	252	297.9

WDF OIB-3

Equipment List: Delta OIB-3 operating impedance bridge
serial #781, factory calibrated 5/23/88.
Rated accuracy +/- 2% +/- 1 ohm.

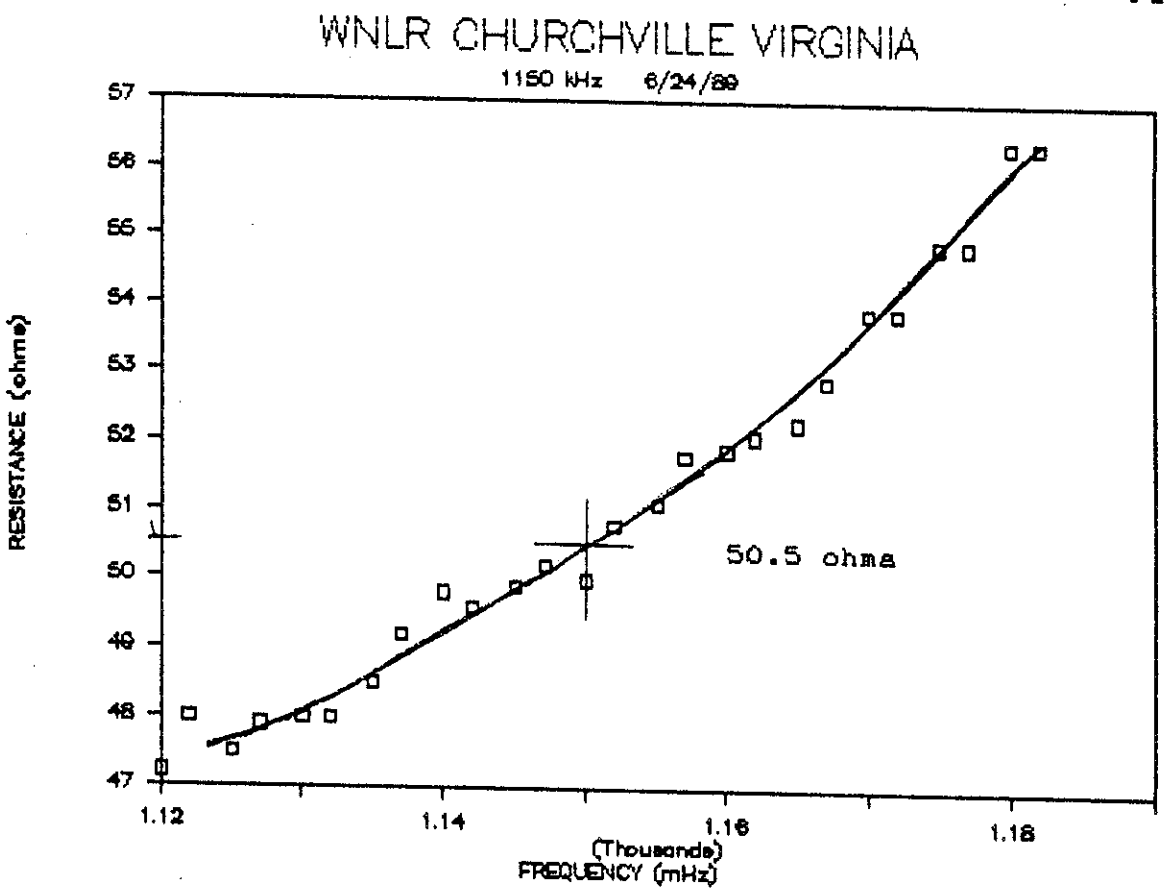
Hewlett-Packard 651B test oscillator
serial #1230A06697

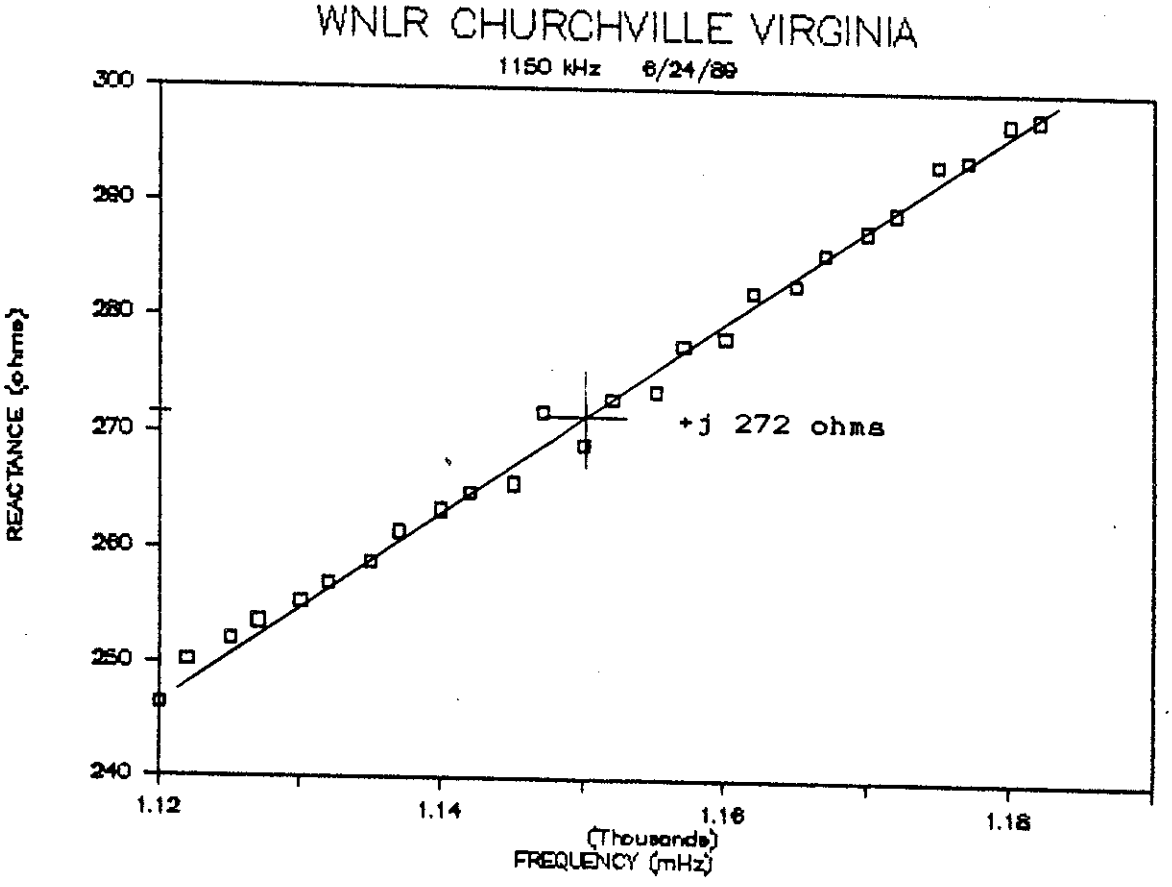
Optoelectronics 8010.1 frequency counter
serial #102871, factory calibrated 1/9/86.
Rated accuracy for 10Mhz TXCO .1PPM
Calibrated to direct NBS traceable standard
with accuracy of one part in ten to the ninth

Collins R-392/URR reciever
serial #4026M

BRIDGE

Figure 4.





WNLR CHURCHVILLE VIRGINIA
1150 kHz 6/24/89

ATU INPUT SWEEP

kHz	R	DIAL X	X	Rp
1135	46.0	4.2	4.8	46.49
1140	48.3	2.9	3.3	48.53
1145	50.0	2.5	2.9	50.16
1150	50.0	0.5	0.6	50.01
1155	49.5	-1.0	-1.2	49.53
1160	47.6	-1.8	-2.1	47.69
1165	42.0	-4.5	-5.2	42.65

5 kHz Rp ratio	98.73
10 kHz Rp ratio	98.28
15 kHz Rp ratio	91.74

WNLR CHURCHVILLE VIRGINIA
1150 kHz 6/24/89

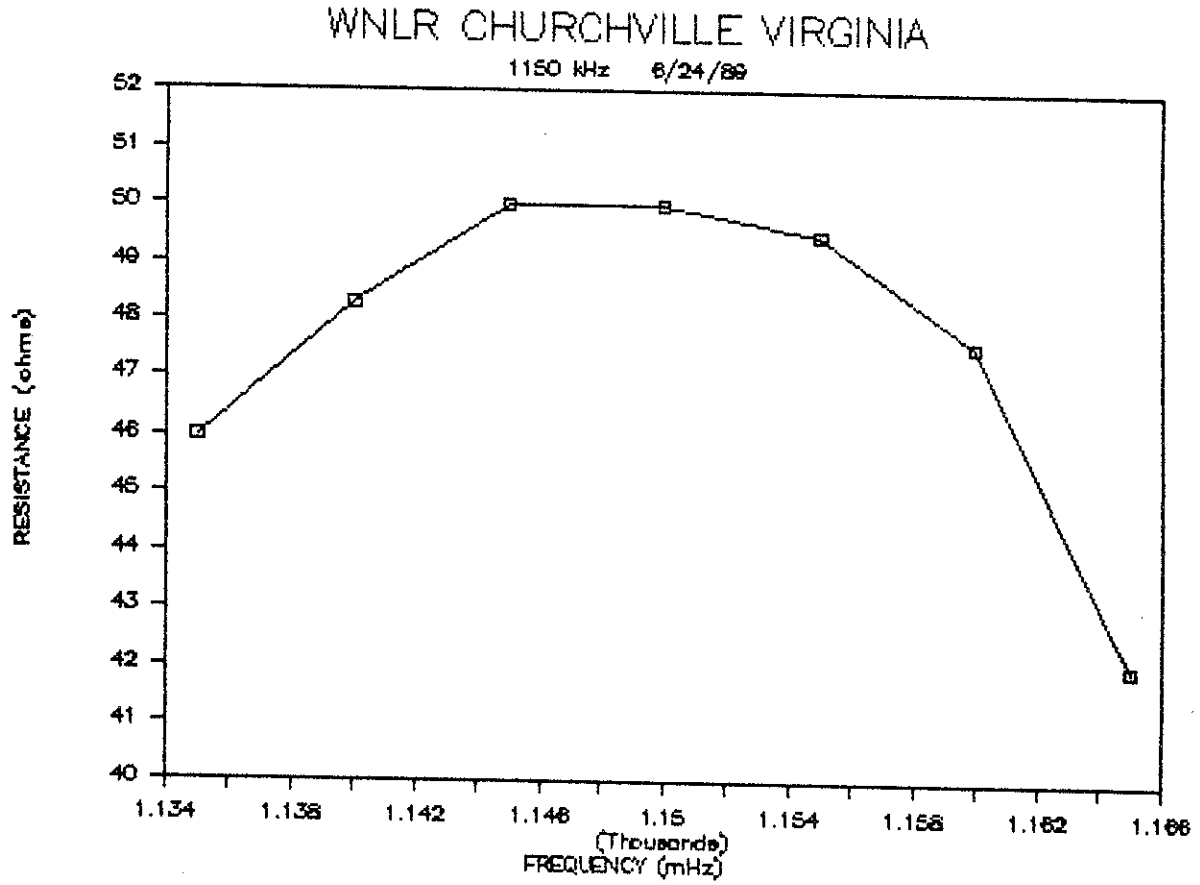
UNIPOLE STUBBING RUNS

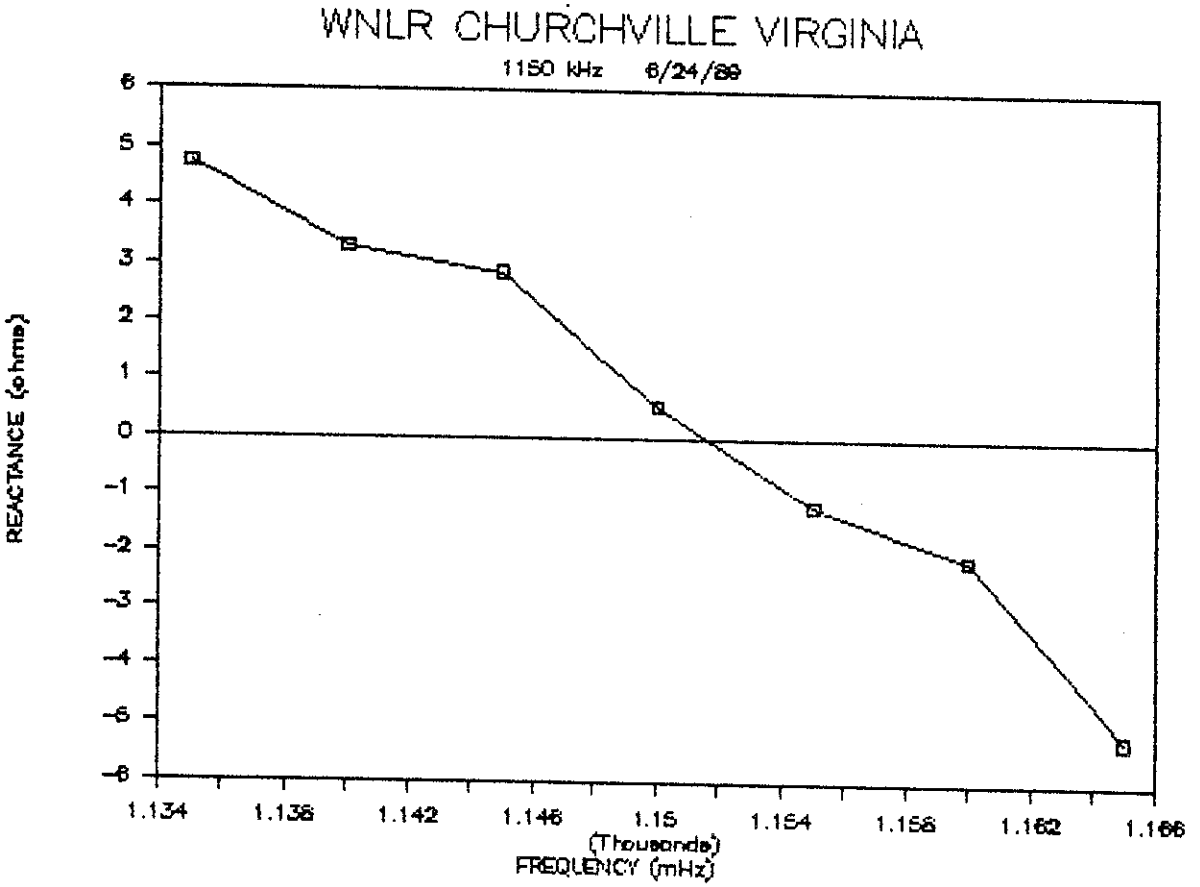
A.G.L. (feet)	wlength degrees	R	DIAL X	X
112	47.7	27.5	177	203.6
115	49.0	32.0	190	218.5
125	53.3	40.0	216	248.4
133	56.7	50.0	236	271.4
135	57.5	54.0	236	271.4

readings with riggers on tower above stub

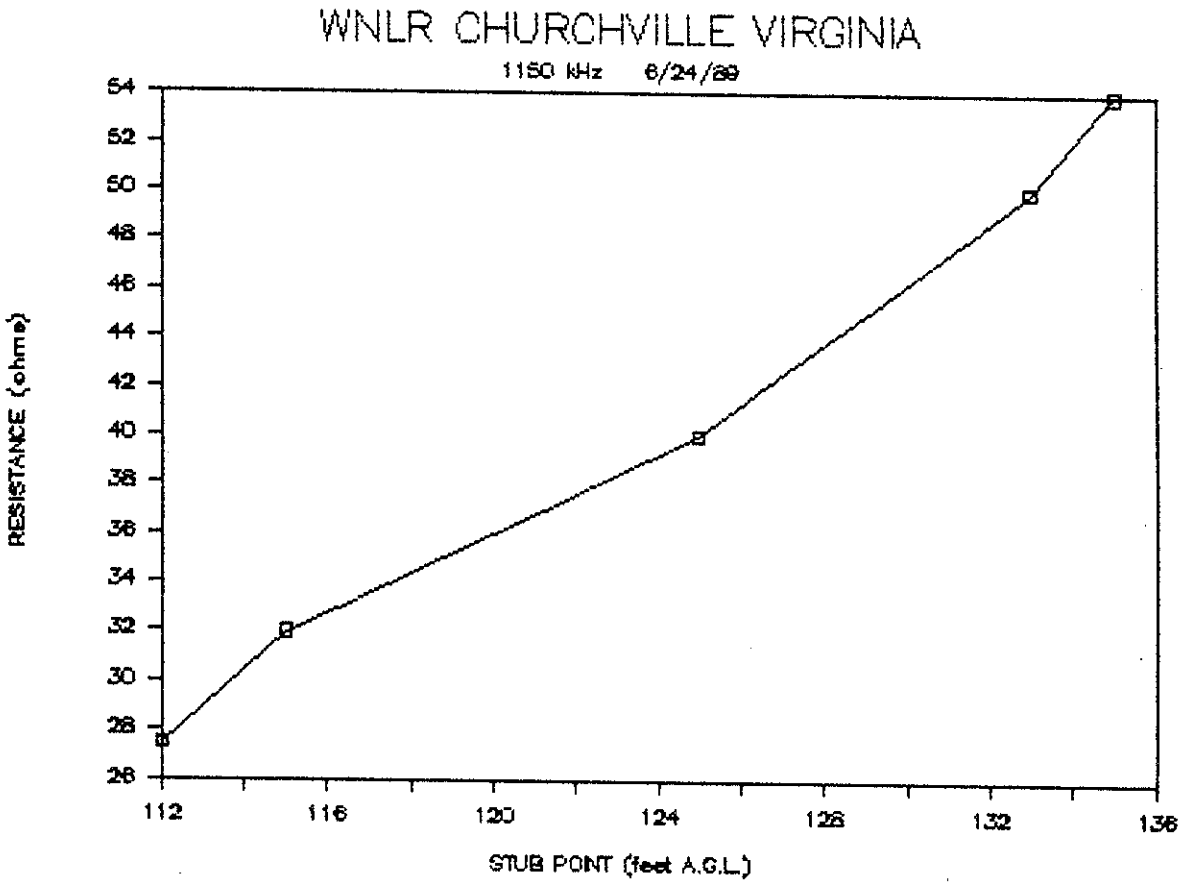
217	92.4 top ring ht. (bonded to tower)
7	3.0 bottom ring ht.

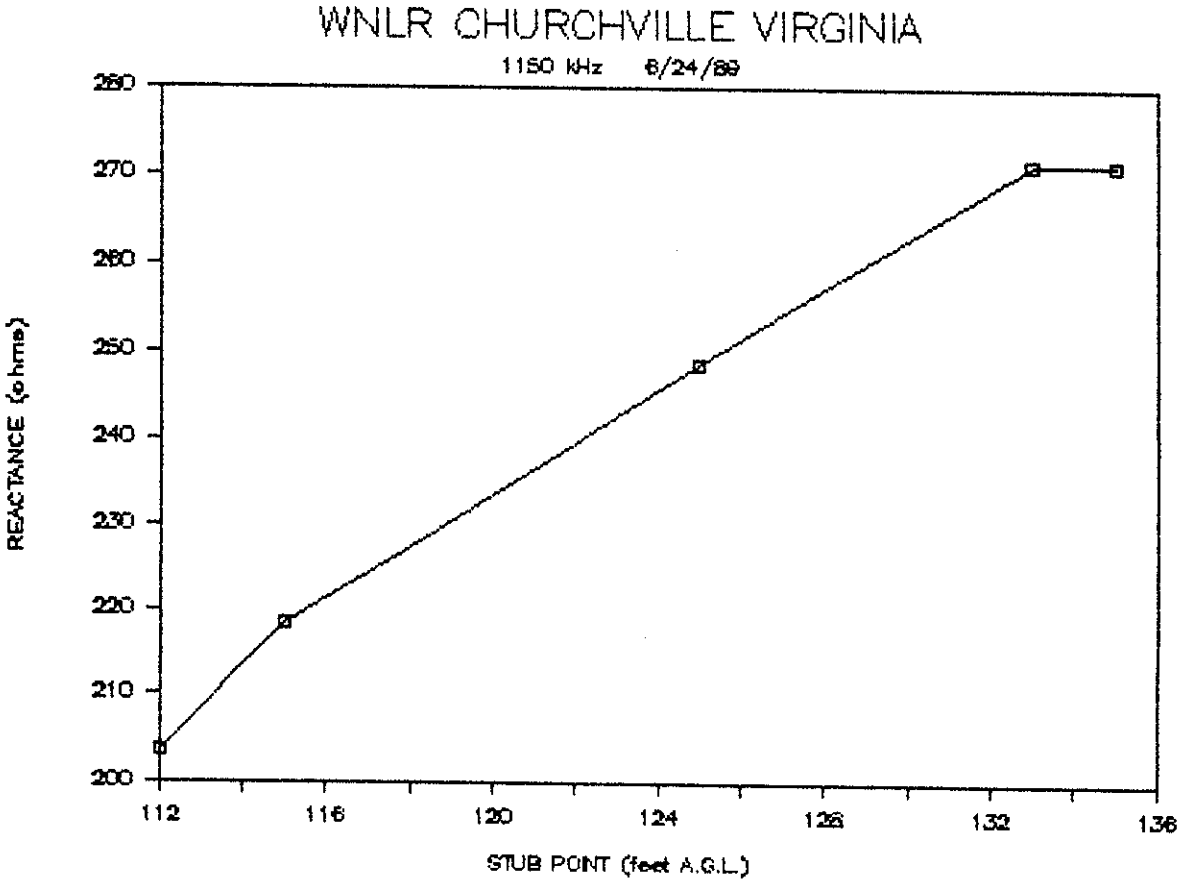
INPUT

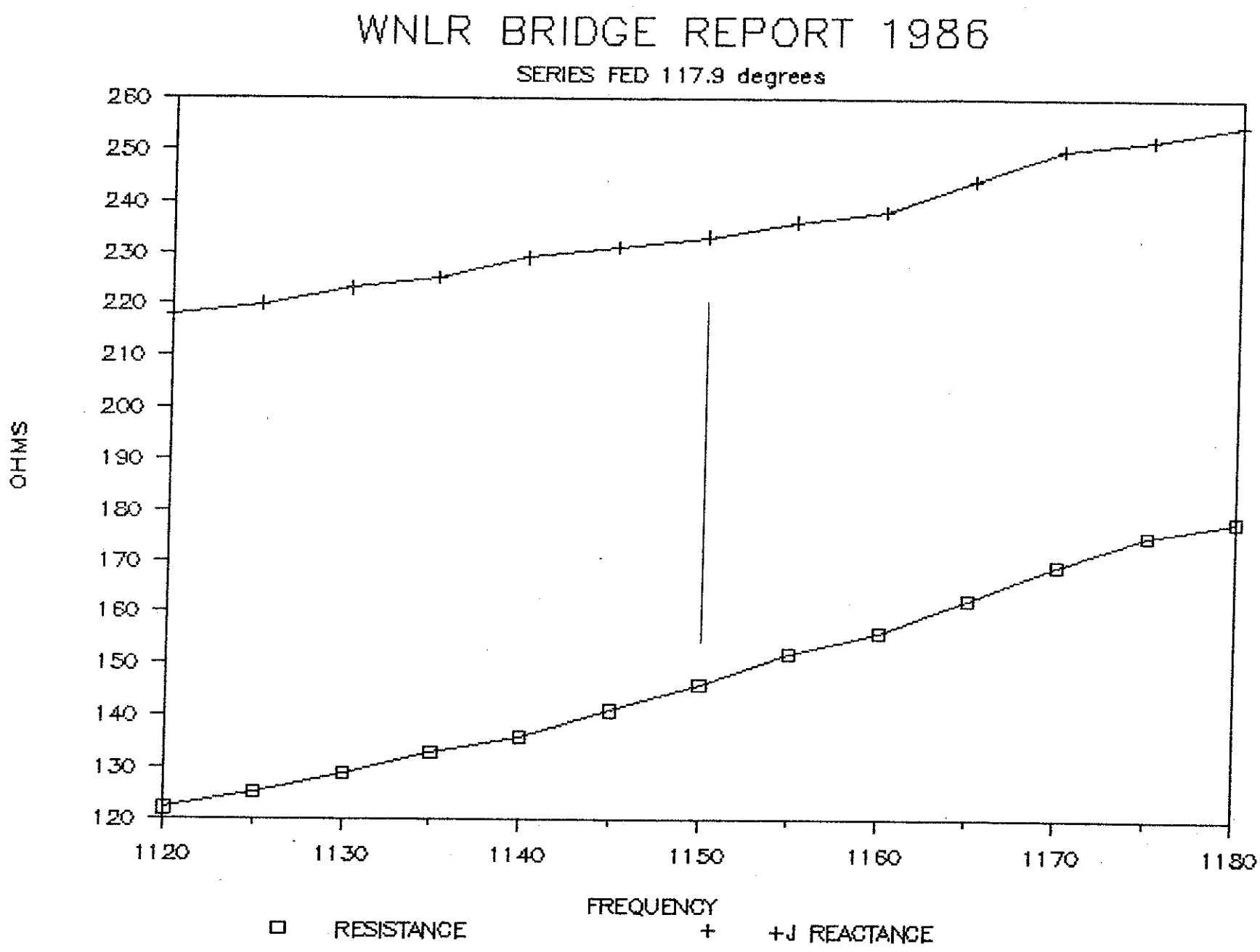

WNLR CHURCHVILLE VIRGINIA
1150 kHz 6/24/89
RESISTANCE (ohms)
52
51
50
49
48
47
46
45
44
43
42
41
40
1.134
1.138
1.142
1.146
1.15
1.154
1.158
1.162
1.166
(Thousands)
FREQUENCY (mHz)


WNLR CHURCHVILLE VIRGINIA
1150 kHz 6/24/89
REACTANCE (ohms)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
1.134
1.138
1.142
1.146
1.15
1.154
1.158
1.162
1.166
(Thousands)
FREQUENCY (mHz)

STUBBING


WNLR CHURCHVILLE VIRGINIA
1150 kHz 6/24/89
RESISTANCE (ohms)
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
112
116
120
124
128
132
136
STUB POINT (feet A.G.L.)


WNLR CHURCHVILLE VIRGINIA
1150 kHz 6/24/89
REACTANCE (ohms)
290
270
260
250
240
230
220
210
200
112
116
120
124
128
132
136
STUB POINT (feet A.G.L.)


WNLR BRIDGE REPORT 1986
SERIES FED 117.9 degrees
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
OHMS
1120
1130
1140
1150
1160
1170
1180
FREQUENCY
RESISTANCE
+J REACTANCE