INVESTIGATION OF TRI-BAND ENTERTAINMENT ANTENNA SYSTEMS ON FORD VEHICLES

by

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EXECUTIVE SUMMARY

The impedance and radiation characteristics of various tri-band antennas mounted on a number of Ford-built vehicles have been studied experimentally. The vehicles chosen were 1978 models: Light Truck, Van, Mark V, Lincoln, Cougar, LTD II, Granada, Monarch, Bronco, Fiesta, and a 1979 Model LTD. Loaded (base, sub-base and center loaded) an unloaded antennas, manual and power operated types, were used as test antennas.

The program involved the measurement of the horizontal plane radiation patterns of test antennas, the received signal strenths, and the impedances at the desired terminals with the test antennas mounted at appropriate locations on the selected vehicle. The relative sensitivities of the test antennas were obtained by comparing the patterns of the test antennas with those of reference antennas. The CB reference antenna was a standard quarter wavelength monopole mounted on the roof of the vehicle and the AM/FM reference antenna was the standard AM/FM entertainment antenna mounted at its appropriate location. The VSWR results were derived from the measured impedances. In addition to the above, the CB isolation characteristics at the FM port of the splitter box and the antenna system C and Q at the AM band frequencies were measured. The impedance characteristics of some typical splitter boxes were also measured at CB and FM frequencies.

Four distinct studies were carried out during the program. These were: (i) determination of the performance characteristics of various sub-base loaded tri-band antenna systems (Chapter IV), (ii) determination of the performance differences between power tri-band antennas with in-line capacitors at the radio connector and in the splitter box (Chaper V), (iii) determination of performance differences between three 1979 Ford/Mercury antenna systems: (a) 123 pf (production) system, (b) 95 ϕF (series capacitance) system and (c) 202 pf (RG59U Cable) system (Chaper VI), (iv) investigation of the impedance characteristics of selected splitter boxes (Chapter VII).

For each test antenna mounted on a selected vehicle, some or all of the following results are presented: (i) horizontal plane radiation patterns at three selected CB (channels 1, 19 and 40) and FM band (88, 98 and 108 MHz) frequencies, (ii) CB and FM band impedances at the appropriate ports,

(iii) the field strengths received at three selected frequencies in the AM band, (iv) relative sensitivity at CB, FM and AM bands, (v) VSWR vs frequency at CB and FM bands, and (vi) antenna system C and Q in the AM band. On the basis of these results tables have been prepared to show the relative performance of the test antennas mounted on a test vehicle, as well as the vehicle effects on the performance of a test antenna.

Detailed impedance characteristics at CB and FM frequencies for four commercial splitter boxes using typical tri-band antennas mounted on a ground plane are also presented. The results are then used to evaluate the performance of existing splitter boxes.

Significant findings of the study are:

(i) The production series antennas have the best, and the MS-series antennas the worst, overall performance with all vehicles.

All tri-band antennas when properly tuned maintain acceptable VSWR at CB frequencies on all test vehicles. Usually, the FM band VSWR is fairly large (typically larger than 5) and as a result the FM band sensitivity is degraded.

(ii) The use of a padder capacitor at the radio input generally increases the AM sensitivity of the SLC antennas and appears to improve their overall performance.

(iii) The Panther Program indicates that 123pF input capacitance of the antenna system provides optimum performance.

(iv) The splitter box provides poor performance at the FM band frequencies. On the basis of the results obtained, it appears that the FM band performance of existing splitter boxes can be improved by introducing some variable reactance in series with the FM branch circuit of the splitter box. It is recommended that further study be initiated along this line.

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I. INTRODUCTION

This report presents the results of an experimental study of the performance of various antennas mounted on Ford vehicles and operating in the commercial AM (0.55 to 1.5 MHz), FM (88 to 108 MHz) and CB (26.965 to 27.406 MHz) bands of frequency. The vehicles chosen were light trucks, vans and passenger automobiles, all manufactured and supplied by the Ford Motor Company. The program mainly consisted of the measurement of the radiation patterns and impedances (VSWR's) of the test antennas, and of the splitter boxes associated with the test antennas. In addition, however, data were obtained for the impedance characteristics at the appropriate ports of the splitter boxes at the FM and CB frequencies, and the effective capacitance C and Q at the receiver end of the cable connecting the test antenna measured at the AM frequencies.

The overall goal of the investigation was to obtain sufficient experimental data to evaluate the relative performance of the test antennas under various conditions, and to compare their performance with that of the standard AM-FM and CB antennas used with Ford vehicles.

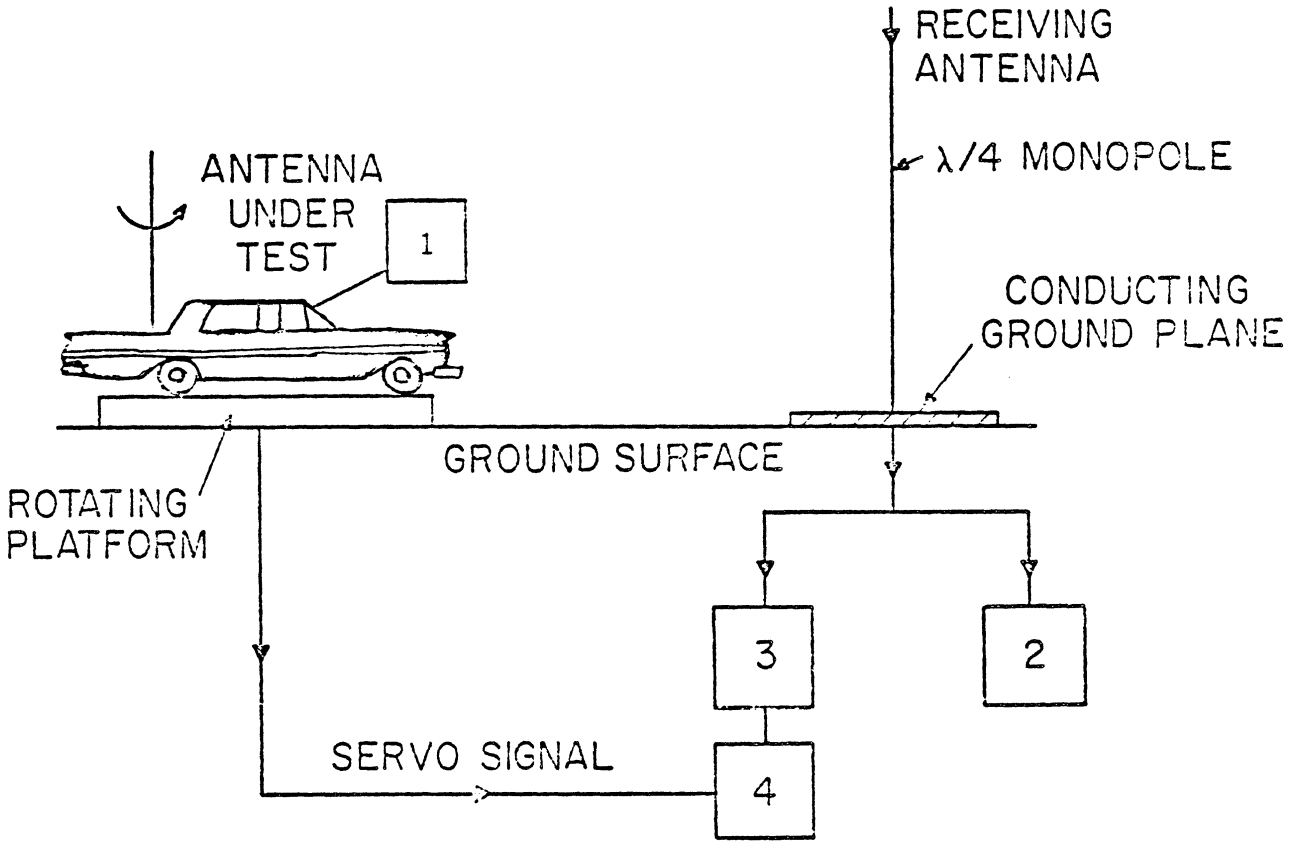
II. OUTLINE OF THE MEASUREMENT PROCEDURES

Standard measurement techniques were employed and it is sufficient to describe only the procedures used to obtain specific results. The radiation pattern and impedance measurements were similar to those in a previous study [1], but a description of the procedures is included here for completeness.

2.1. Radiation Pattern measurement

For the radiation pattern measurements the antenna under test was installed at the desired location on a given vehicle located on a rotating platform. The test antenna radiates signals at the desired CB or FM band frequency supplied by a suitable transmitter located inside the vehicle. The CB signals were obtained from the CB transceiver installed in the vehicle; signals in the FM band were obtained from a General Radio Unit oscillator (CW) which has a nominal output power rating of 325 mw. The signals radiated by the rotating test antenna were received by a monopole antenna located at a distance of approximately 150 feet from the test vehicle. In each band, the receiving monopole consisted of a metal tubing a quarter wavelength long at the center of the band and mounted vertically at the center of a 4' x 4' ground plane placed horizontally on the surface of the earth. The CB and FM receiving monopoles were 108" and 30" long respectively, and were made of 3/8" outer diameter aluminum tubing. In general, the output of the receiving antenna was coupled to a spectrum analyzer and to a receiver and polar recorder. The spectrum analyzer was used to monitor the frequency and amplitude of the desired signal, and the nature of the ambient signals. As the vehicle was rotated, the polar recorder displayed the horizontal plane transmitting pattern of the test antenna. By the reciprocity theorem, the measured pattern is also the receiving pattern of the test antenna. Figure 1 shows the block diagram of the measurement set-up for obtaining radiation patterns at the CB and FM band frequencies.

Due to the long wavelength of the AM band broadcast frequencies, the 150 feet distance between the test and receiving antennas was too small



1 CITIZEN'S BAND TRANSMITTER OR FM BAND GR UNIT OSCILLATOR

2 SPECTRUM ANALYZER HP 8558B

3 MICROWAVE RECEIVER: SCI. ATLANTA 1600

4 PATTERN RECORDER: ANT. LAB POLAR RECORDER

Figure 1: Block diagram of the experimental arrangement for antenna pattern measurements at CB and FM frequencies.

to provide meaningful patterns in this band. The block diagram in Figure 2 shows the experimental set-up for pattern measurements of the test antennas at these frequencies, and as indicated in Figure 2, the test antenna is used as a receiving antenna, receiving signals from a distant AM broadcast transmitting station. The horizontal plane pattern of a typical antenna obtained in this manner was found to be omnidirectional throughout the entire AM band [1]. For this reason, all the AM band field strengths were measured with a stationary vehicle at 3 selected frequencies in the AM broadcast band. The desired field strength was obtained from the response of the spectrum analyzer which was used as a receiver along with the test antenna.

Prior to measuring the radiation pattern of each test antenna, three calibration patterns were recorded with a standard Ford 30 inch whip antenna for the AM and FM bands, mounted in accordance with Ford Motor Company instructions, and a 108 inch monopole for the CB frequencies, mounted in the center of the roof of each test car. The calibration patterns were recorded at the desired frequencies within each frequency band. Care was exercised to ensure that the transmitter power level and the receiver sensitivity were the same for both the calibration and test antennas.

2.2. Impedance Measurement

Figure 3 shows the block diagram of the experimental set-up used to measure the input impedance at the desired terminals of the test antenna. The vector voltmeter gives the input reflection coefficient from which the desired impedance and VSWR data were obtained.

For each test antenna the impedance or VSWR measurements were carried out prior to the pattern measurements. Initially, the VSWR of each test antenna was measured and recorded at 27.185 MHz (Channel 19 of the CB band) with the antenna installed at the appropriate location on the test vehicle. In the event the VSWR was greater than 1.5:1, the antenna was appropriately tuned to obtain a VSWR less than 1.5:1. The VSWR's at the CB band edges 26.96 MHz (Channel 1) and 27.405 (Channel 40) were required to be less than 2.5:1.

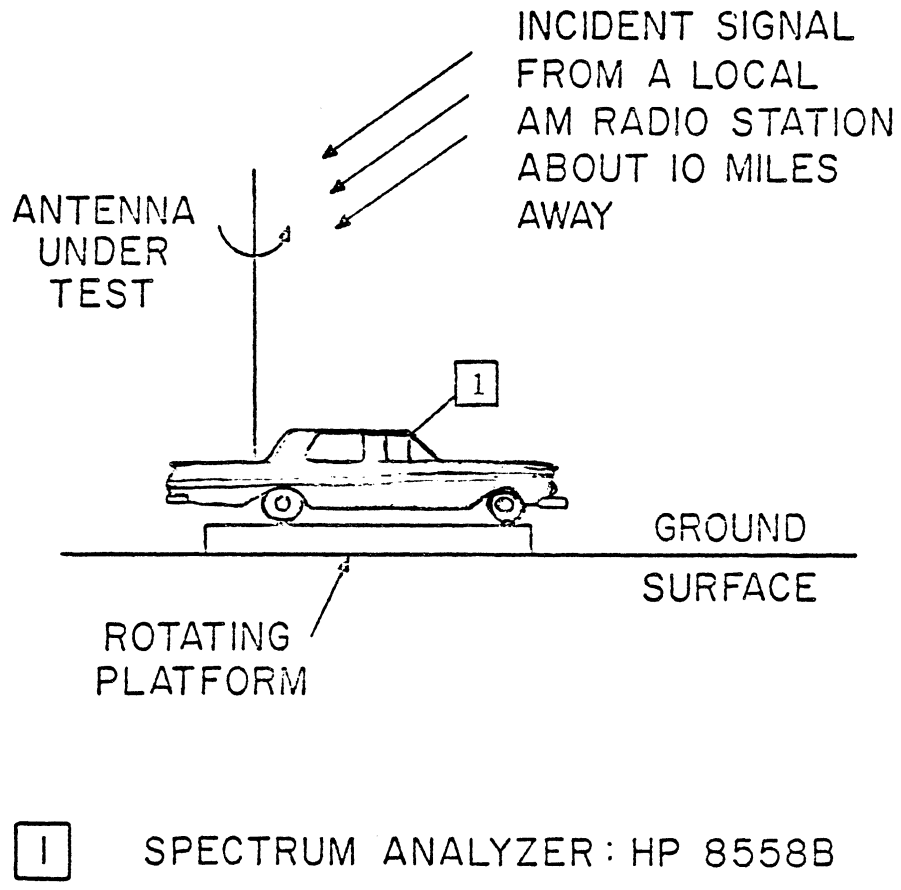
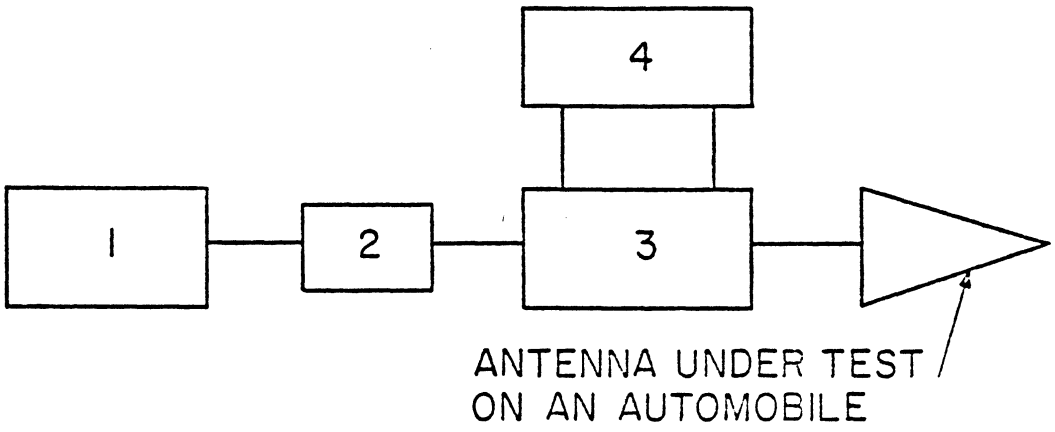


Figure 2: Block diagram of the experimental arrangement for antenna patterns or field strength measurement at AM frequencies.



UNIT NO	CB	FM
1	CITIZEN'S BAND TRANSMITTER	FM BAND GR UNIT OSCILLATOR
2	18 dB ATTENUATION	6 dB ATTENUATION
3	DUAL DIRECTIONAL COUPLER ANZAC CH 134	DUAL DIRECTIONAL COUPLER ANZAC CH 134
4	VECTOR VOLTMETER HP 8405 A	VECTOR VOLTMETER HP 8405

Figure 3: Block diagram showing the experimental arrangement for VSWR measurements.

2.3. Signal Isolation Measurement

To measure the signal isolation between the CB and AM/FM port of the splitter box of each test antenna, the output of the vehicle-installed CB transceiver was appropriately cabled to the CB port of the test antenna splitter box. A 100 ohm (5 Watt) load with a high impedance RF voltmeter (HP3406-A or equivalent) was attached in parallel with the AM/FM port of the splitter box. With the CB transceiver keyed to transmit 4 Watts of RF signal power, the RF voltmeter level was observed and recorded. Typically the voltmeter reading was less than or equal to 200 millivolts and gave an indication of the degree of isolation between the two ports of the splitter box.

2.4. Measurement of Effective C and Q

With the test antenna installed on the vehicle the effective capacitance 'C' and quality factor 'Q' at the receiver end of the cable connecting the test antenna were measured with a standard Q-meter. These measurements were carried out at the AM band frequencies only.

2.5. Measurement of Splitter Box Impedance

Figure 4 shows a schematic diagram of a splitter box with the test antenna connected at port 3. The impedance characteristics at the AM/FM

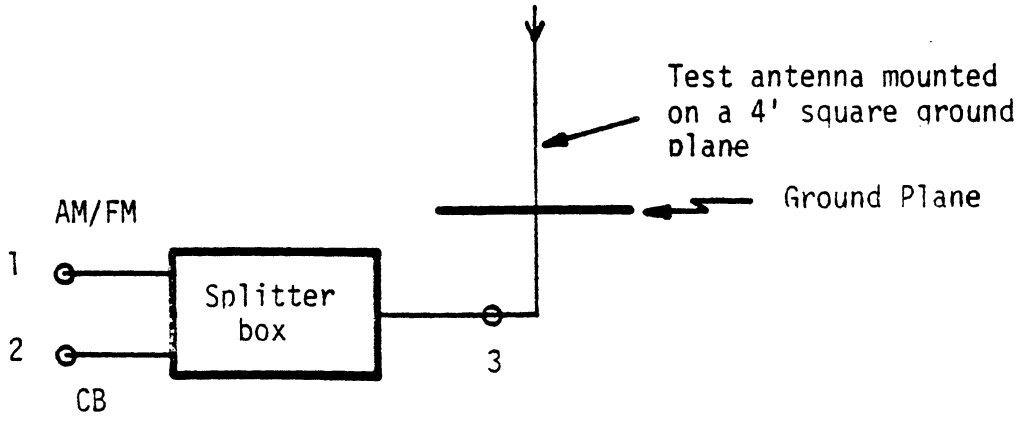


Figure 4. Schematic diagram of the splitter box connected to the test antenna.

and CB ports of the splitter box were measured according to the following scheme:

(i) a. Measure impedance at the port 1 with port 2 terminated in 50 Ω with the test antenna connected to port 3.

b. Measure impedance at port 1 with ports 2 and 3 terminated in 50 Ω .

(ii) a. Measure impedance at port 2 with port 1 terminated in 100 Ω with the test antenna connected to port 3.

b. Measure impedance at port 2 with ports 1 and 3 terminated in 100 Ω and 50 Ω , respectively.

Note that during these measurements the test antenna was mounted on a 4' square ground plane.

2.6. Test Frequencies

As mentioned earlier measurements were carried out in the AM, FM and CB bands of frequencies. The specific frequencies used for the measurements of the patterns and impedances of the test antennas were as follows:

AM Band	0.8 MHz	1.2 MHz	1.6 MHz
CB Band	26.965 MHz (Channel 1)	27.185 MHz (Channel 19)	27.405 MHz (Channel 40)
FM Band	88 MHz	98 MHz	108 MHz

2.7. Comments

The AC power supply for the test instruments inside the vehicle was obtained from the vehicle battery with the help of an inverter. This was done to avoid undesirable effects on the measured, AM band, patterns and impedances (VSWR's) produced by the long extension cord that would have been required if an external power source had been employed.

The standard AM/FM antenna used had a nominal length of 31" and a cable whose length varied depending on the test car model. The antenna cable length was adjusted so that the antenna cable system provided 95 pF and 202 pF capacitance in the AM band for front and rear mounting respectively. The standard antenna used for CB frequencies was 104" long (~ $\lambda/4$ long at Channel 19) and was mounted vertically on the roof of the test car.

III. TEST ANTENNAS AND VEHICLES

All the test antennas were commercially made tri-band antennas suitable for use in the FM, CB and AM bands of frequency, and were supplied by the Ford Motor Company. Basically they are monopole antennas mounted vertically at suitable locations on the given test vehicles. Each tri-band test antenna uses a loading coil whose main purpose is to increase the base current of the antenna at the CB frequencies. The loading coil itself consists of a variable inductance shunted by a capacitor, and is connected in series with the antenna. The tuning of the antenna to obtain the desired VSWR at CB frequencies is accomplished by adjusting the inductance of the loading coil.

Figure 5 shows a schematic diagram of a test antenna connected to the AM/FM radio and the CB transceiver of a test vehicle. The loading coil (of variable length ℓ_1, ℓ_2) is located at any one of the three dotted positions (A, B, C) in Figure 5. According to the locations of the loading coil the test antennas are classified as follows:

Center Loaded (CL) Antennas: These are power tri-band antennas having a loading coil located in the central region (A) of the antenna.

Base Loaded Antennas: These use loading coils of length ℓ_2 located at the base (B) of the antenna and above the fender of the vehicle, i.e. the ground plane of the antenna. They are manual antennas.

Sub-Base Loaded Antennas: These use loading coils of length ℓ_2 located at the base (C) of the antenna but below the ground so that the loading coils cannot be seen from outside. They are also manual antennas.

Tables 1(a) - (c) list the vehicles and associated test antennas evaluated. The antennas are referred to by abbreviations or by their production codes, whose meaning is an follows:

CL: Power tri-band antennas with in-line capacitors in the radio connector.

Antennas with code numbers starting with D: These are production tri-band antennas, some of which are power operated (with loading coil at the center) and some base loaded manual antennas. All are denoted

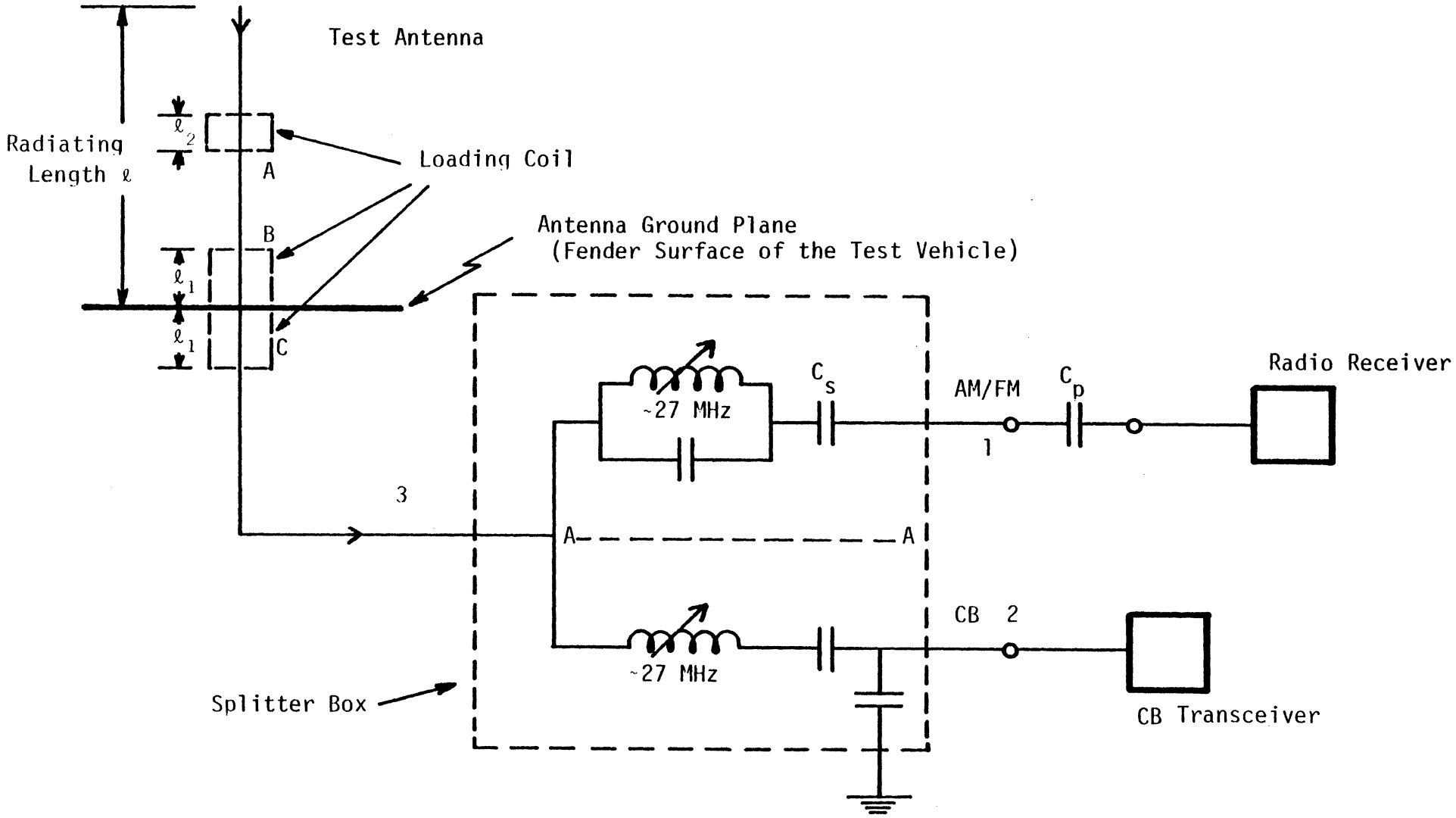


Figure 5. Test antenna connected to the entertainment system in the test vehicle.

TABLE 1. TEST VEHICLES AND ASSOCIATED TEST ANTENNAS.

Car Line	Lincoln	Thunderbird/Cougar	Versailles	Mark V	Cougar
Test Antennas	in-line capacitor CL power rear mounted	in-line capacitor (CL) power rear mounted	in-line capacitor (CL) power rear mounted	(CL) power front mounted	in-line capacitor (CL) power rear mounted
	D8VF-18B12-AC power rear mounted production	D80F18B812-CE power rear mounted production	D84F-18B812-AC power rear mounted production	D85F-18B812-AC power front mounted production	D85F-18B812-AA power rear mounted production

TABLE 1(a) in-line capacitor

Car Line	Granada/Monarch	LTD II Thunderbird	Fiesta	Light Truck	Bronco	Van
Test Antennas	D8DF1812-AC manual front mounted	RP-111-60 manual front mounted	RP-111-20 manual front mounted	RP-111-20 manual front mounted	RP-111-20 manual front mounted	RP-111-20 manual front mounted
	X	EPL-60 manual front mounted	EPL-20 manual front mounted	EPL-20 manual front mounted	EPL-20 manual front mounted	EPL-20 manual front mounted
	X	MS-60	MS-20	MS-20	MS-20	MS-20
		D80F-18B812-AD	D8TF-18B812-AD	D8TF-18B812-AD	D8TF-18B812-AD	D8UF-18B812-AC
		manual front mounted	manual front mounted	manual front mounted	manual front mounted	manual front mounted

TABLE 1(b) sub-base manual tri-band

NOTE: word "in-line capacitor" denotes use of a padder capacitor at the radio. All other power tri-band antennas use padder capacitors in the splitter box.

TABLE 1. TEST VEHICLES AND ASSOCIATED TEST ANTENNAS, CONTINUED.

Car Line	1979 Ford LTD						1979 Ford LTD/1978 Mark V					
Test Antennas	Manual Entertainment (ME) front, right			Power Entertainment (PE) front, right			Manual Tri-Band (MT) front, right			Power Tri-Band (PT) front, right		
	AM Band Capacitance			AM Band Capacitance			AM Band Capacitance			AM Band Capacitance		
	95 pF	123 pF	202 pF	95 pF	123 pF	202 pF	95 pF	123 pF	202 pF	95 pF	123 pF	202 pF

TABLE 1(c) 1979 Ford Mercury 95 pF and 202 pF vs 123 pF.

by the production part numbers for the splitter box assembly.

RP-111-60, 20
EPL-60, 20 : sub-base loaded manual tri-band antennas; the numbers 60, 20 signify the cable lengths (in inches) between the antenna and the splitter box.

MS-60-, 20: sub-base loaded manual tri-band antennas, with numbers 60 and 20 having the same meaning as above.

Motorola: based-loaded tri-band antenna

The capacitances of the test antennas given in Table 1 (c) represent the antenna system capacitance measured at the input side of the cable looking towards the antenna; the antenna system may or may not have a padder capacitance.

Some physical and other characteristics of the test antennas are given in Table 2.

TABLE 2. CHARACTERISTICS OF TEST ANTENNAS

ANTENNA			LOADING COIL	
Type	Manual/ Power	Length (ℓ)	Length ℓ_1 or ℓ_2	Sub-base (S.B.) Base (B) or Middle (M)
SLC	P	40 1/2"	1 1/4"	M
RP-111-60,20	M	40 1/2"	1 3/4"	S.B.
EPL-60, 20	M	41"	2"	S.B.
MS-60, 20	M	41"	1 3/4"	No Coil
D8DF-18B812-AC	M	40"	3"	B
D80F-18B812-CE	P	40"	2 1/2"	M
D84F-18B812-AC	P	40 1/2"	2 1/2"	M
D8LF-18B812-AC	P	42 1/4"	2 1/2"	M
D8VF-18B812-AC	P	39"	2 1/2"	M
D8UF-18B812-AC	M	40"	3"	B
D8TF-18B812-AD	M	40"	3"	B
D8SF-18B812-AA	P	34"	2 1/2"	M
ME	M	32 1/4"	N/A	N/A
PE	P	32"	N/A	N/A
MT	M	40"	3"	B
PT	P	40"	2 1/2"	M
Motorola	M	40"	2 1/2"	B
Std AM/FM	fixed length	32"	N/A	N/A
$\lambda/4$ CB	fixed length	108"	---	---

IV. BASE AND SUB-BASE LOADED ANTENNAS

The results obtained with different base and sub-base loaded test antennas mounted on a variety of test vehicles are now presented and discussed. The main purpose of this set of measurements was to evaluate the performance of sub-base loaded antennas vis-a-vis the base-loaded antennas. Manual tri-band antennas were appropriately tested on 1978 models of a Light Truck, Van, Bronco, Thunderbird (T-Bird), LTD II, Cougar, Fiesta, and Granada/Monarch.

4.1. Light Truck

Figures 6(a)-(c) show the horizontal plane radiation patterns at selected CB frequencies obtained with the four test antennas listed in Table 1(b), of which the RP-111-20 and EPL-20 are sub-base loaded, the D8TF-18B812AD is base loaded and the MS-20 is unloaded. The corresponding patterns obtained with a standard $\lambda/4$-long CB antenna mounted on the roof top of the test vehicle are also shown. The test antennas were mounted on the right hand side of the front fender of the test car, as shown by the inset in each of Figures 6(a)-(c). The convention in Figures 6(a)-(c) and all subsequent patterns is that the 0° - reference angle is in the forward direction for the test car.

Observe that at all the CB frequencies, the $\lambda/4$-long antenna patterns are almost omnidirectional, as they should be. Since the power output from the CB transmitter was kept constant during the measurements, the results shown in Figure 6 can be used directly to estimate the CB sensitivity of a test antenna relative to that of the standard $\lambda/4$-antenna. The relative sensitivity of a test antenna in a given direction may be defined as the difference (in dB) between the field strengths obtained with the test and standard $\lambda/4$ antennas in that direction. The results shown in Figure 6 indicate that each of the four test antennas has less sensitivity than the standard antenna in all directions. The asymmetry in the test antenna patterns are attributed to their asymmetric location. Each of the test antenna patterns has minimum sensitivity at right angles to the forward

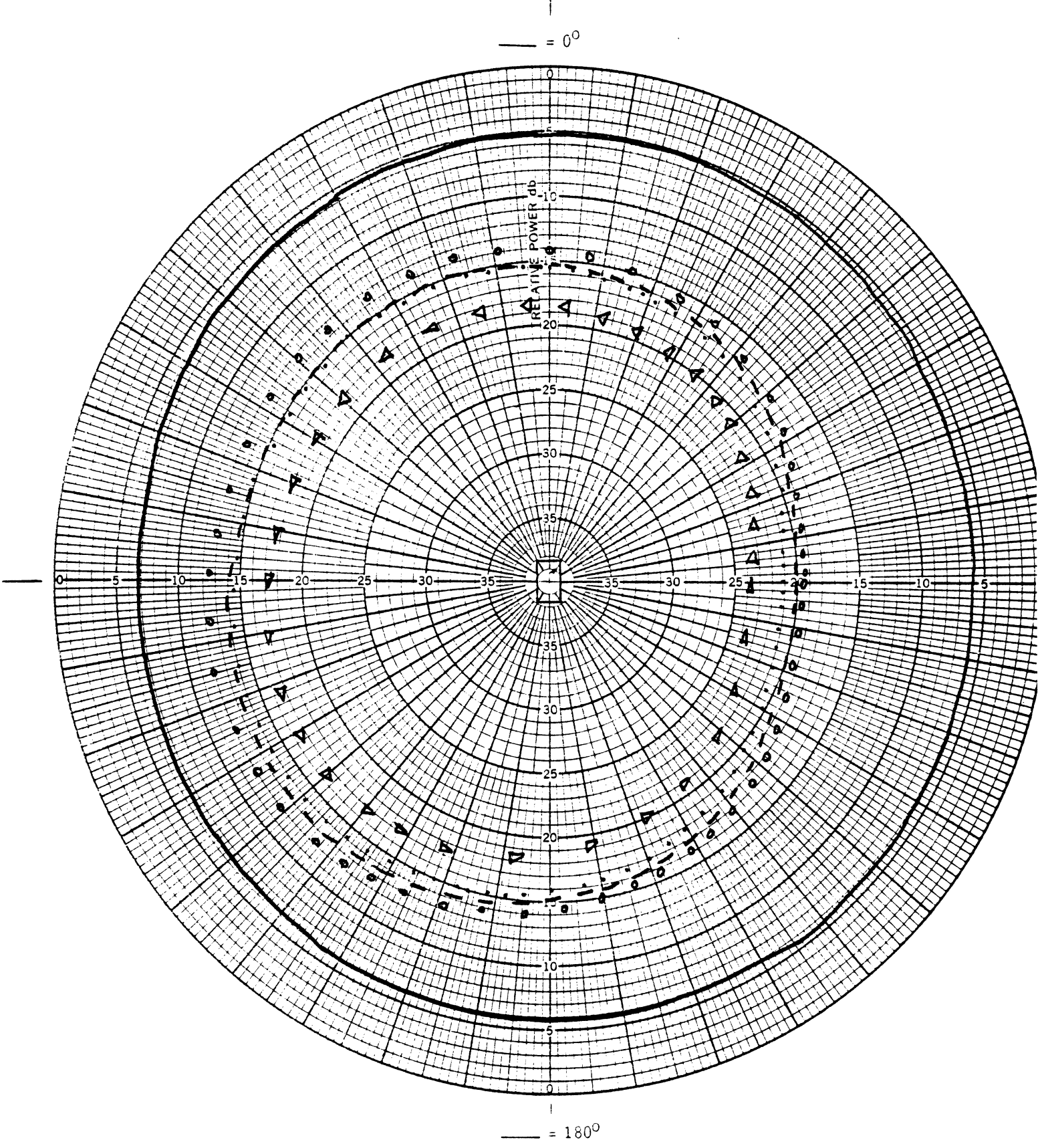


Figure 6(a). Radiation patterns at CB Channel 1 for test and reference antennas on 1978 Light Truck.

—— CB Reference, ---- EPL-20, ···· RP-111-20, °°°° D8TF-18B812-AD, ΔΔΔΔ MS-20.

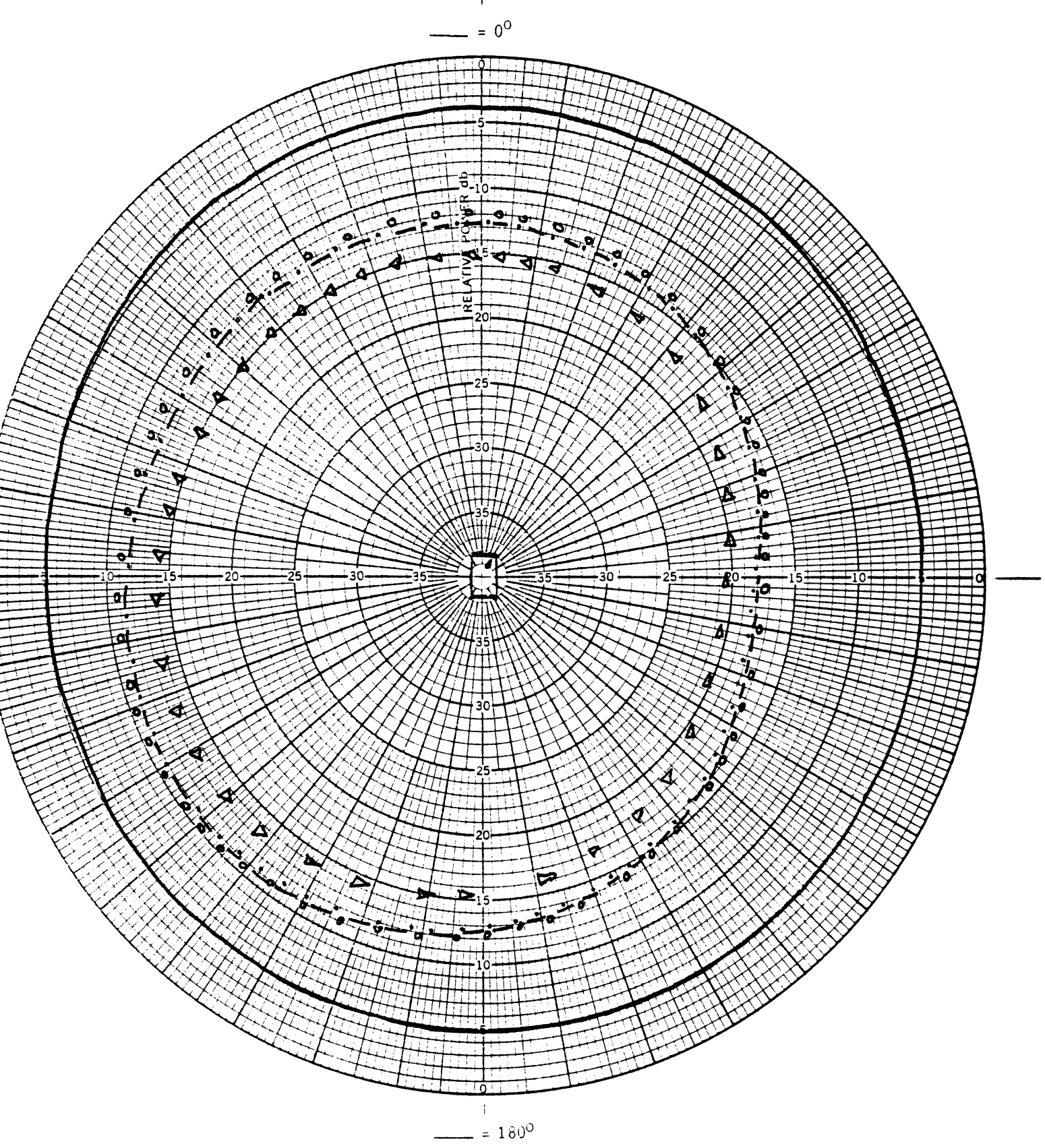


Figure 6(b). Radiation patterns at CB Channel 19 for test and reference antennas on 1978 Light Truck.

—— CB Reference, ---- EPL-20, ···· RP-111-20, °°°° D8TF-18B812-AD, ΔΔΔΔ MS-20.

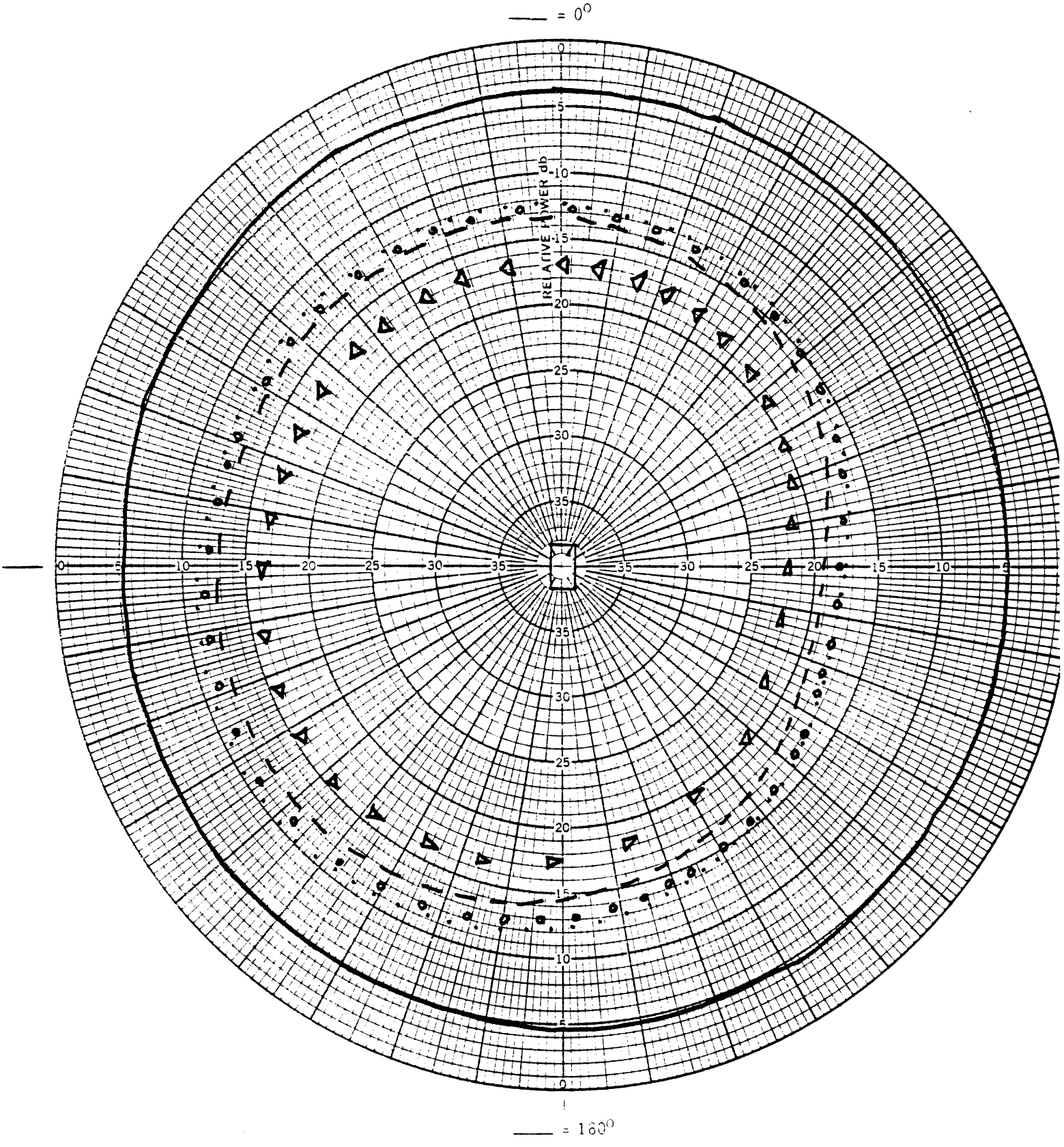


Figure 6(c). Radiation patterns at CB Channel 40 for test and reference antennas on 1978 Light Truck.

—— CB Reference, ---- EPL-20, ···· RP-111-20, °°°° D8TF-18B812-AD, ΔΔΔΔ MS-20.

direction and on the side where the antenna is located. This is a general trend observed with all CB patterns. From Figure 6 it can be seen that the unloaded antenna (MS-20) has the least CB sensitivity in all directions.

Figures 7(a)-(c) show the corresponding patterns at selected FM band frequencies obtained with the same four test antennas; the standard antenna used was the FM Entertainment antenna. Compared with the CB pattern in Figure 6, the FM-band patterns show more variations, a behavior which can be attributed to the fact that the operating wavelength is now comparable to the dimensions of the test vehicle. Here again, the test antennas are found to be less sensitive than the standard antenna, with the MS-20 antenna having the least sensitivity at 98 and 108 MHz.

Figures 8 and 9 show the impedance of the test antennas at the selected CB and FM band frequencies. The corresponding VSWRs can be obtained from these results, and will be discussed later.

In addition to the above, the AM band field strengths (i.e. AM-band patterns), the isolation characteristics at CB frequencies, and the system C and Q were measured for each test antenna. The results of these measurements and also the average sensitivity and VSWRs derived from Figures 6-9 are shown in Table 3, and can be used to judge the comparative performance of the four antennas tested. As regards the sensitivity and VSWR properties at the CB and FM band frequencies, the unloaded antenna (MS-20) appears to be the poorest.

4.2. Van

The horizontal plane radiation patterns at CB and FM band frequencies obtained with the test antennas mounted on a van are shown in Figures 10 and 11, respectively. The patterns at the CB frequencies show variations similar to those in Figure 6 except for the considerable decrease in sensitivity in the direction near 90°. The corresponding impedances are shown in Figures 12 and 13. Table 4 summarizes the results necessary for a performance comparison. As concluded in Section 4.1, the unloaded

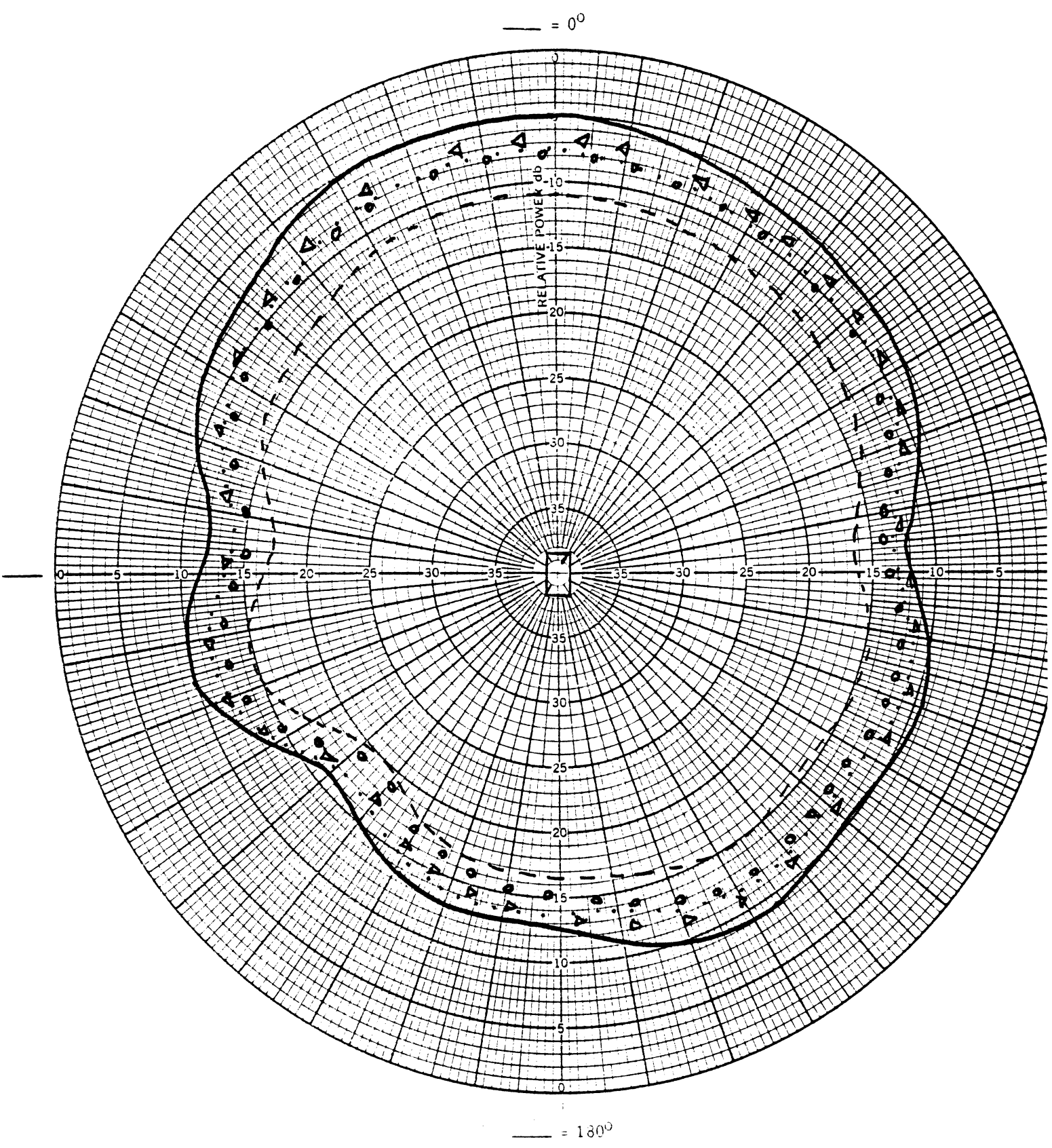


Figure 7(a). Radiation patterns at 88 MHz for test and FM reference antennas on 1978 Light Truck.

—— FM Reference, --- EPL-20, ····· RP-111-20, °°°° D8TF-18B812-AD, ΔΔΔΔ MS-20.

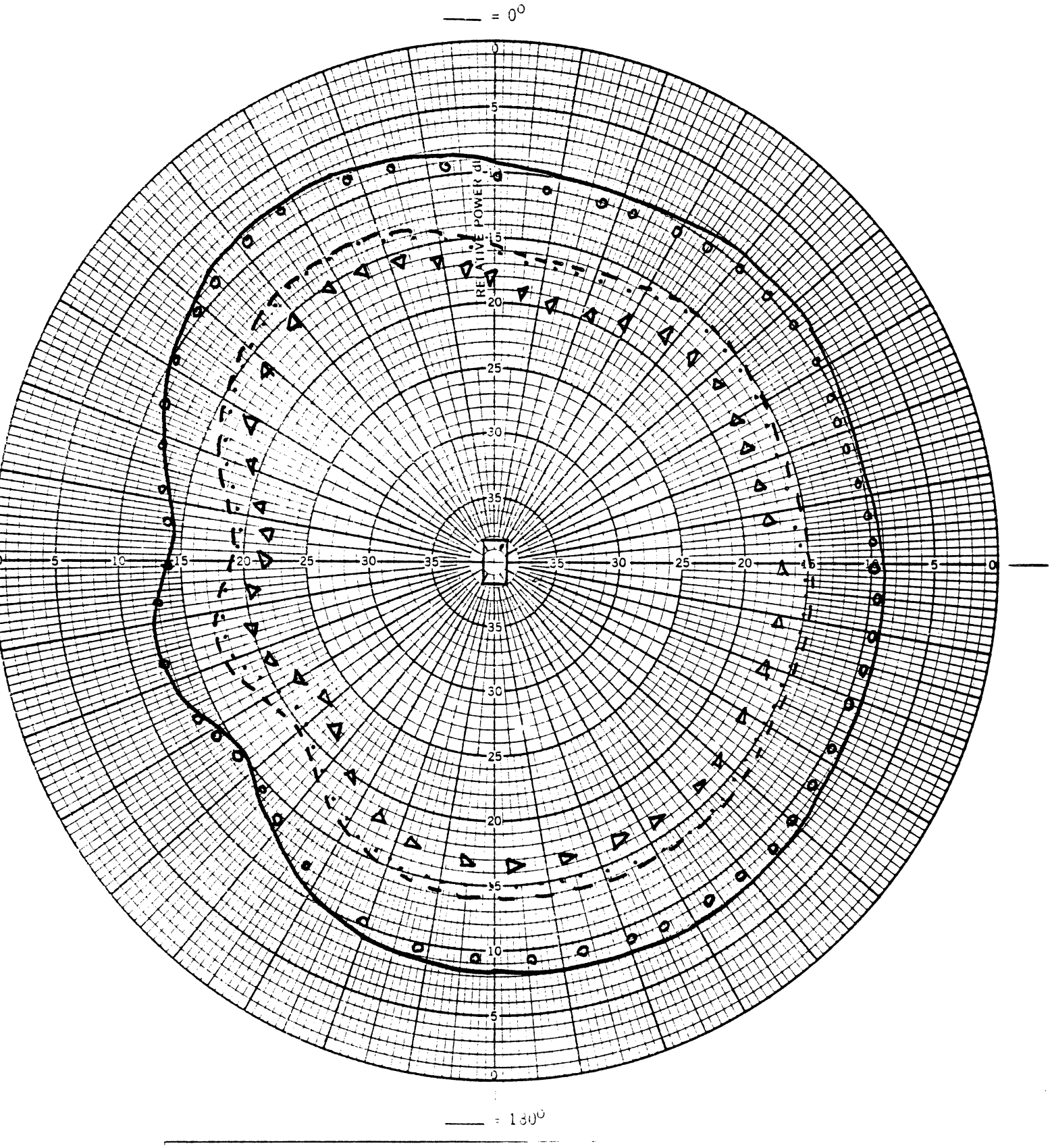


Figure 7(b). Radiation patterns at 98 MHz for test and FM reference antennas on 1978 Light Truck.

—— FM Reference, ---- EPL-20, ···· RP-111-20, ∘∘∘∘ D8TF-18B812-AD, ΔΔΔΔ MS-20.

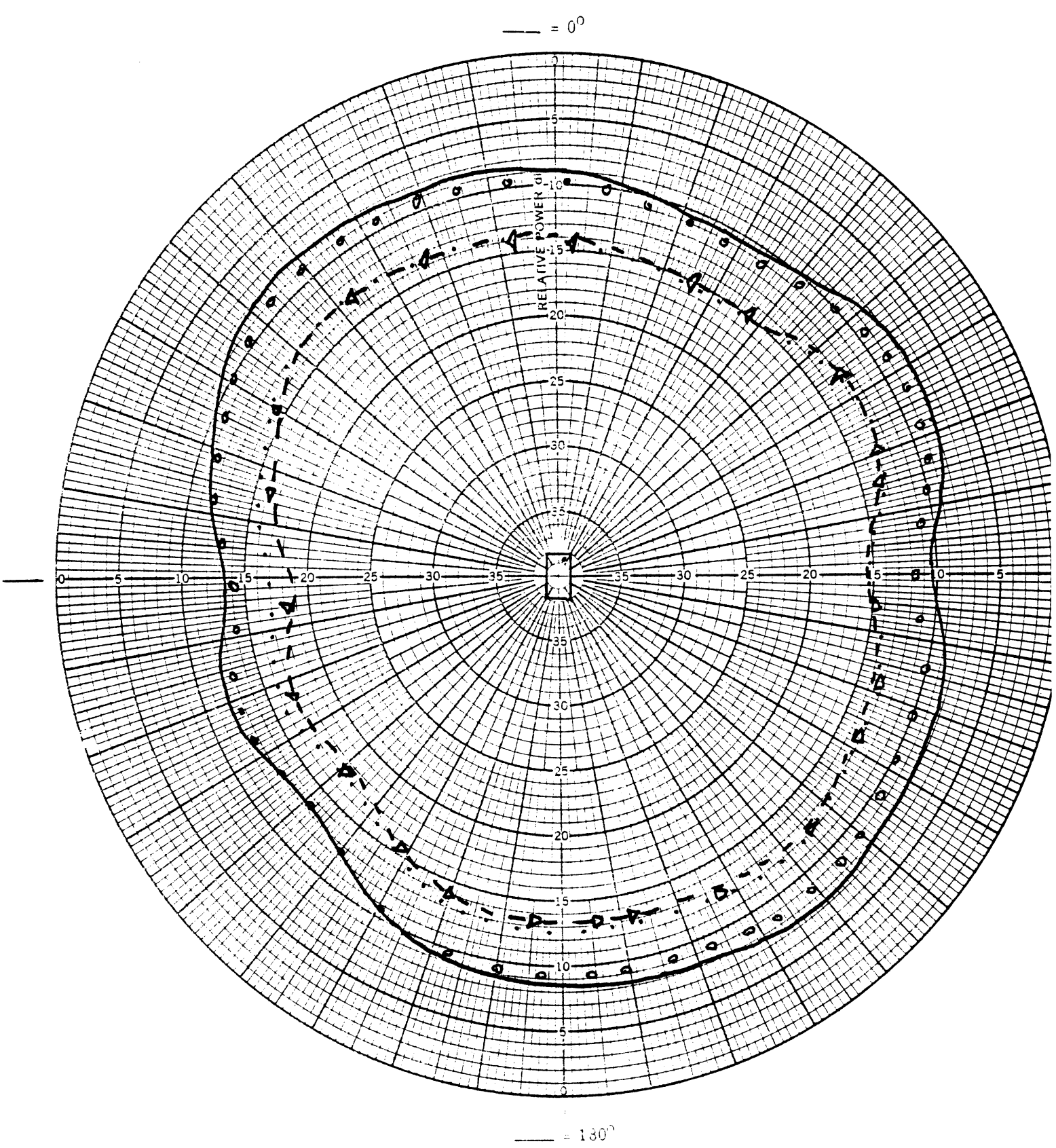
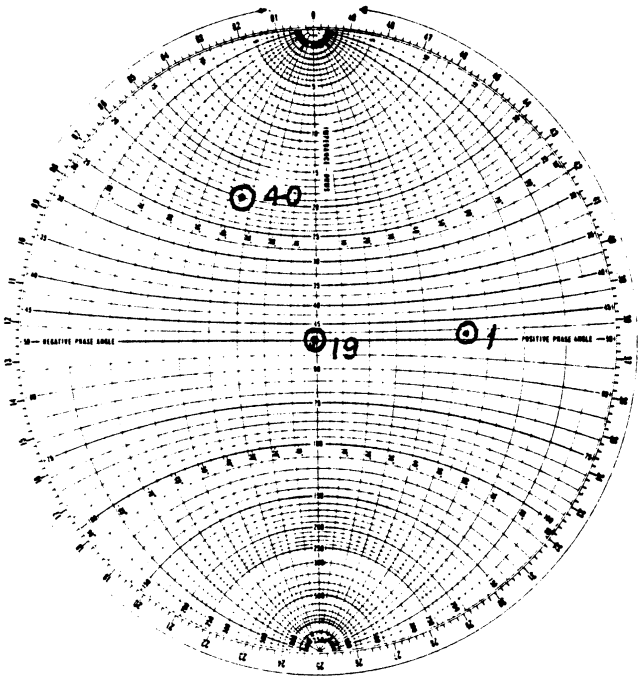
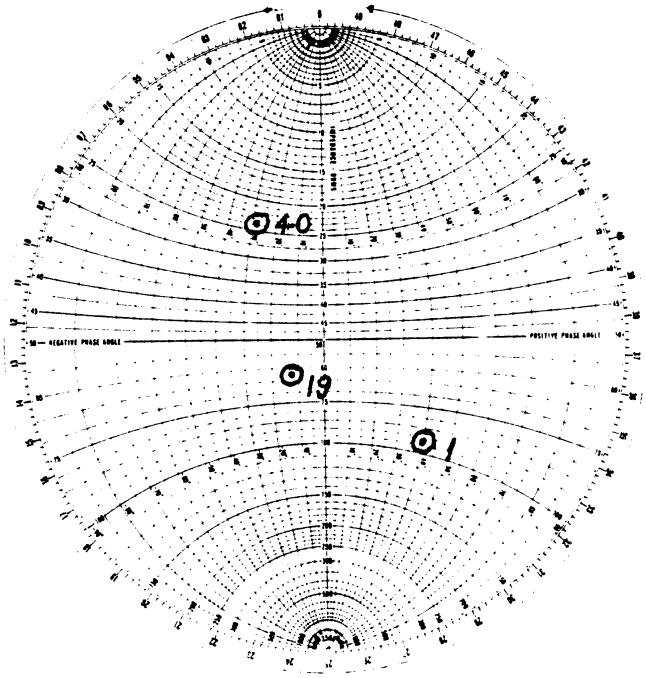


Figure 7(c). Radiation patterns at 108 MHz for test and FM reference antennas on 1978 Light Truck.

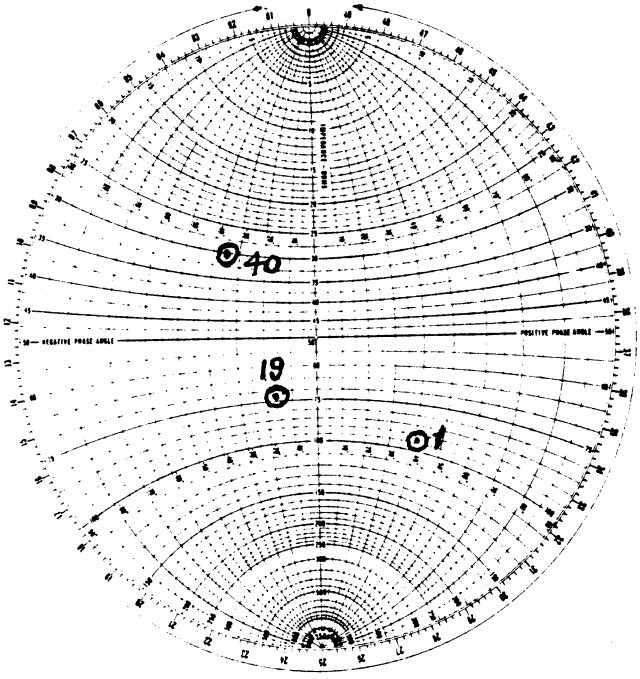
—— FM Reference, ---- EPL-20, ···· RP-111-20, ○○○○ D8TF-18B812-AD, ΔΔΔΔ MS-20.



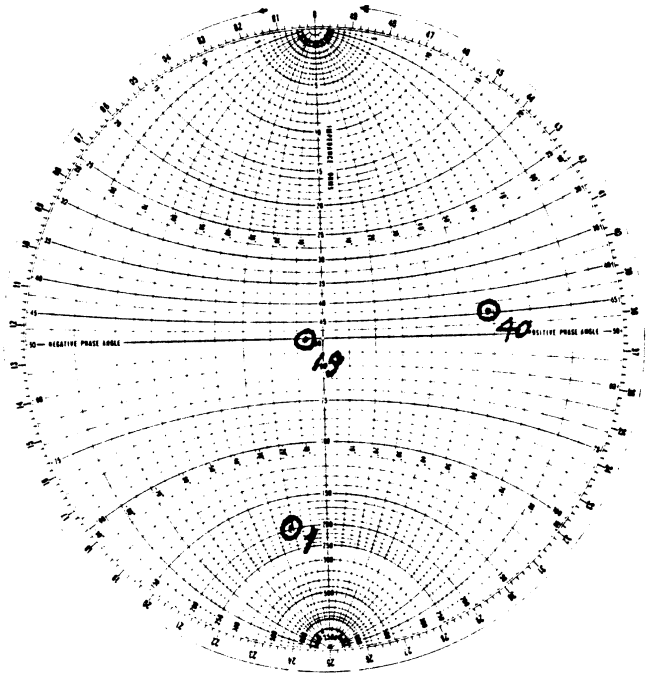
(a)



(b)

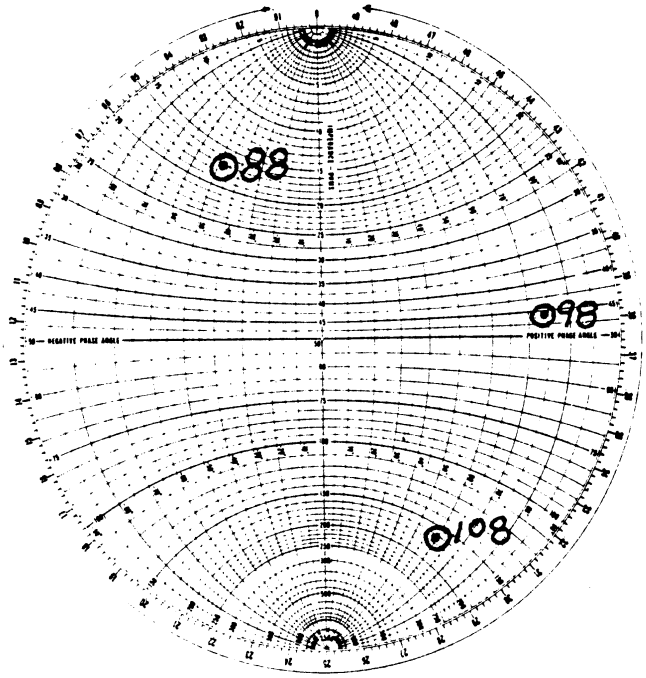


(c)

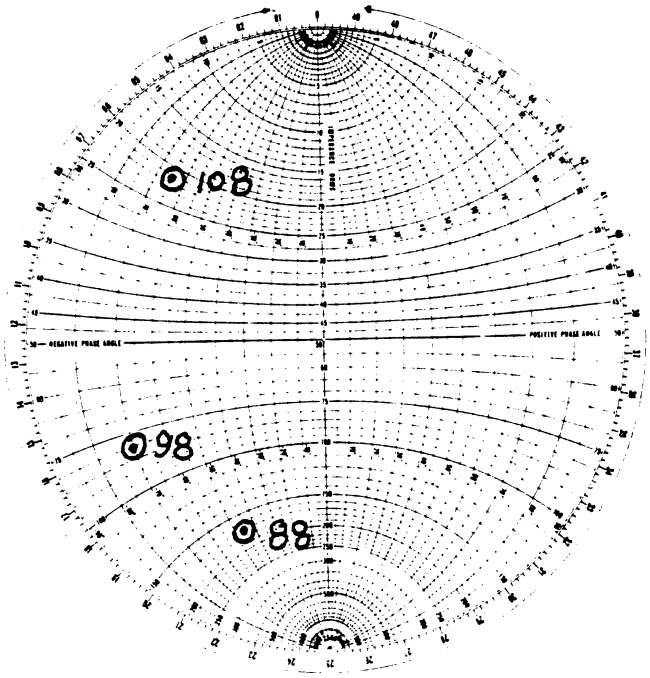


(d)

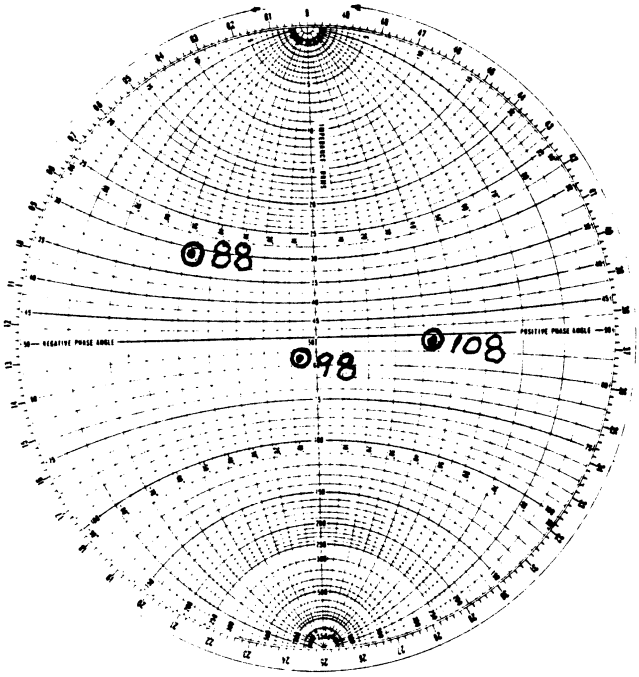
Figure 8. Impedance characteristics at CB Channel 1, 19 and 40 for test antennas on 1978 Light Truck.
(a) EPL-20, (b) RP-111-20, (c) D8TF-18B812-AD, (d) MS-20.



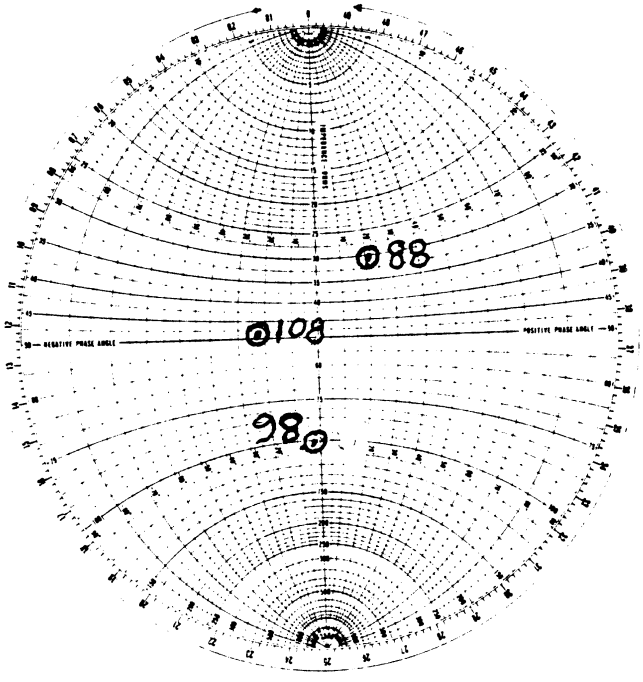
(a)



(b)

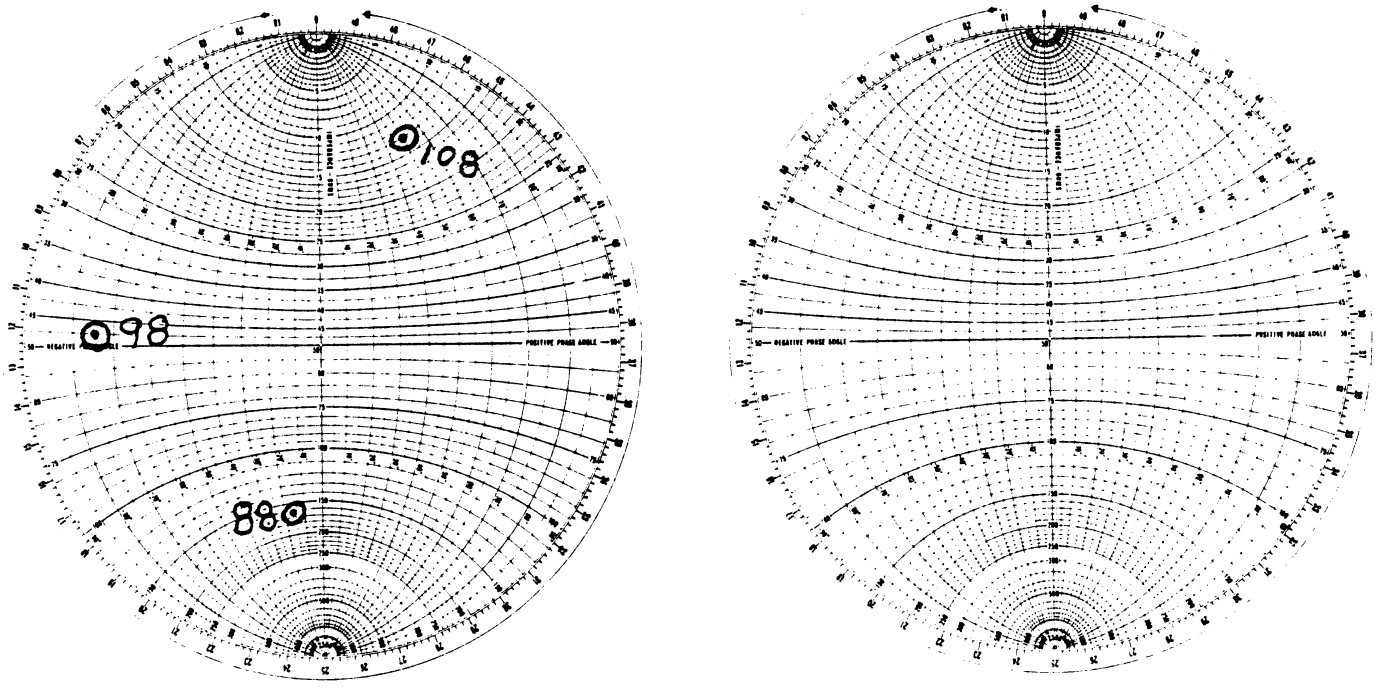


(c)



(d)

Figure 9(a)-(d). Impedance characteristics at 88, 98 and 108 MHz for test antennas on 1978 Light Truck.
(a) EPL-20, (b) RP-111-20, (c) D8TF-18B812-AD, (d) FM Reference,
(Continued on next page)



(e)

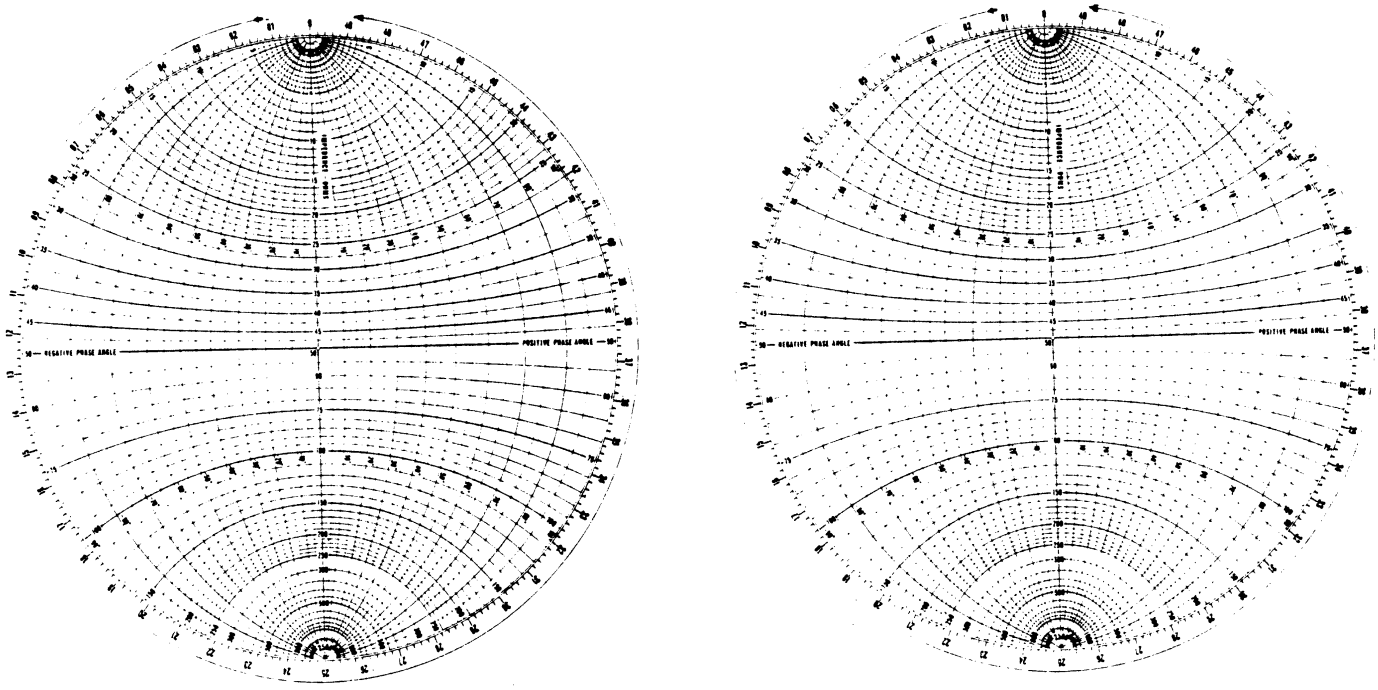


Figure 9(e). Impedance characteristics at 88, 98 and 108 MHz for test antennas on 1978 Light Truck.
(e) MS-20.

TABLE 3. PERFORMANCE DATA FOR TEST ANTENNAS ON 1978 LIGHT TRUCK.

PERFORMANCE COMPARISON					
PARAMETER	ANTENNA TYPE				
	STD ENT	PRODUCTION	EPL	RP	MS
AM Sensitivity (dB/m)					
0.76 MHz	-68	-71	-66	-68	-74
1.10 MHz	---	---	---	---	---
1.60 MHz	---	---	---	---	---
Relative FM Sensitivity (dB)					
88.0 MHz	0	- 2.3	- 4.8	- 1.8	- 1.1
98.0 MHz	0	- 0.2	- 5.6	- 6.1	- 8.1
108.0 MHz	0	- 0.7	- 3.7	- 3.3	- 3.5
Relative CB Sensitivity (dB)					
CH 1	0	- 8.0	- 9.8	- 9.8	-13.0
CH 19	0	- 8.0	- 8.0	- 8.0	-11.0
CH 40	0	- 8.3	- 9.7	- 8.3	-11.3
FM VSWR					
88.0 MHz	1.81	2.89	4.83	5.26	3.50
98.0 MHz	2.03	1.23	7.16	7.36	7.75
108.0 MHz	1.47	2.32	6.87	6.54	6.06
CB VSWR					
CH 1		2.77	3.00	2.77	4.42
CH 19		1.63	1.05	1.40	1.13
CH 40		2.36	3.14	2.50	3.54
Isolation (mV)					
CH 1		95	300	274	164
CH 19		95	164	206	204
CH 40		123	245	245	136
AM C(PF)					
0.5 MHz	68	95	68	91	98
1.0 MHz	72	100	71	95	97
1.5 MHz	66	92	67	87	98
AM Q					
0.5 MHz	4724	402	630	286	155
1.0 MHz	2247	380	515	143	72
1.5 MHz	714	985	440	212	38

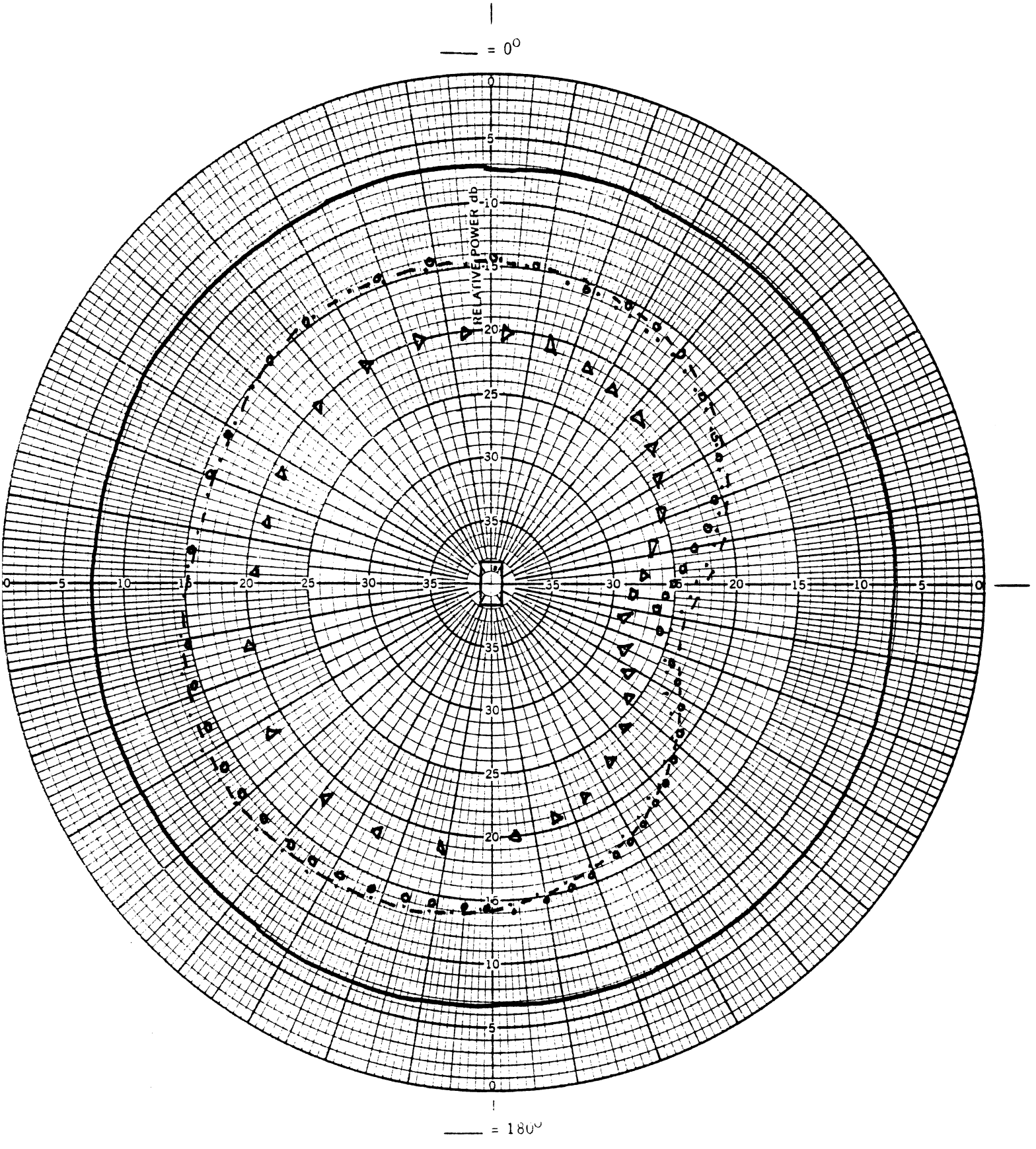


Figure 10(a). Radiation patterns at CB Channel 1 for test and reference antennas on 1978 Van.

—— CB Reference, ---- EPL-20, ···· RP-111-20, °°°° DU8F-18B812-AC, ΔΔΔΔ MS-20.

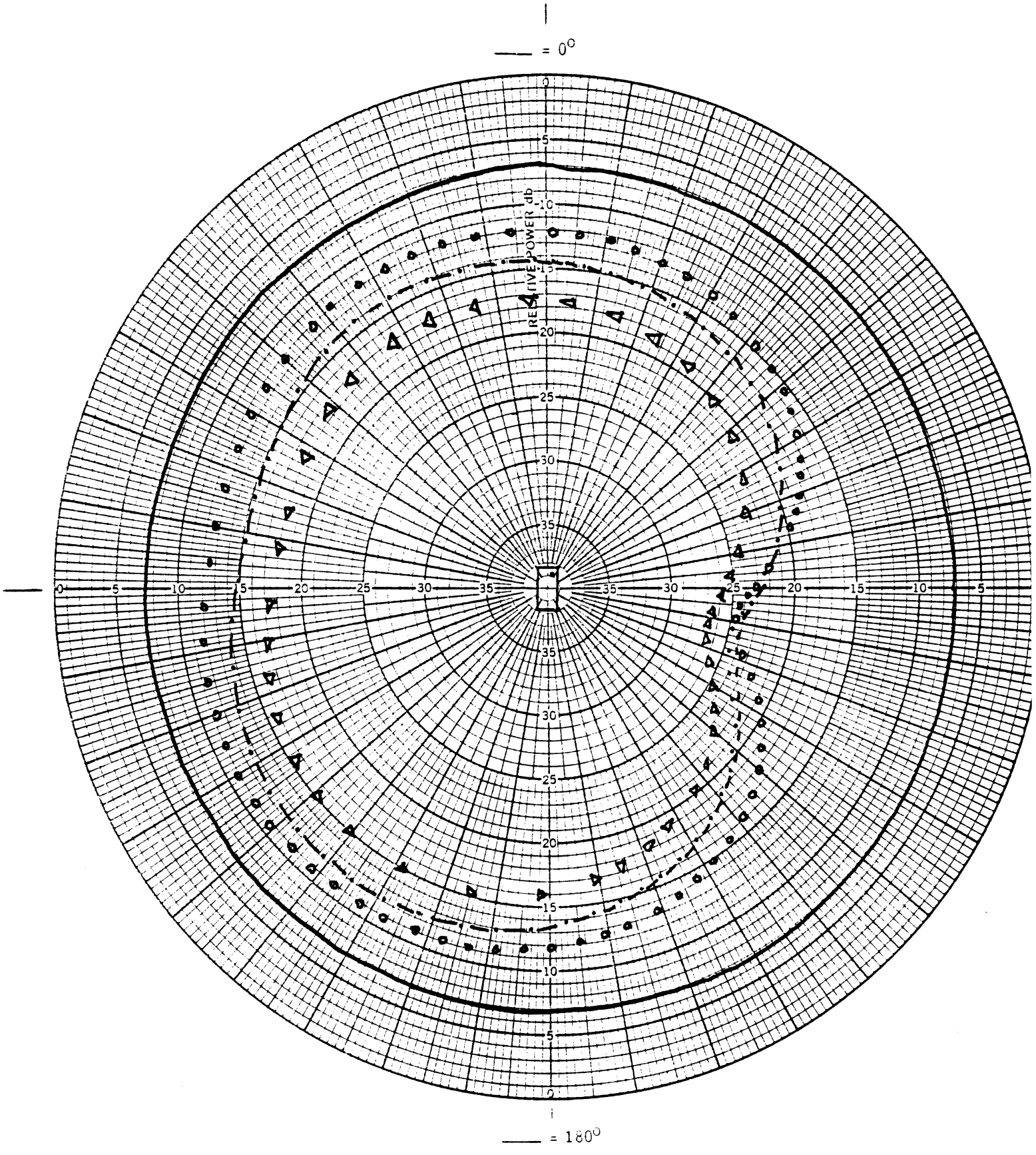


Figure 10(b). Radiation patterns at CB Channel 19 for test and reference antennas on 1978 Van.

—— CB Reference, ---- EPL-20, ···· RP-111-20, °°°° D8UF-18B812-AC, ΔΔΔΔ MS-20.

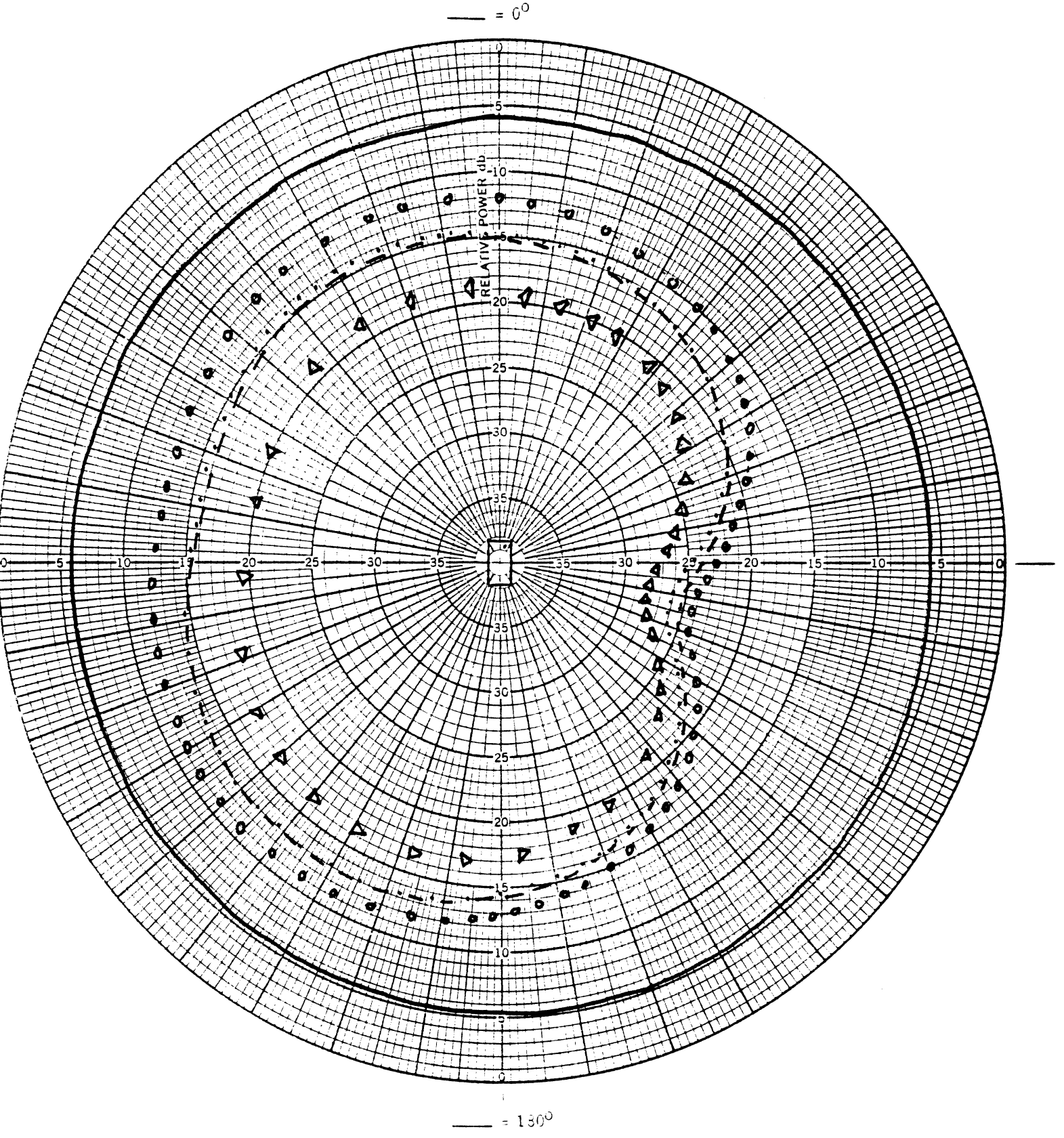


Figure 10(c). Radiation patterns at CB Channel 40 for test and reference antennas on 1978 Van.

—— CB Reference, ---- EPL-20, ···· RP-111-20, ∘∘∘∘ D8UF-18B812-AC, ΔΔΔΔ MS-20.

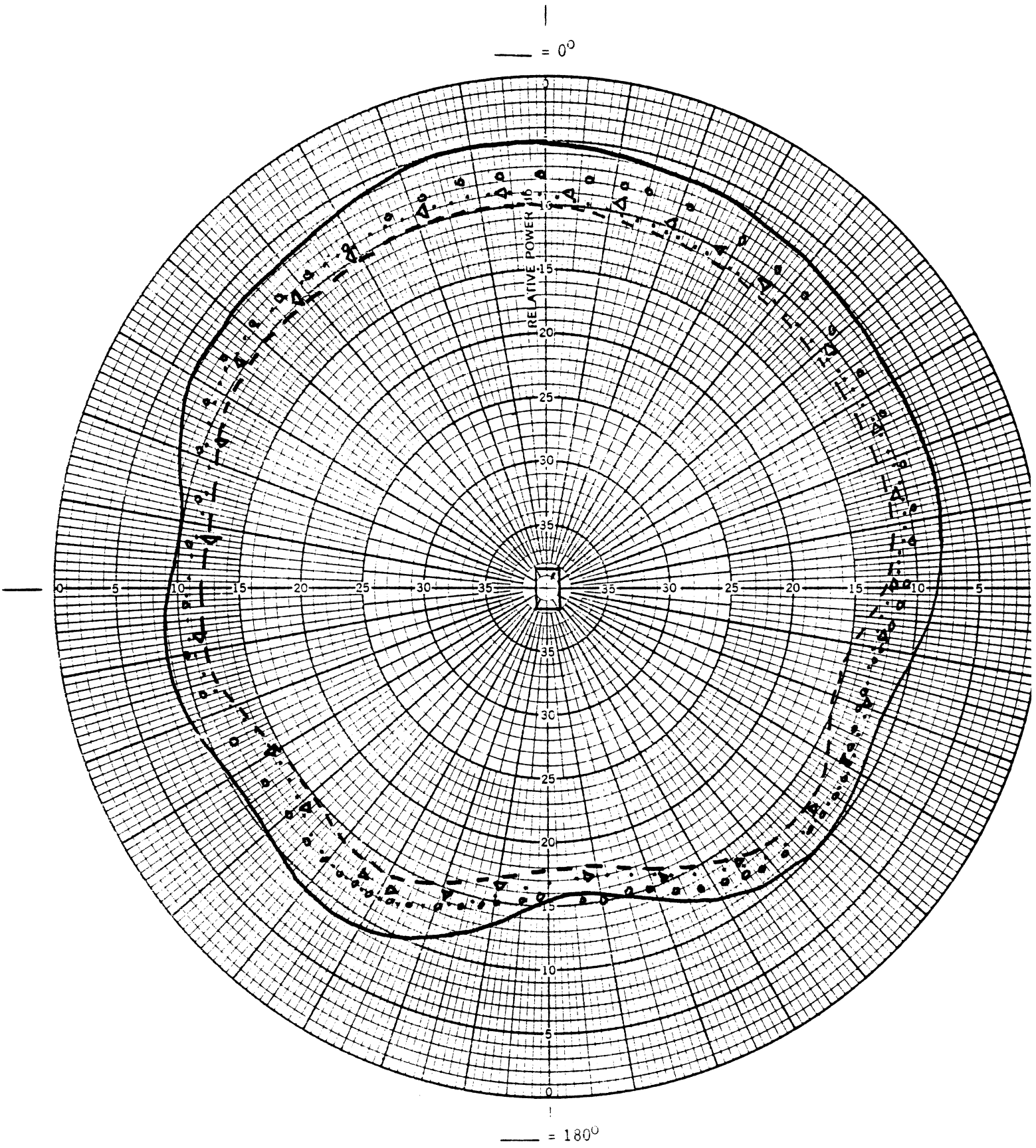


Figure 11(a). Radiation patterns at 88 MHz for test and FM reference antennas on 1978 Van.

—— FM Reference, ---- EPL-20, ···· RP-111-20, ∘∘∘∘ D8UF-18B812-AC, ΔΔΔΔ MS-20.

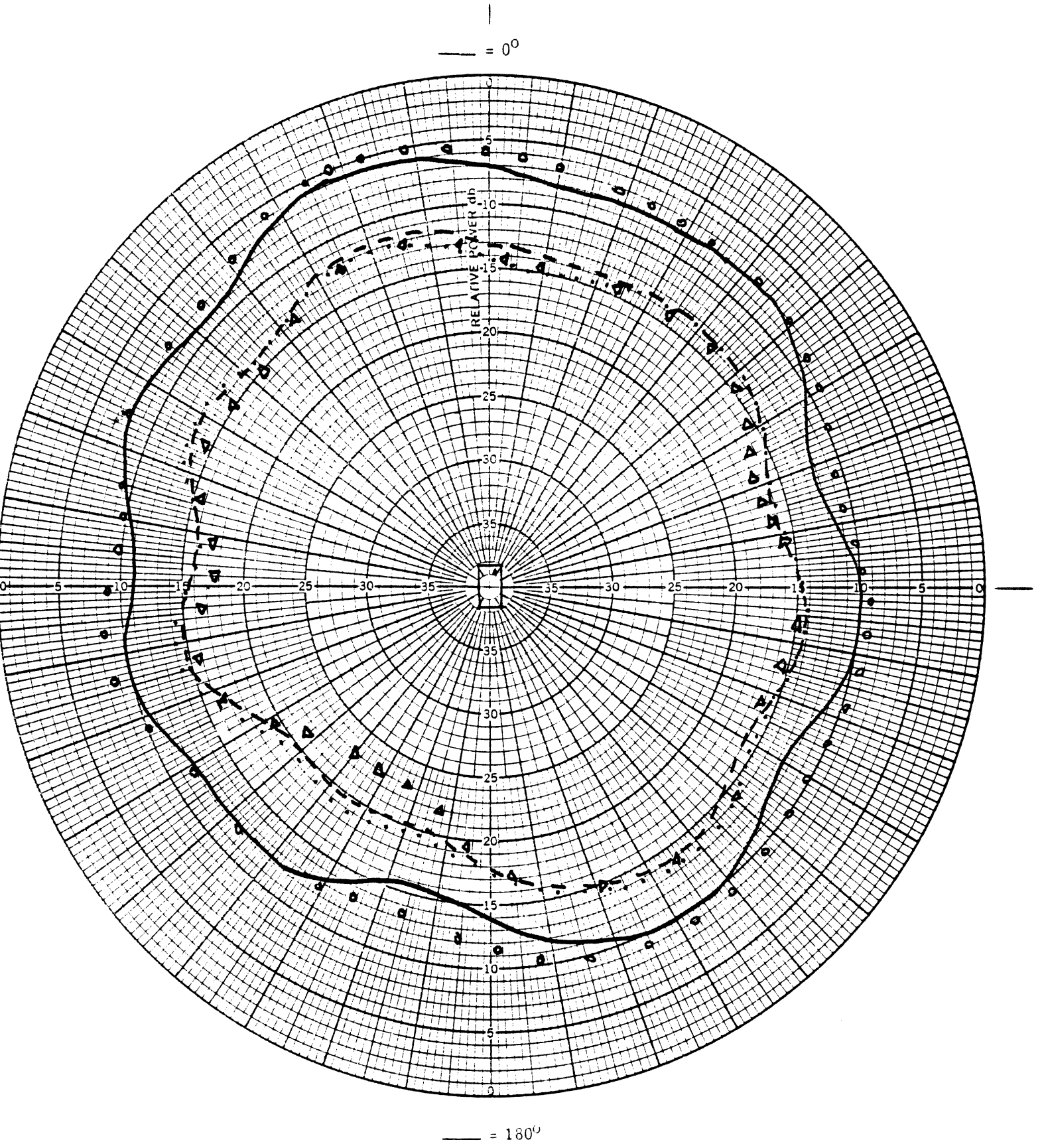


Figure 11(b). Radiation patterns at 98 MHz for test and FM reference antennas on 1978 Van.

—— FM Reference, ---- EPL-20, ···· RP-111-20, ∘∘∘∘ D8UF-18B812-AC, ΔΔΔΔ MS-20.

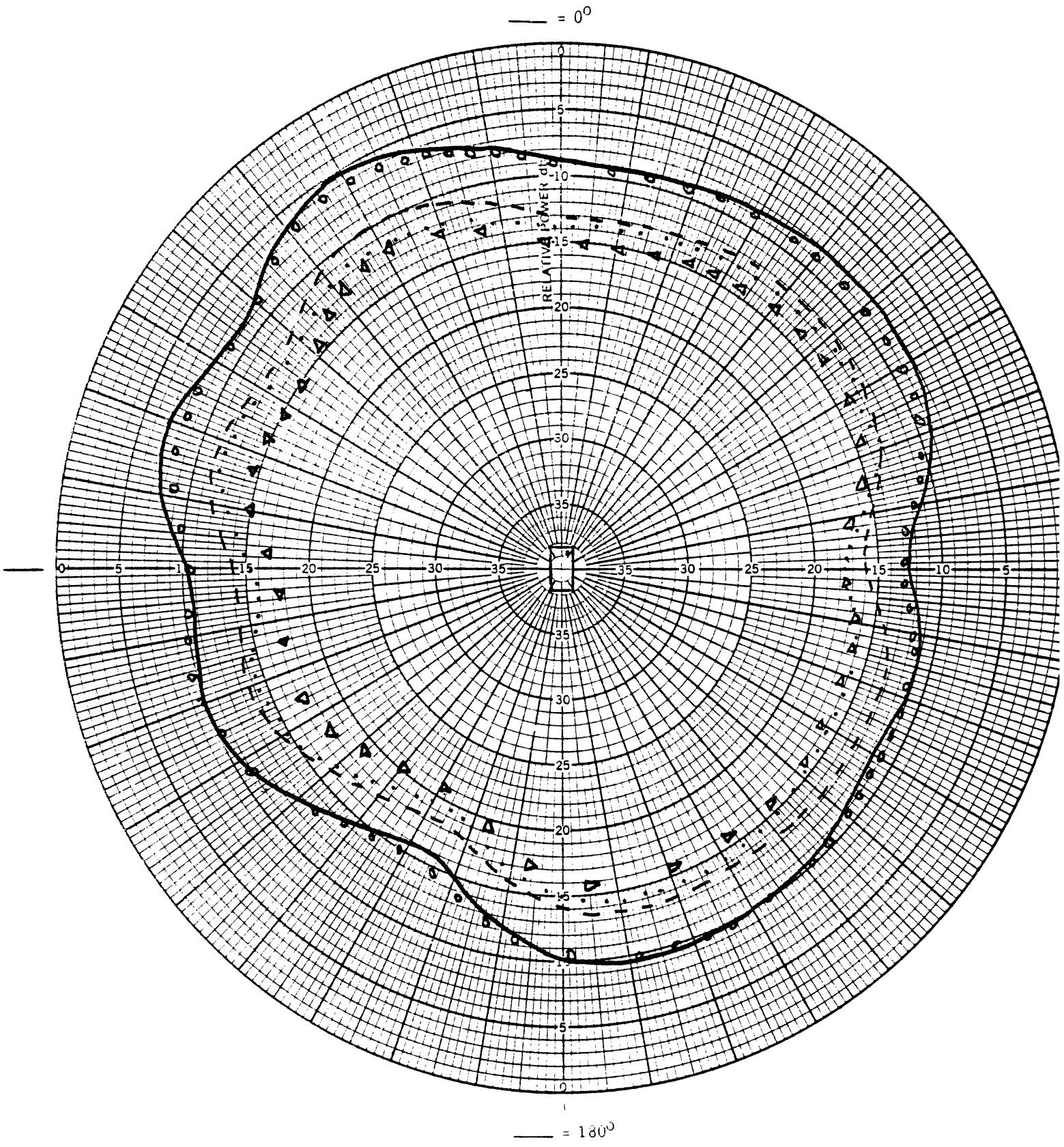
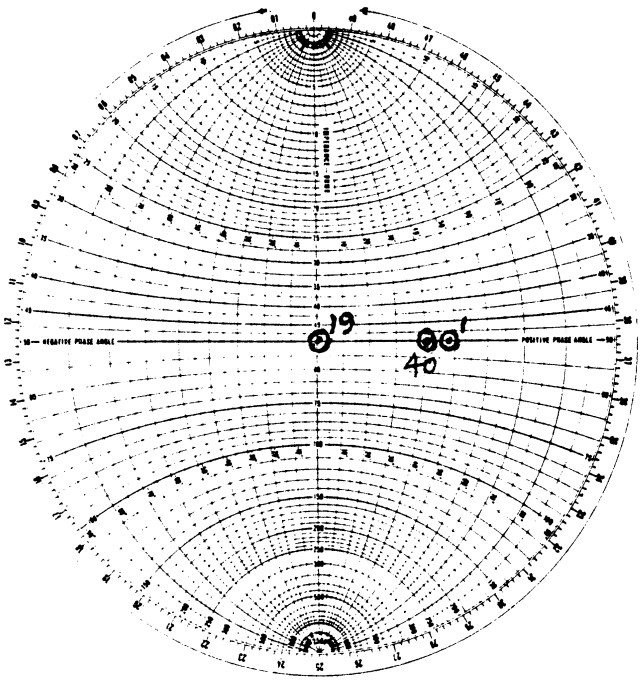
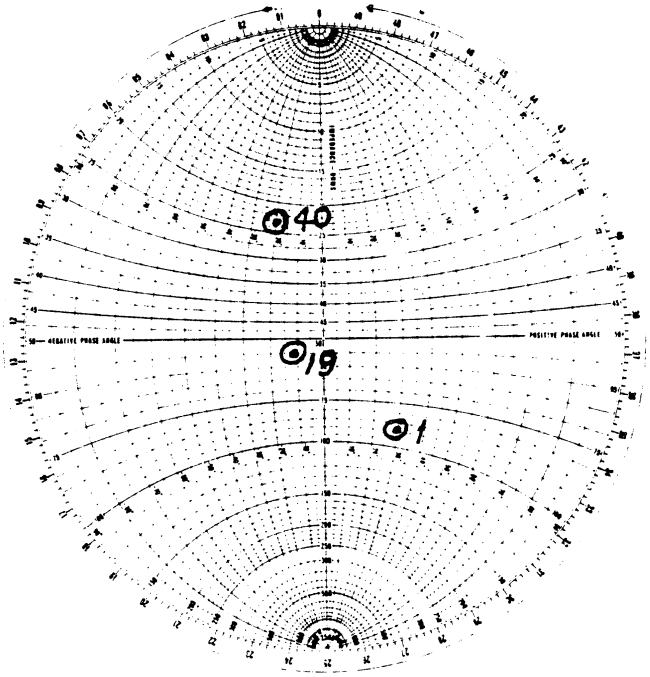


Figure 11(c). Radiation patterns at 108 MHz for test and FM reference antennas on 1978 Van.

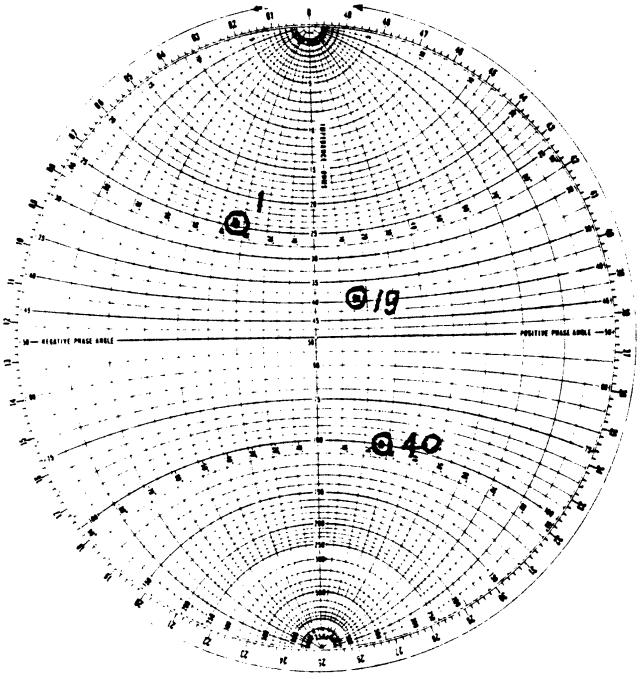
—— FM Reference, ---- EPL-20, ···· RP-111-20, °°°° D8UF-18B812-AC, ΔΔΔΔ MS-20.



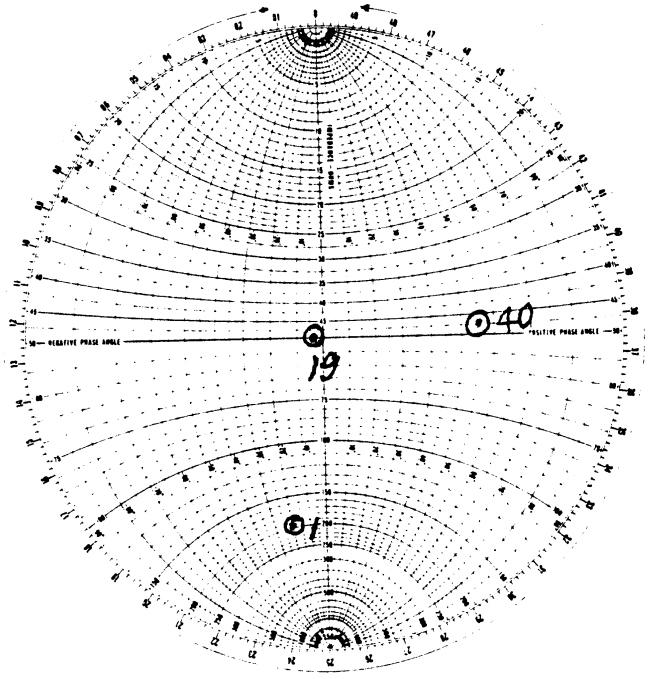
(a)



(b)

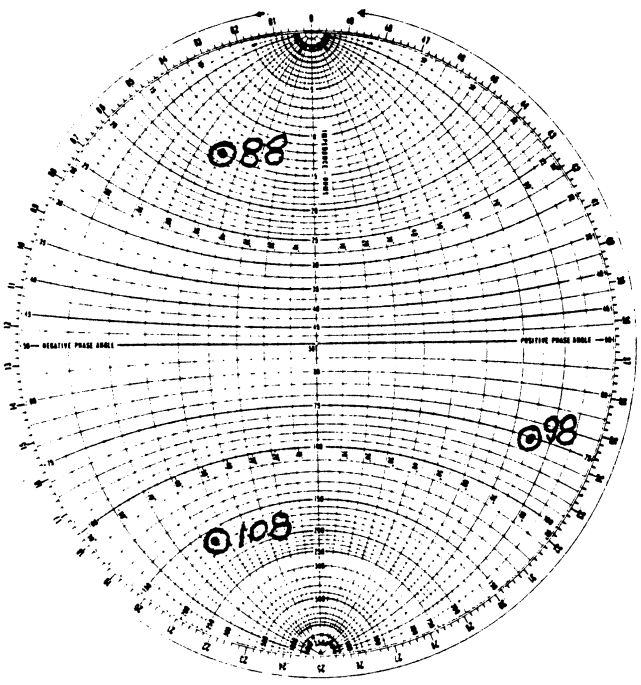


(c)

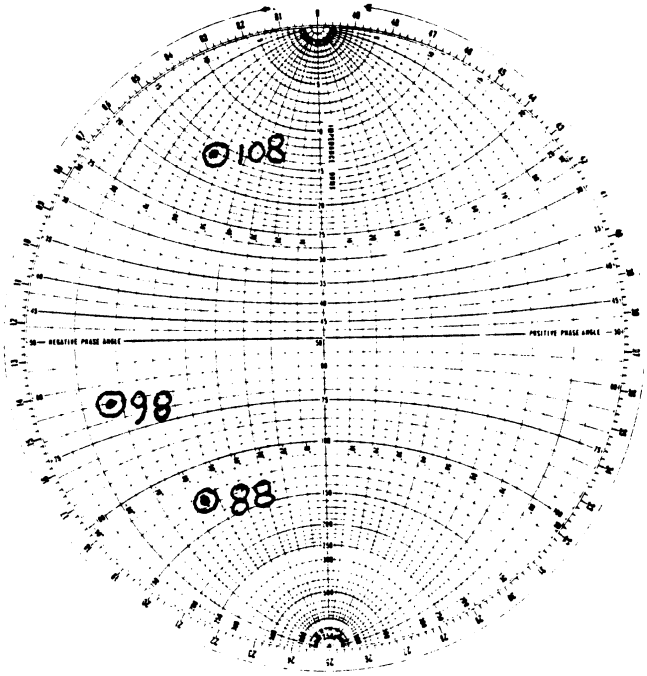


(d)

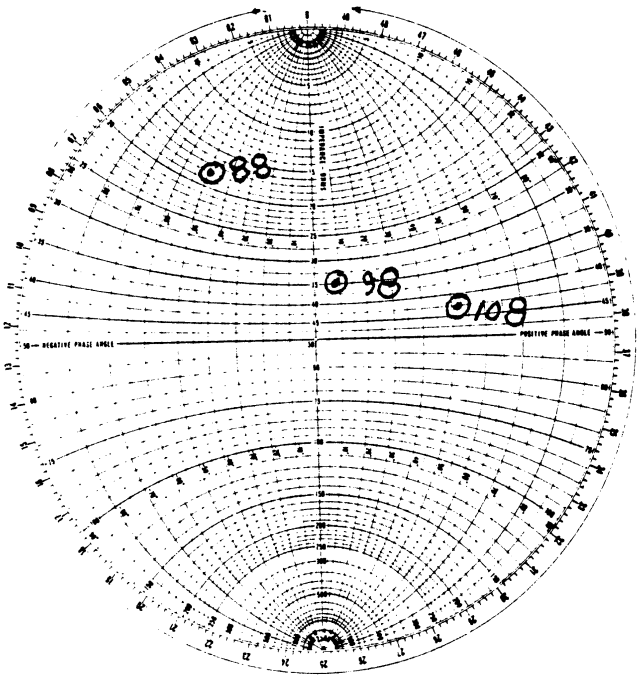
Figure 12. Impedance characteristics at CB Channel 1, 19 and 40 for test antennas on 1978 Van.
(a) EPL-20, (b) RP-111-20, (c) D8UF-18B812-AC, (d) MS-20.



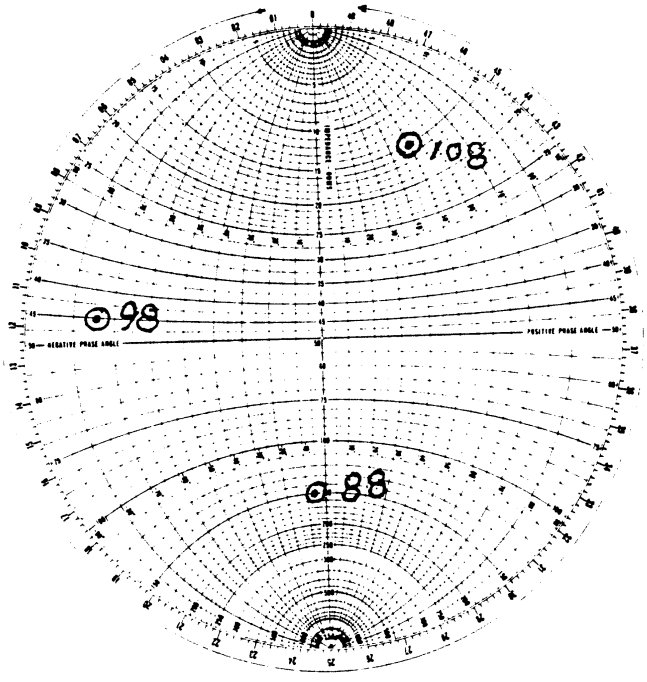
(a)



(b)

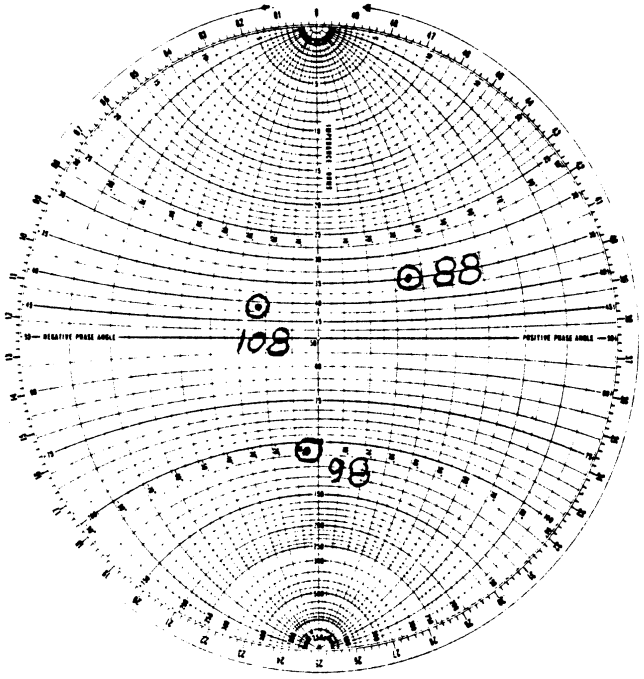


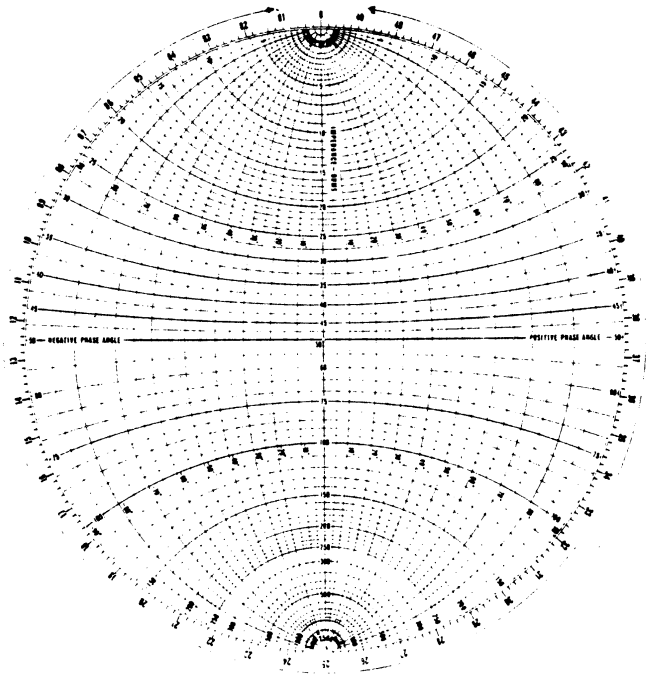
(c)



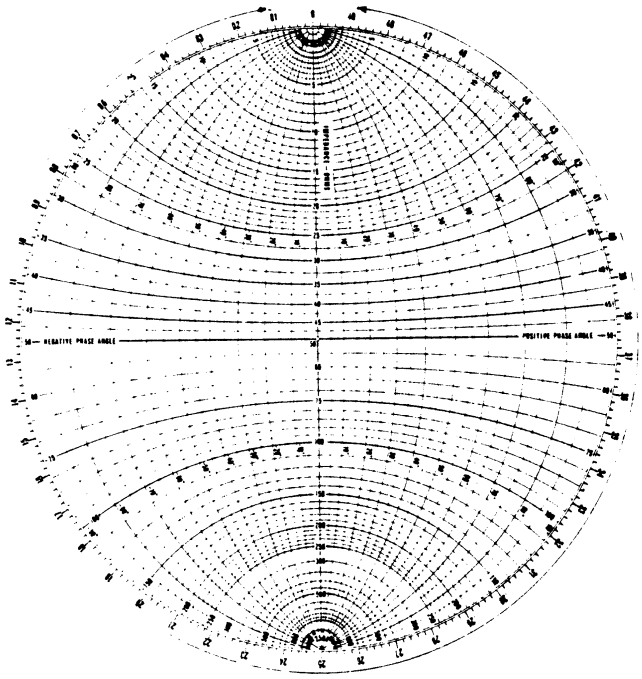
(d)

Figure 13(a)-(d). Impedance characteristics at 88, 98 and 108 MHz for test and FM reference antennas on 1978 Van.
(a) EPL-20, (b) RP-111-20, (c) D8UF-18B812-AC, (d) FM Reference,
(Continued on next page)





(e)



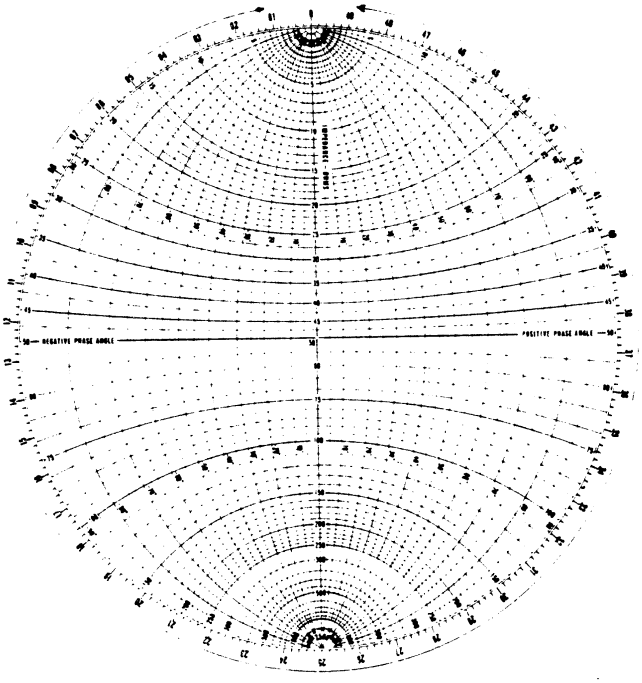


Figure 13(e). Impedance characteristics at 88, 98 and 108 MHz for test and FM reference antennas on 1978 Van.
(e) MS-20.

TABLE 4. PERFORMANCE DATA FOR TEST ANTENNAS ON 1978 VAN.

PERFORMANCE COMPARISON					
PARAMETER	ANTENNA TYPE				
	STD ENT	PRODUCTION	EPL	RP	MS
AM Sensitivity (dB/m)					
0.76 MHz	-74	-68	-60	-68	-74
1.10 MHz	---	---	---	---	---
1.60 MHz	---	---	---	---	---
Relative FM Sensitivity (dB)					
88.0 MHz	0	+1.7	-3.2	-2.7	-2.7
98.0 MHz	0	-1.0	-6.0	-6.0	-6.4
108.0 MHz	0	-0.2	-3.2	-4.6	-5.6
Relative CB Sensitivity (dB)					
CH 1	0	-8.3	-8.6	-8.6	-13.7
CH 19	0	-5.7	-8.0	-8.0	-10.7
CH 40	0	-7.5	-10.0	-10.0	-13.6
FM VSWR					
88.0 MHz	2.06	4.62	5.29	4.94	3.34
98.0 MHz	2.09	1.44	7.77	7.00	7.74
108.0 MHz	1.58	3.00	6.29	6.18	5.91
CB VSWR					
CH 1		2.60	2.57	2.25	4.26
CH 19		1.46	1.07	1.28	1.12
CH 40		2.29	2.21	2.43	3.44
Isolation (mV)					
CH 1		236	410	320	195
CH 19		174	310	250	226
CH 40		198	174	245	177
AM C(PF)					
0.5 MHz	68	99	68	91	98
1.0 MHz	72	93	71	95	97
1.5 MHz	66	91	67	87	98
AM Q					
0.5 MHz	4724	182	630	286	155
1.0 MHz	2247	102	515	143	72
1.5 MHz	714	14	440	212	38

antenna is inferior in performance.

4.3. LTD II, Cougar/T-Bird

These three cars have similar bodies, and the results shown apply to all of them. The actual test vehicle used was the Cougar. The radiation patterns and impedances are shown in Figures 14-17, and we note that the CB patterns shown in Figures 14(a)-(c) are all omnidirectional. Table 5 summarizes the results necessary for a performance comparison. The sensitivity of the unloaded antenna is inferior at CB and AM frequencies, but in other respects its performance is slightly better or at least equal to that of the other three antennas.

4.4. Bronco

The results obtained with the test antennas mounted on a Bronco are shown in Figures 18-21 and in Table 6. The results indicate that, in general, the performance of the unloaded antenna is inferior to that of the other antennas.

4.5. Fiesta

The results obtained with tested antennas mounted on the Fiesta are shown in Figures 22-25 and in Table 7. Our previous comments about the unloaded antenna apply here also.

4.6. Granada/Monarch/Versailles

These three cars have similar bodies and the results shown apply to all of them. The actual test vehicle used was the Versailles. Only the production model test antenna was used for this set of measurements, and the corresponding results are shown in Figures 26-29 and in Table 8.

4.7. Discussion

Although it has been found that the performance of a test antenna depends on the vehicle it is mounted on, there seem to be no general

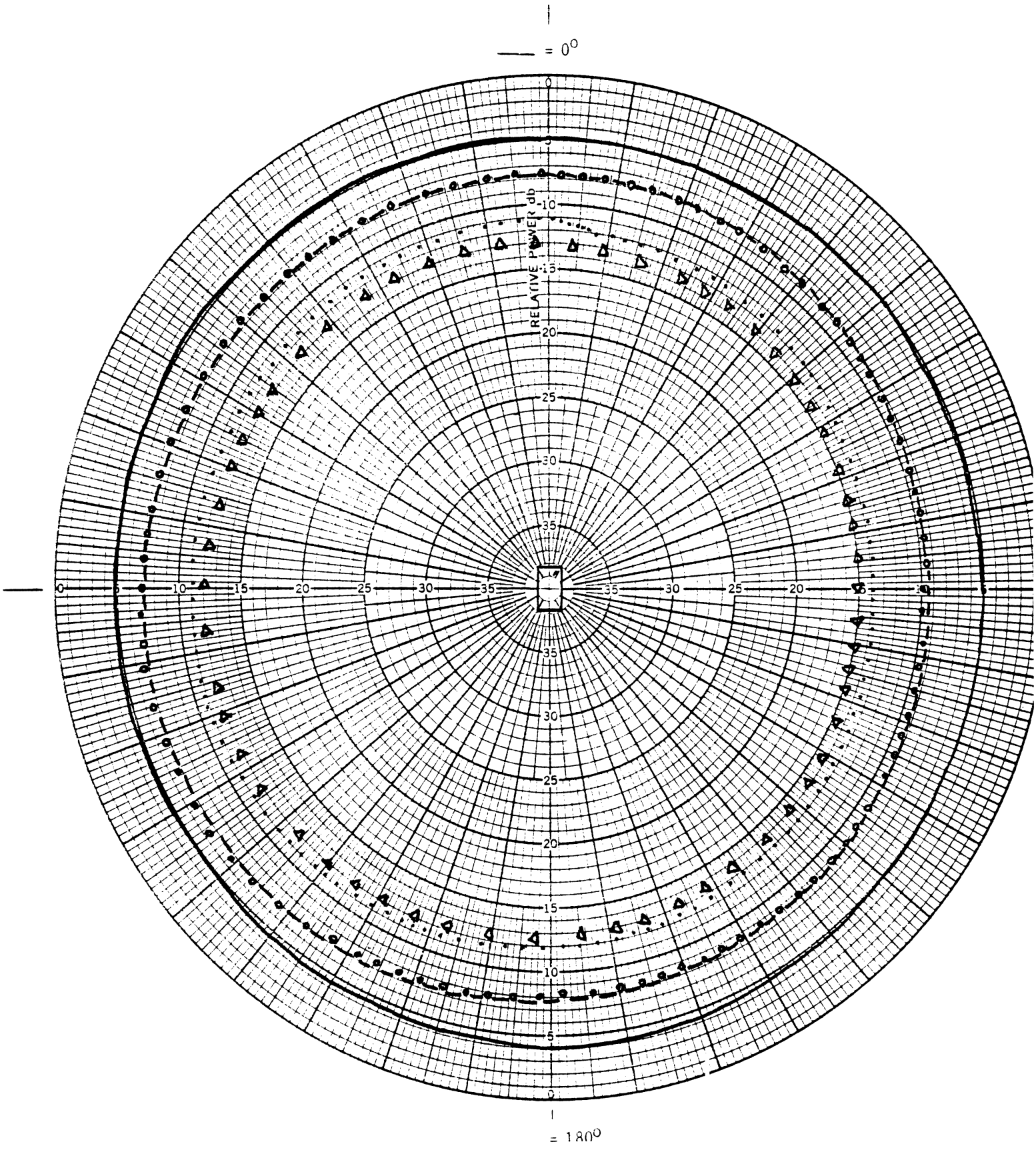


Figure 14(a). Radiation patterns at CB Channel 1 for test and reference antennas on 1978 LTD II/Cougar/T-Bird.

—— CB Reference, ---- EPL-60, ···· RP-111-60, ∘∘∘∘D8OF-18B12-CE, ΔΔΔΔ MS-60.

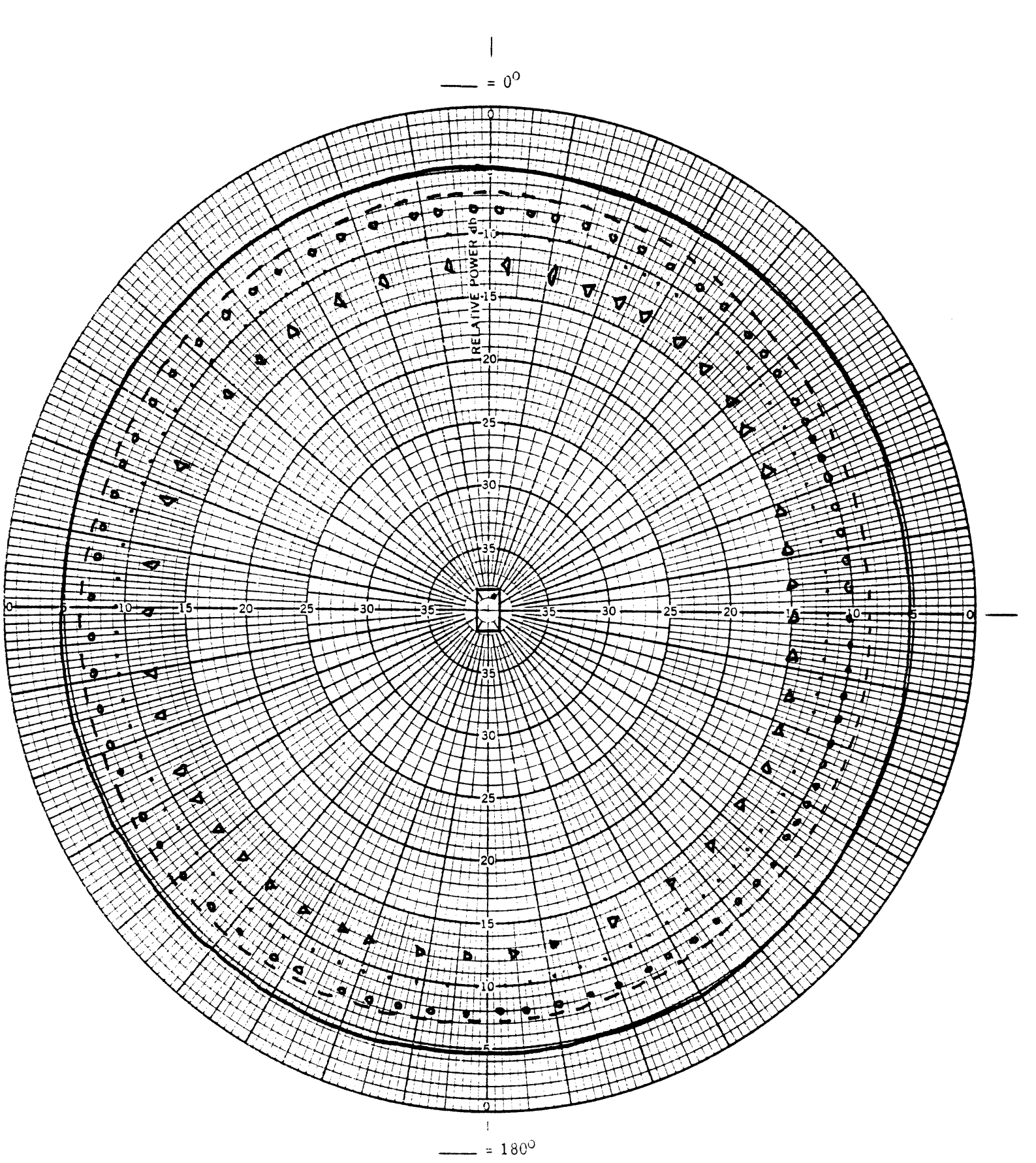


Figure 14(b). Radiation patterns at CB Channel 19 for test and reference antennas on 1978 LTD II/Cougar/T-Bird.

—— CB Reference, ---- EPL-60, ···· RP-111-60, ○○○○ D80F-18B12-CE, ΔΔΔΔ MS-60.

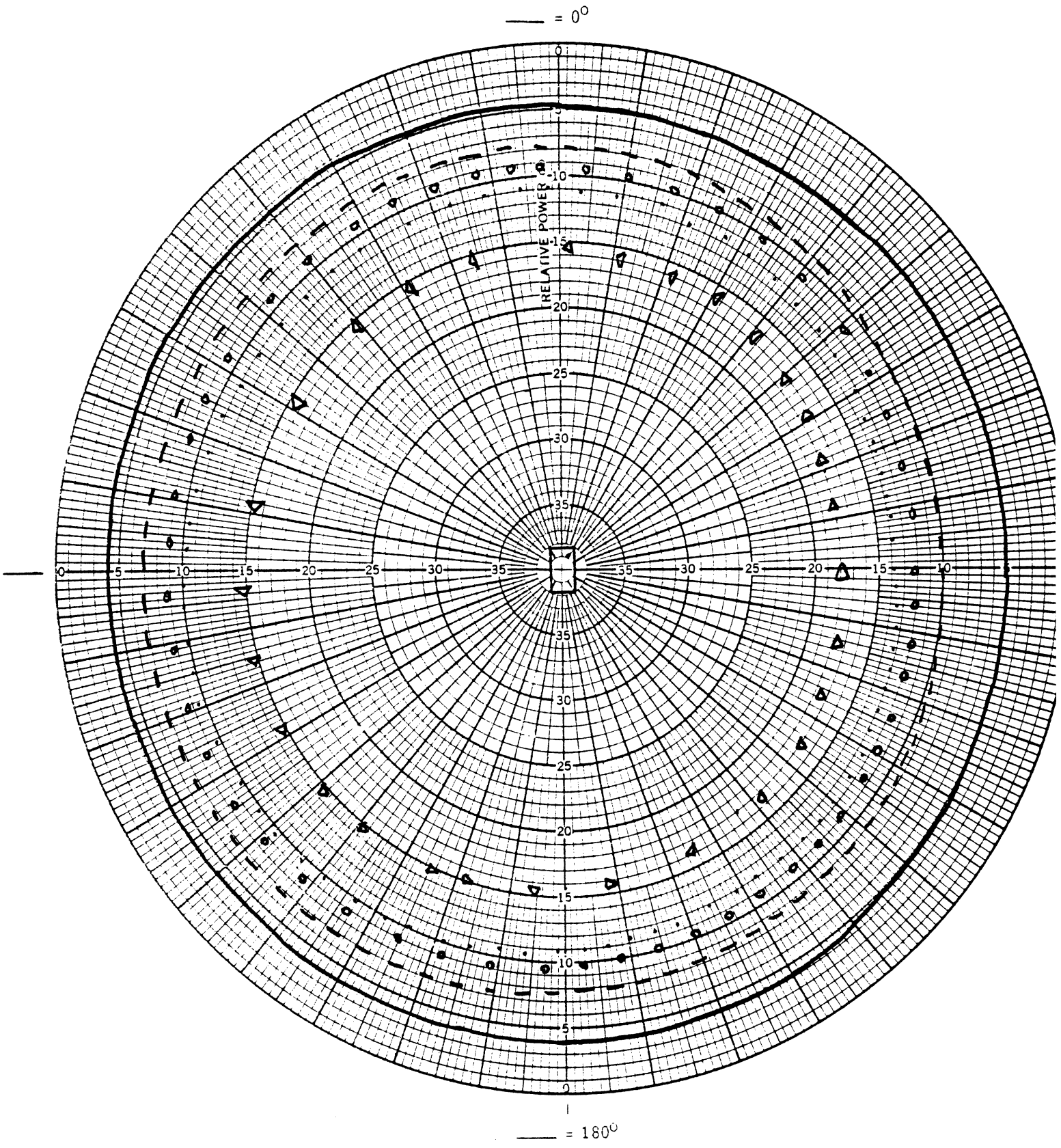


Figure 14(c). Radiation patterns at CB Channel 40 for test and reference antennas on 1978 LTD II/Cougar/T-Bird.

—— CB Reference, ---- EPL-60, ···· RP-111-60, ○○○○ D8OF-18B12-CE, ΔΔΔΔ MS-60.

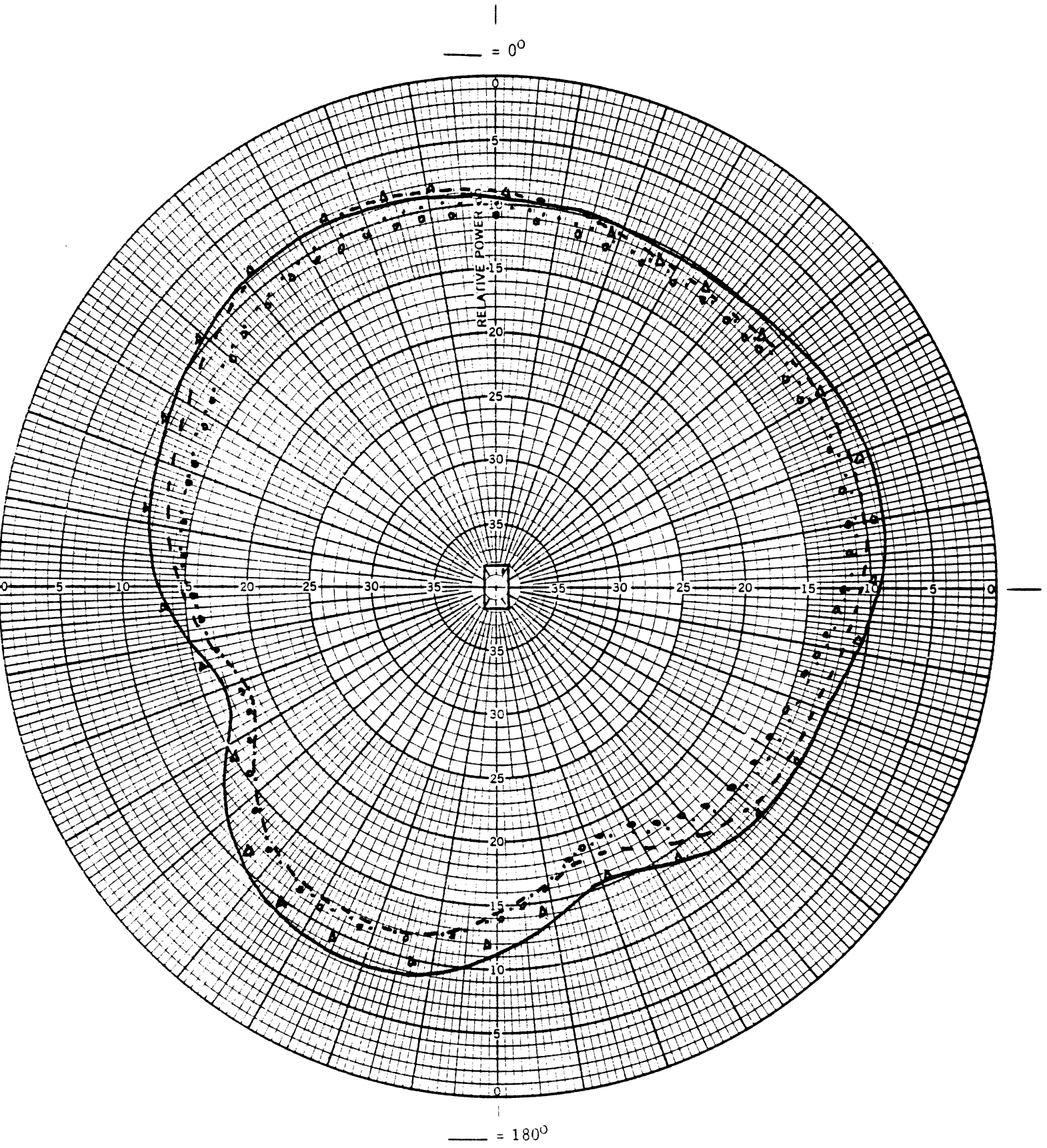


Figure 15(a). Radiation patterns at 88 MHz for test and FM reference antennas on 1978 LTD II/Cougar/T-Bird.

—— FM Reference, ---- EPL-60, ···· RP-111-60, °°°° D80F-18B12-CE, ΔΔΔΔ MS-60.

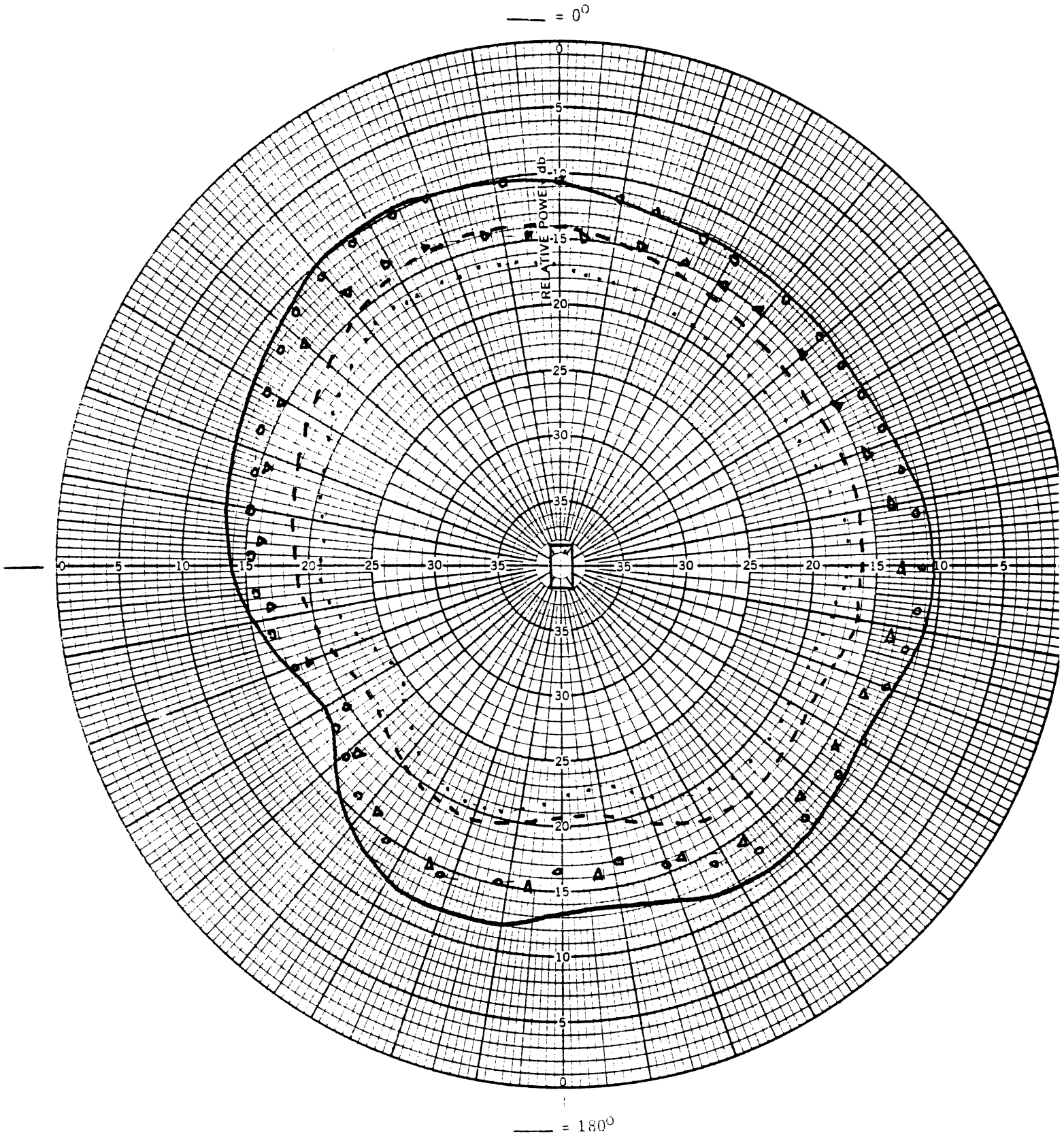


Figure 15(b). Radiation patterns at 98 MHz for test and FM reference antennas on 1978 LTD II/Cougar/T-Bird.

—— FM Reference, ---- EPL-60, ···· RP-111-60, oooo D80F-18B12-CE, ΔΔΔΔ MS-60.

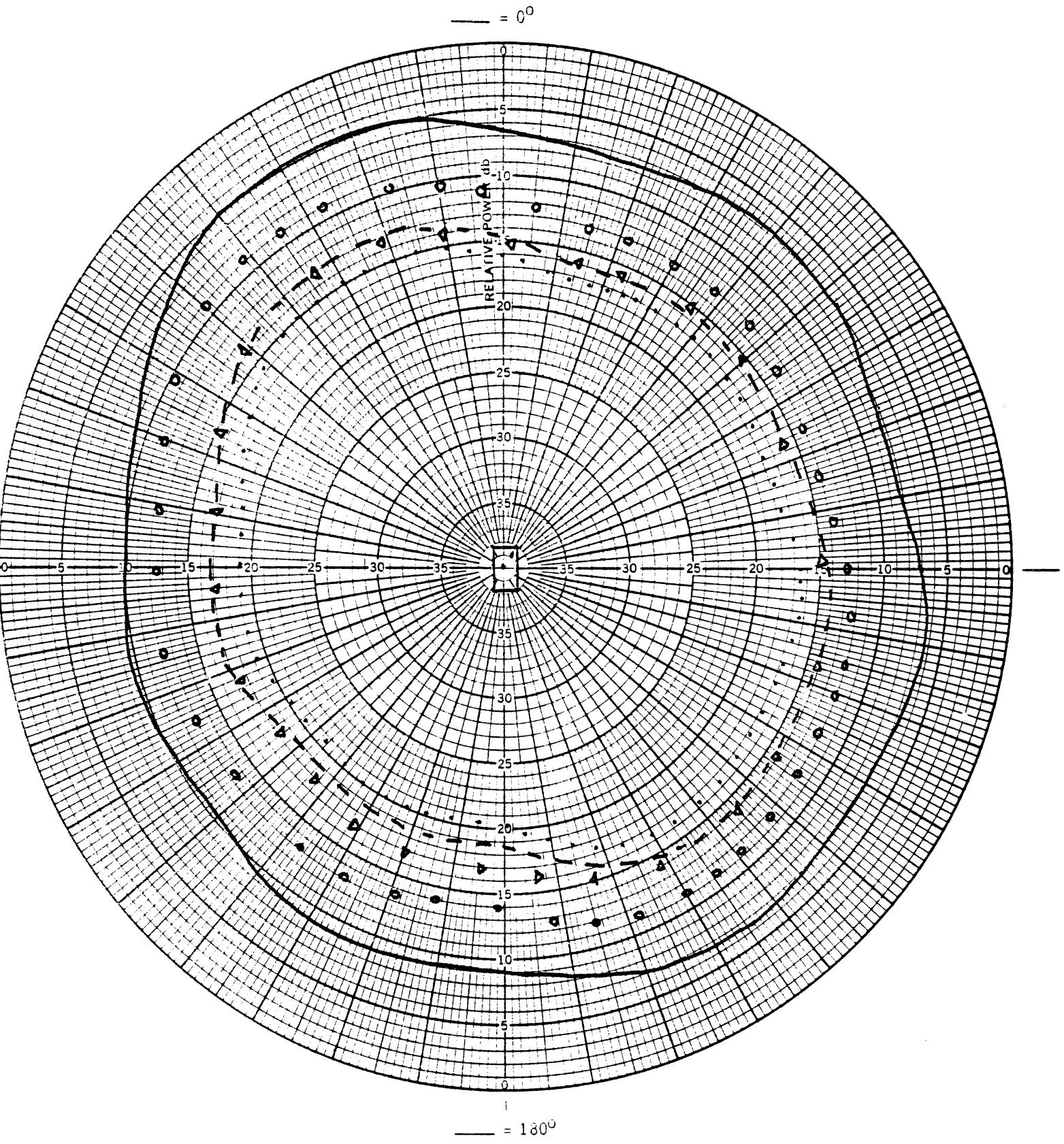
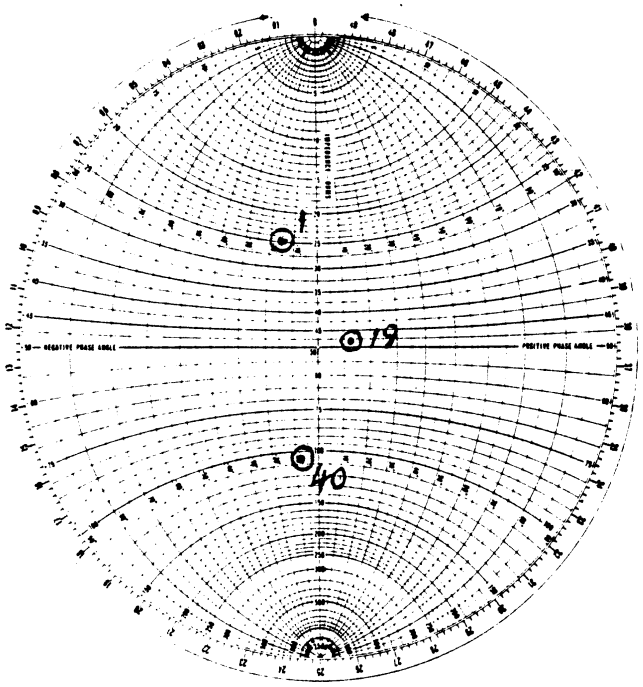
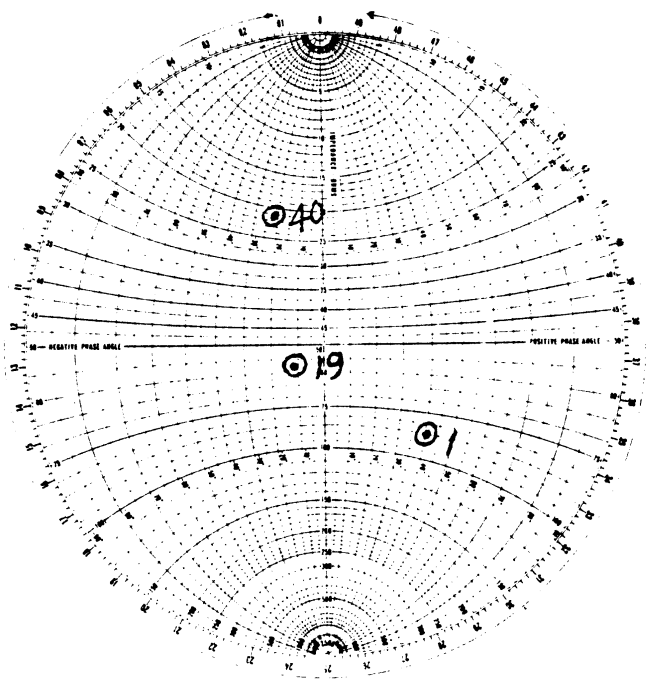


Figure 15(c). Radiation patterns at 108 MHz for test and FM reference antennas on 1978 LTD II/Cougar/T-Bird.

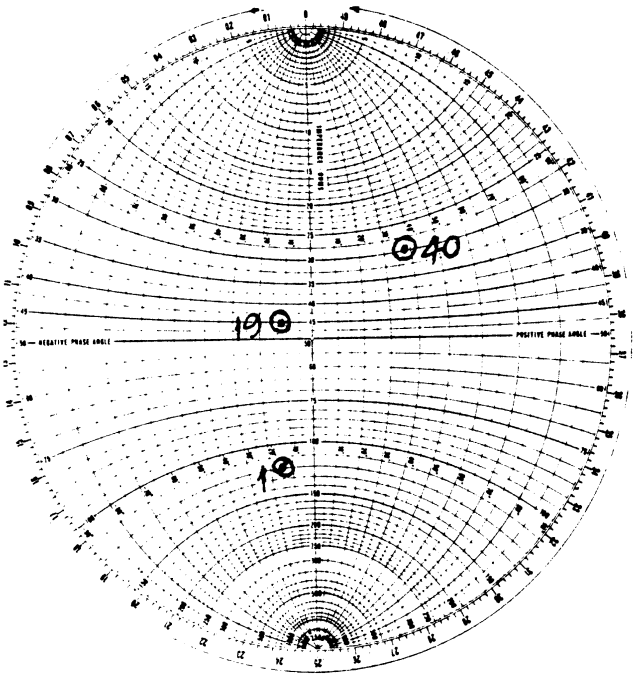
—— FM Reference, ---- EPL-60, ···· RP-111-60, ○○○○ D80F-18B12-CE, ΔΔΔΔ MS-60.



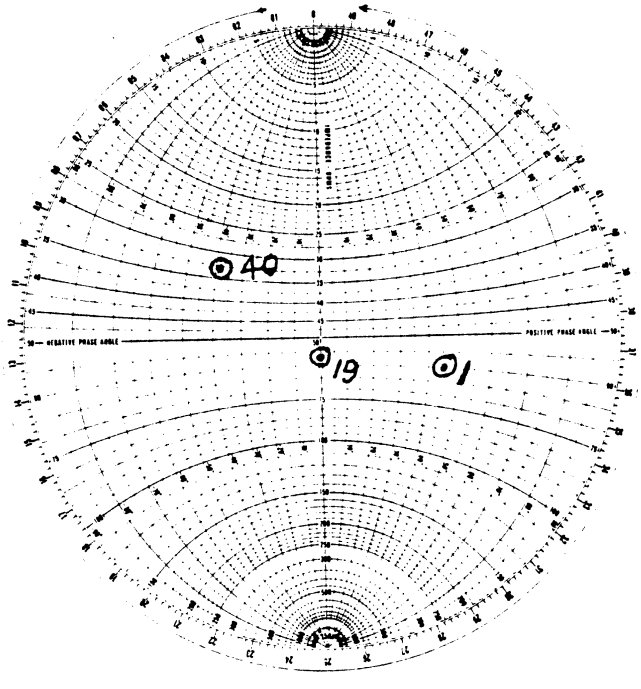
(a)



(b)

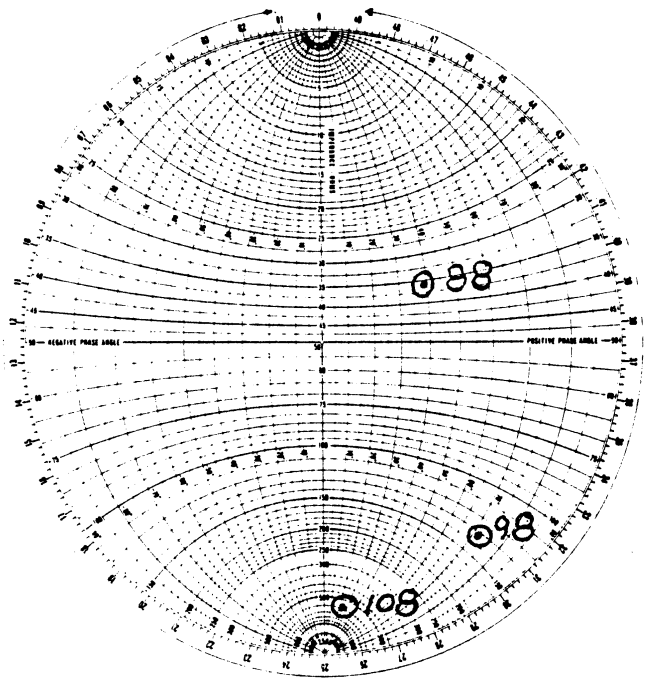


(c)

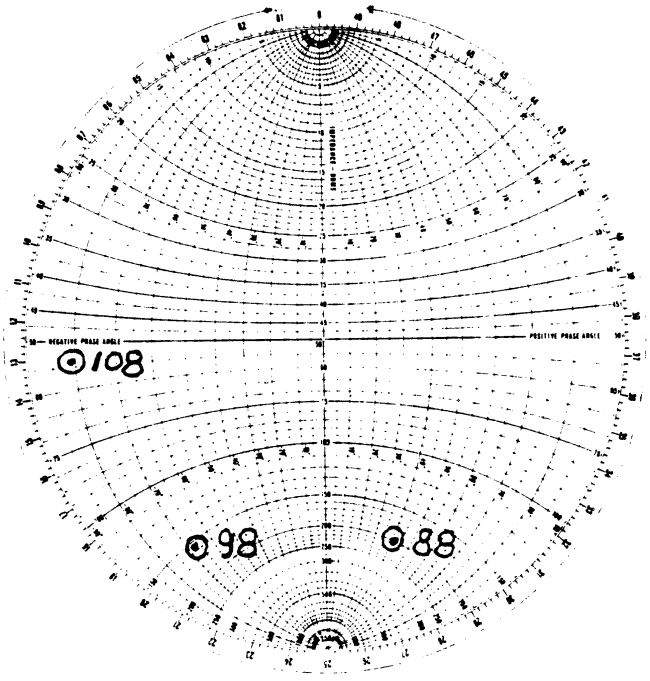


(d)

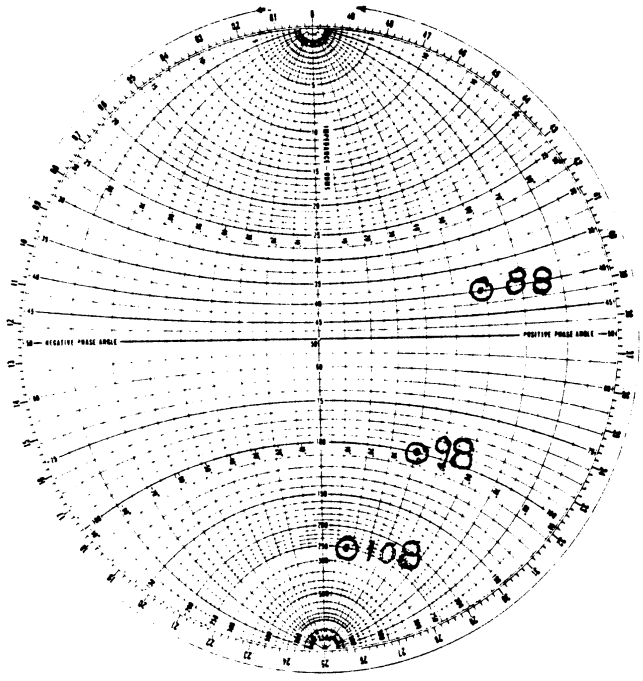
Figure 16. Impedance characteristics at CB Channels 1, 19 and 40 frequencies for test antennas on 1978 LTD II/Cougar/T-Bird. (a) EPL-60, (b) RP-111-60, (c) D80F-18B12-CE, (d) MS-60.



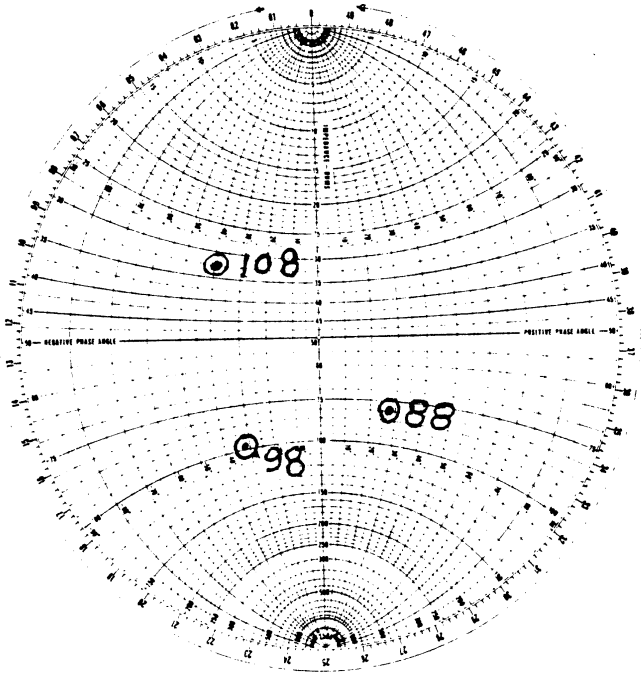
(a)



(b)



(c)



(d)

Figure 17. Impedance characteristics at 88, 98 and 108 MHz for test antennas on 1978 LTD II/Cougar/T-Bird.
(a) EPL-60, (b) RP-111=60, (c) D80F-18B12-CE, (d) MS-60.

TABLE 5. PERFORMANCE DATA FOR TEST ANTENNAS ON 1978 THUNDERBIRD/LTD II/COUGAR.

PERFORMANCE COMPARISON					
PARAMETER	ANTENNA TYPE				
	STD ENT	PRODUCTION	EPL	RP	MS
AM Sensitivity (dB/m)					
0.76 MHz	-66	-67	-64	-67	-72
1.10 MHz	---	---	---	---	---
1.60 MHz	---	---	---	---	---
Relative FM Sensitivity (dB)					
88.0 MHz	0	-2.5	-1.3	-2.0	-0.3
98.0 MHz	0	-1.0	-4.8	-7.0	-2.6
108.0 MHz	0	-4.3	-8.0	-10.0	-7.9
Relative CB Sensitivity (dB)					
CH 1	0	-3.1	-3.1	-7.1	-8.2
CH 19	0	-3.3	-2.2	-5.4	-7.9
CH 40	0	-5.8	-3.6	-6.9	-11.4
FM VSWR					
88.0 MHz	1.36	3.65	2.27	5.21	2.02
98.0 MHz	1.33	2.91	10.38	9.21	2.39
108.0 MHz	1.45	5.21	12.67	13.00	6.86
CB VSWR					
CH 1		2.58	2.16	2.63	2.50
CH 19		1.25	1.22	1.27	1.15
CH 40		2.47	2.13	2.69	2.14
Isolation (mV)					
CH 1		350	470	420	147
CH 19		190	310	295	192
CH 40		350	150	410	180
AM C(PF)					
0.5 MHz					
1.0 MHz					
1.5 MHz					
AM Q					
0.5 MHz					
1.0 MHz					
1.5 MHz					

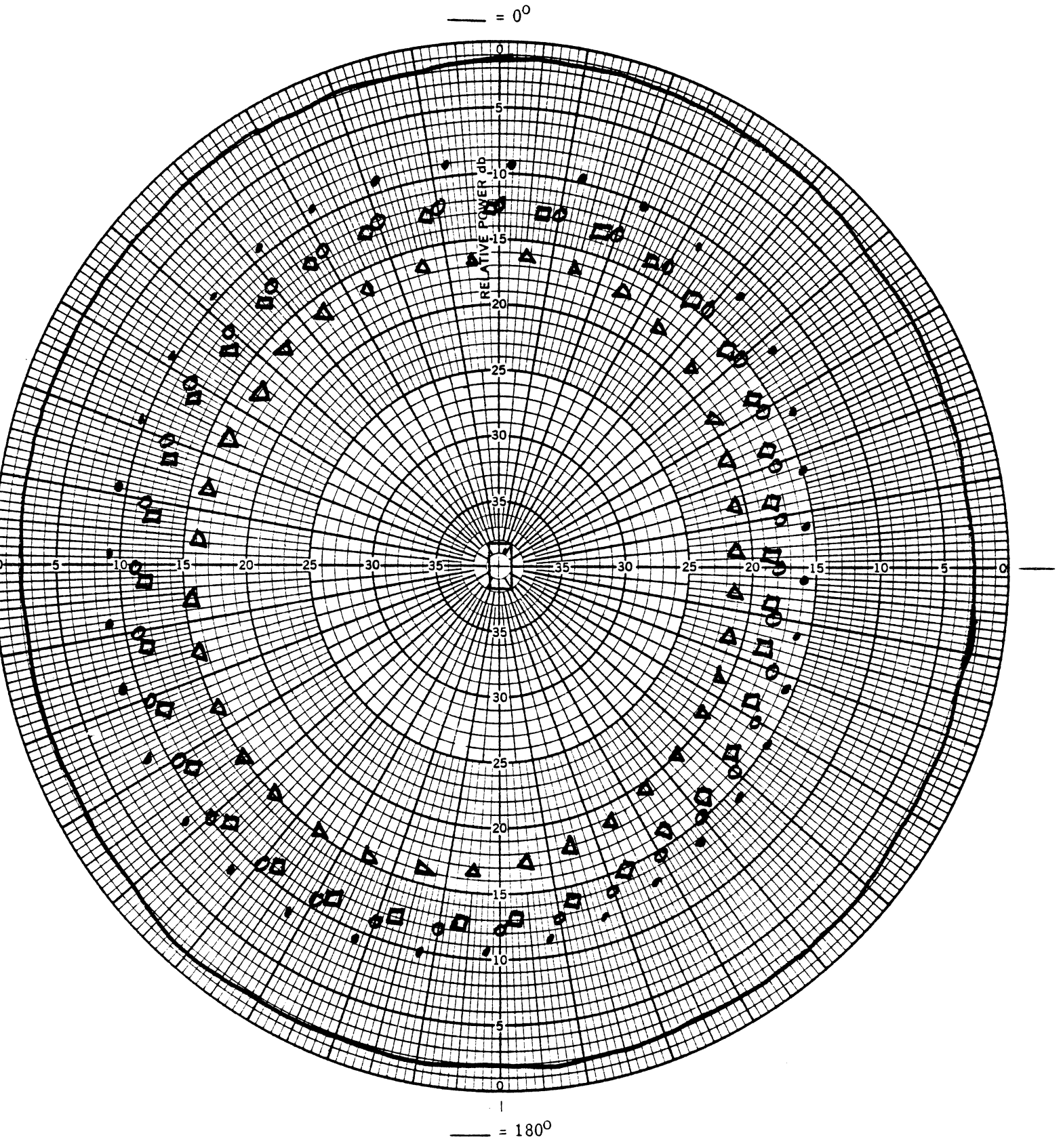


Figure 18(a). Radiation patterns at CB Channel 1 for test and reference antennas on 1978 Bronco.

—— CB Reference, ···· EPL-20, □□□ RP-111-20, ○○○○ D8TF-18B812-AD

ΔΔΔΔ MS-20

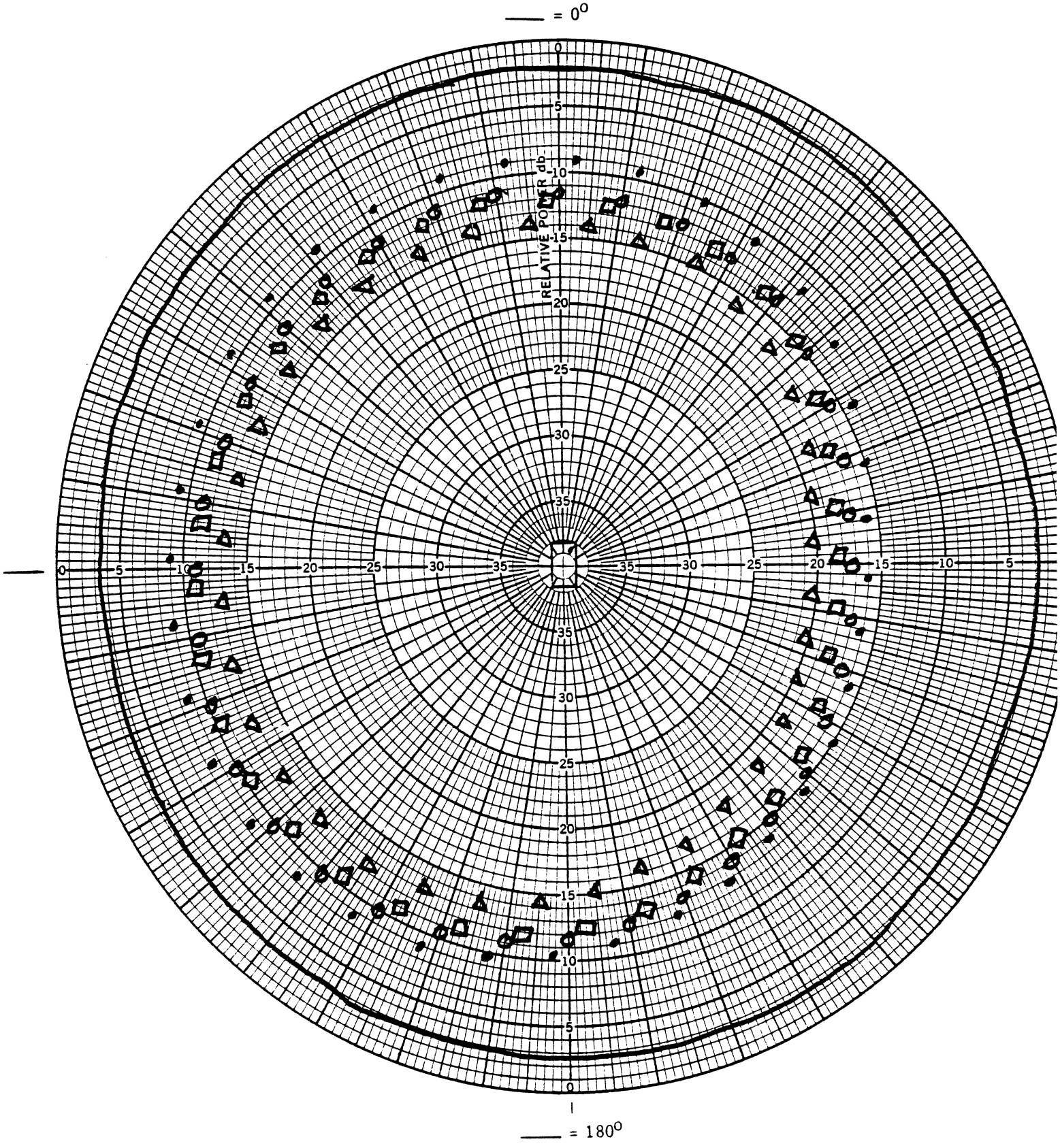


Figure 18(b). Radiation patterns at CB Channel 19 for test and reference antennas on 1978 Bronco.

—— CB Reference, ... EPL-20, □□□ RP-111-20, ○○○○ D8TF-18B812-AD

ΔΔΔΔ MS-20

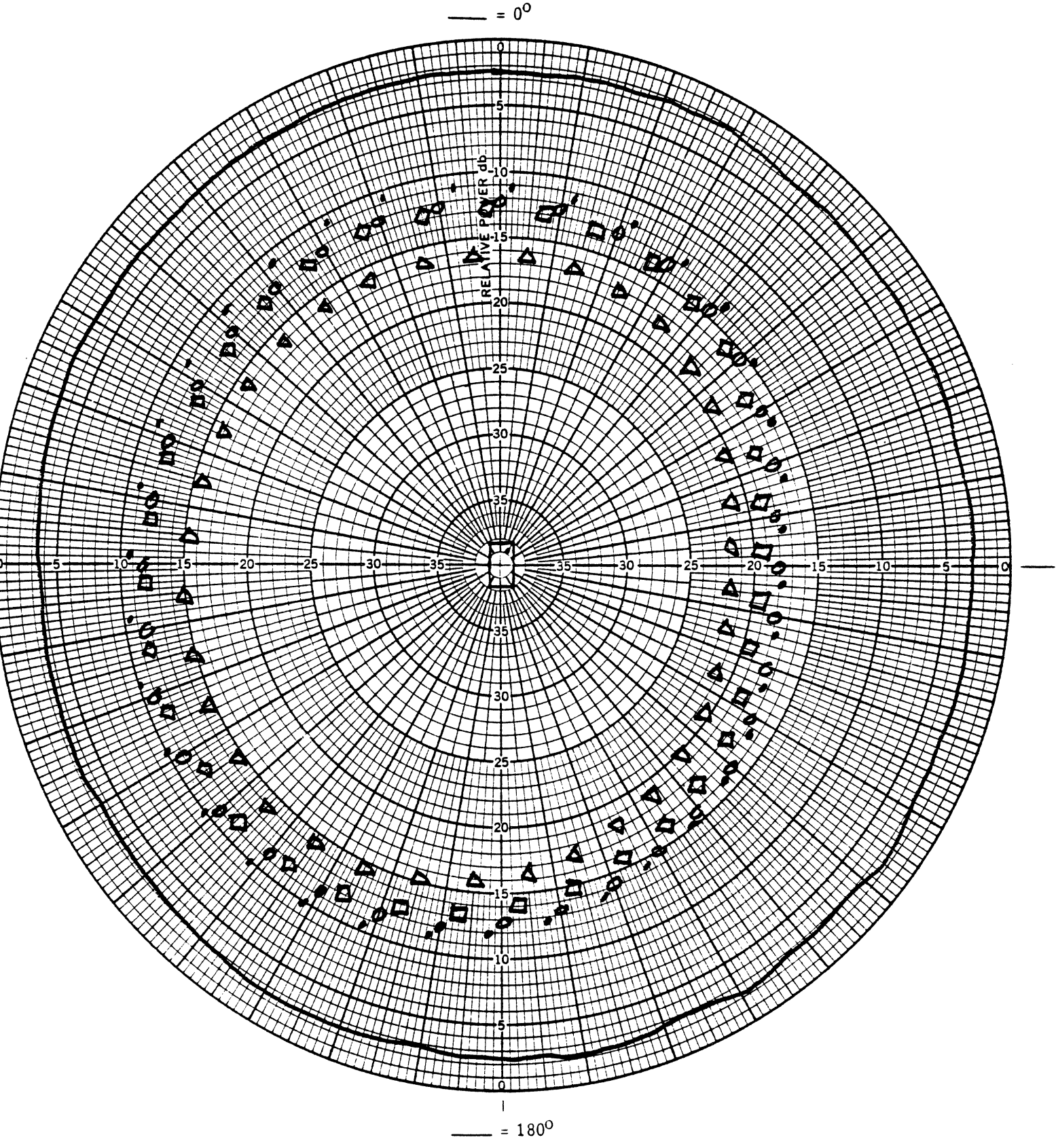


Figure 18(c). Radiation patterns at CB Channel 40 for test and reference antennas on 1978 Bronco.

—— CB Reference, ... EPL-20, □□□ Rp-111-20 ○○○○ D8TF-18B812-AD

ΔΔΔΔ MS-20.

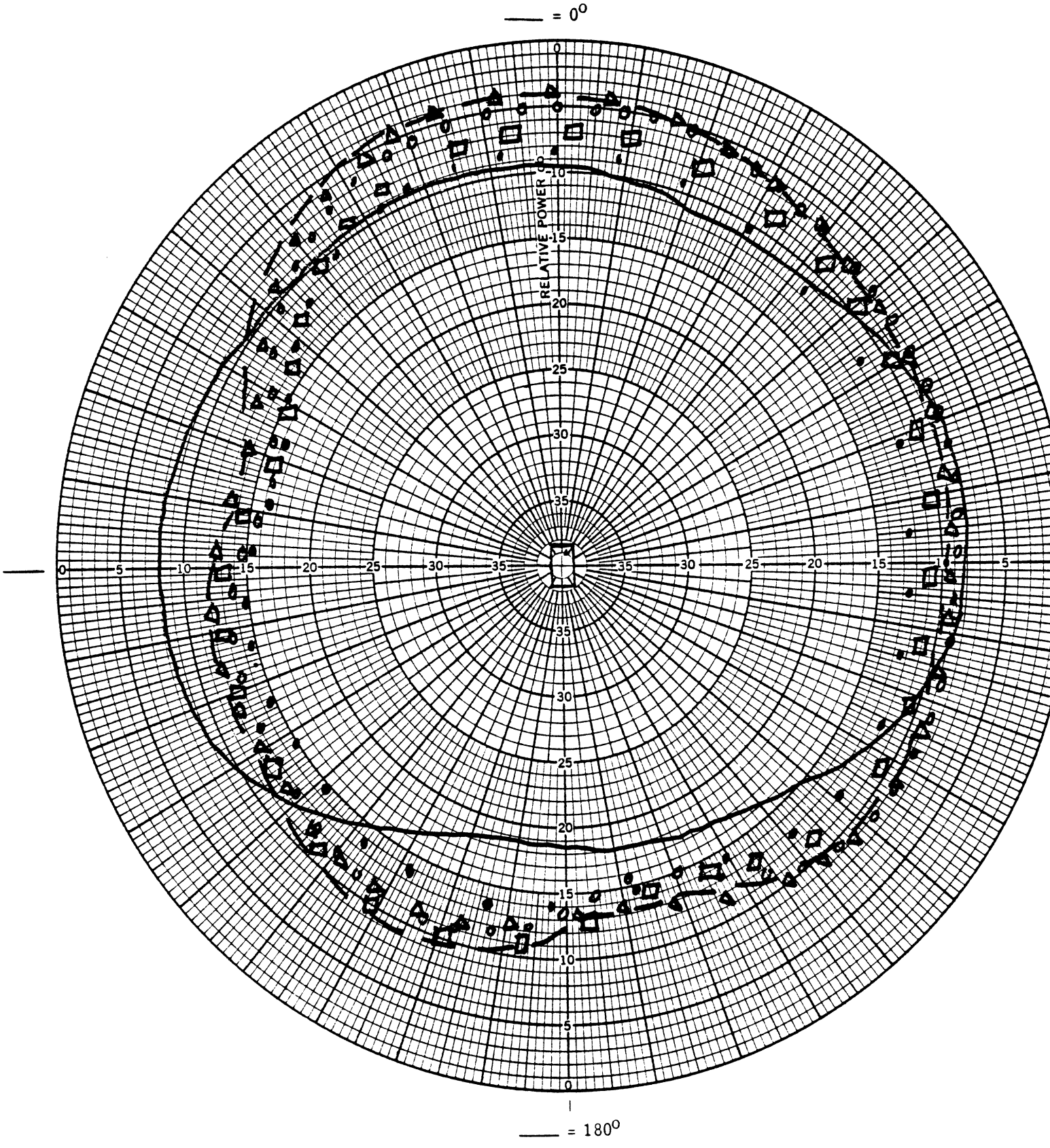


Figure 19(a). Radiation patterns at 88 MHz for test and reference antennas on 1978 Bronco.

—— λ/4 FM Reference, ... EPL-20, □□□ RP-111-20, ○○○○ D8TF-B812-AD

ΔΔΔΔ MS-20.

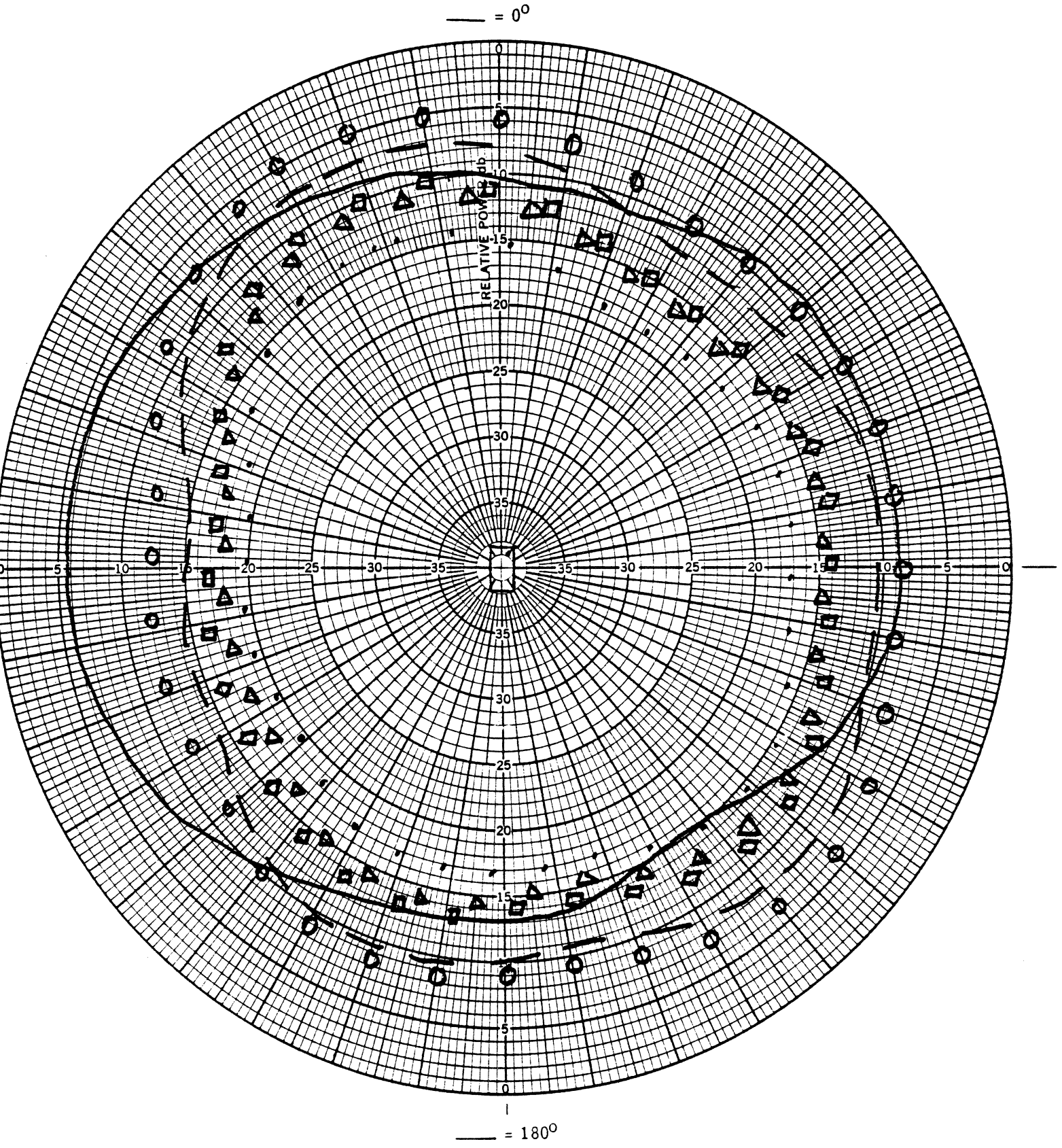


Figure 19(b). Radiation patterns at 98 MHz for test and FM reference antennas on 1978 Bronco.

—— λ/4 FM Reference, ... EPL-20, ▫▫▫ RP-111-20, ∘∘∘∘ D8TF-18B812-AD

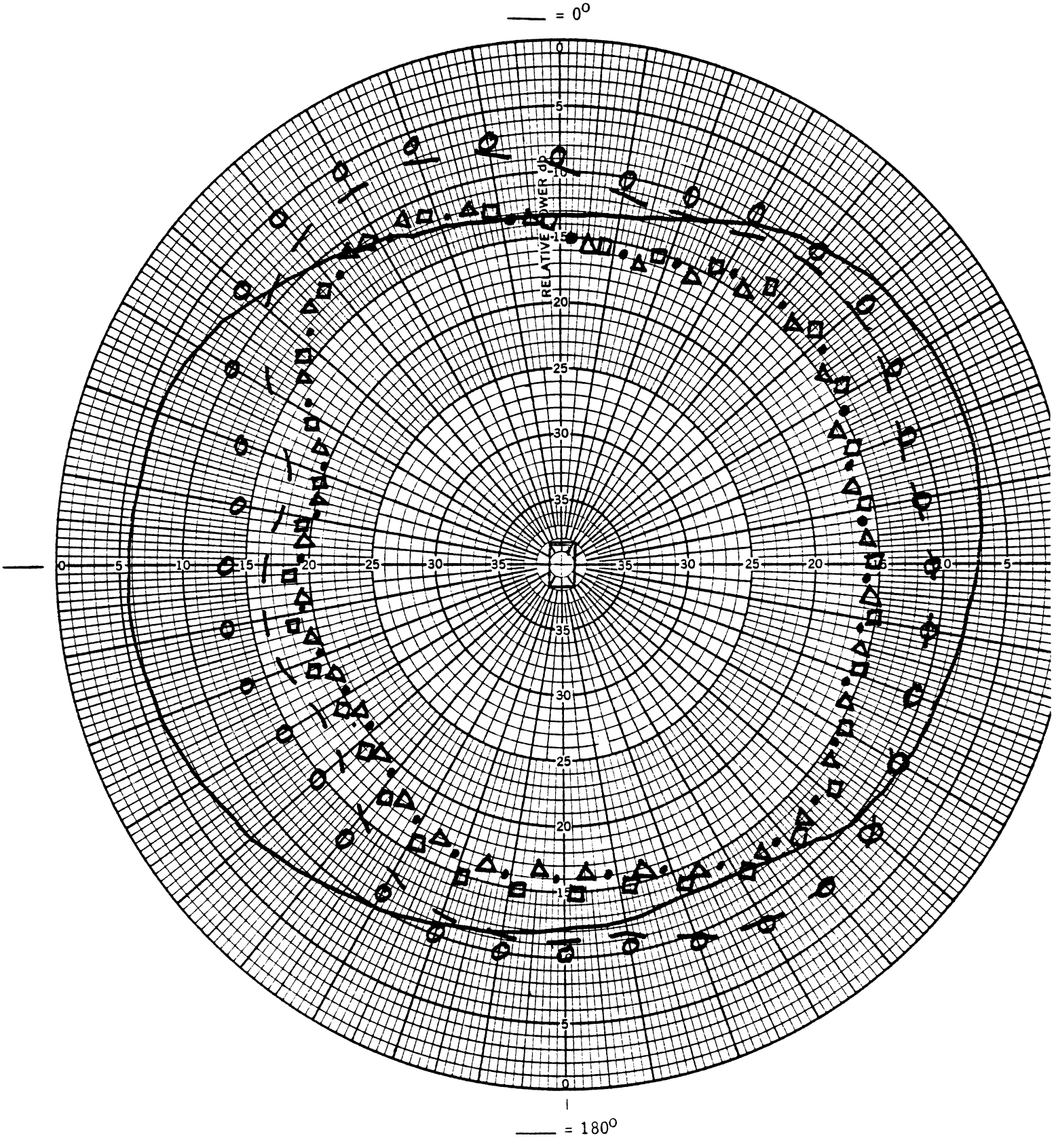


Figure 19(c). Radiation patterns at 108 MHz for test and FM reference antennas on 1978 Bronco.

—— λ/4 FM Reference, ---- FM Reference, □ □ □ EPL-20, ... RP-111-20, ○○○○ D8TF-13B312-AD

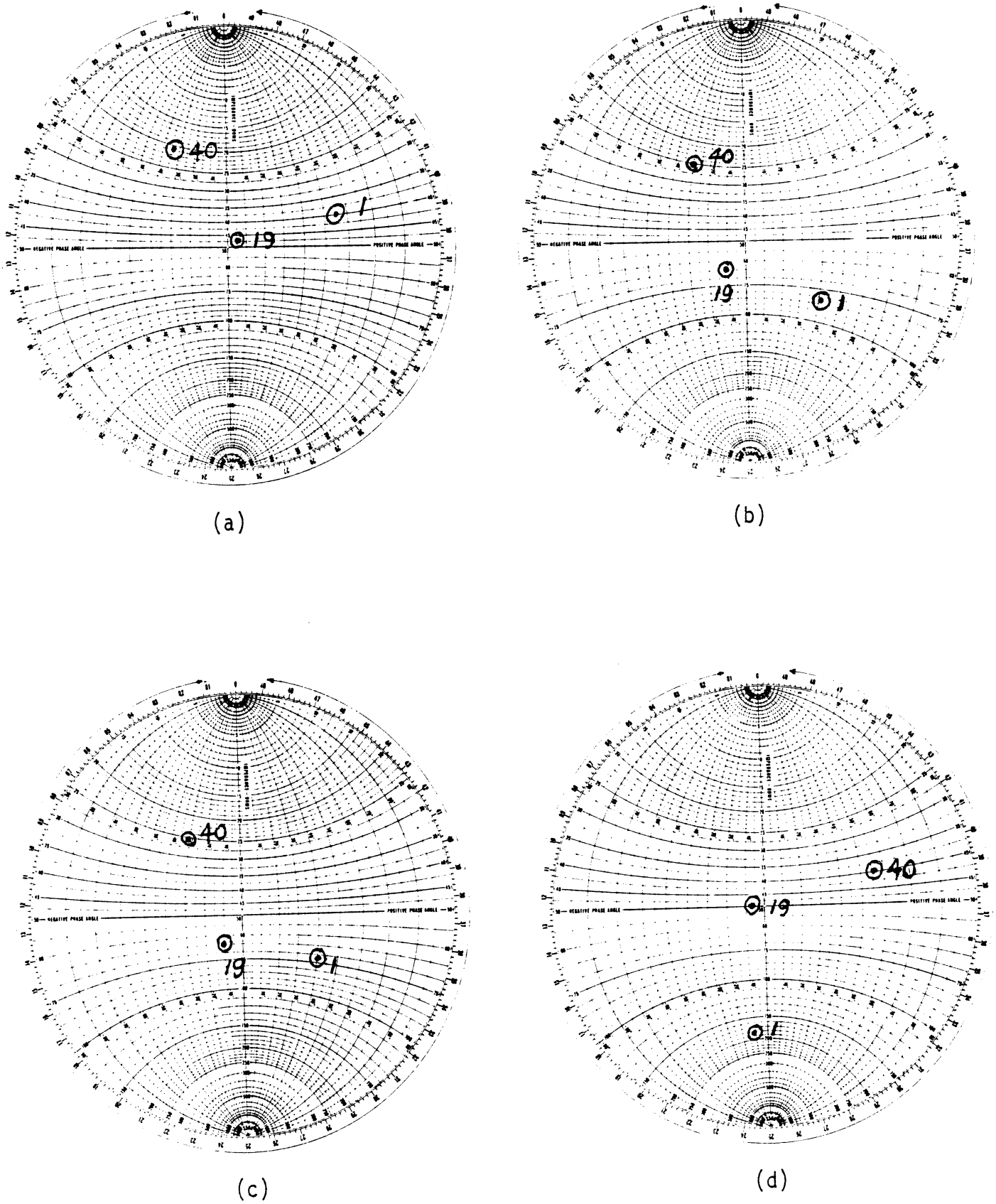
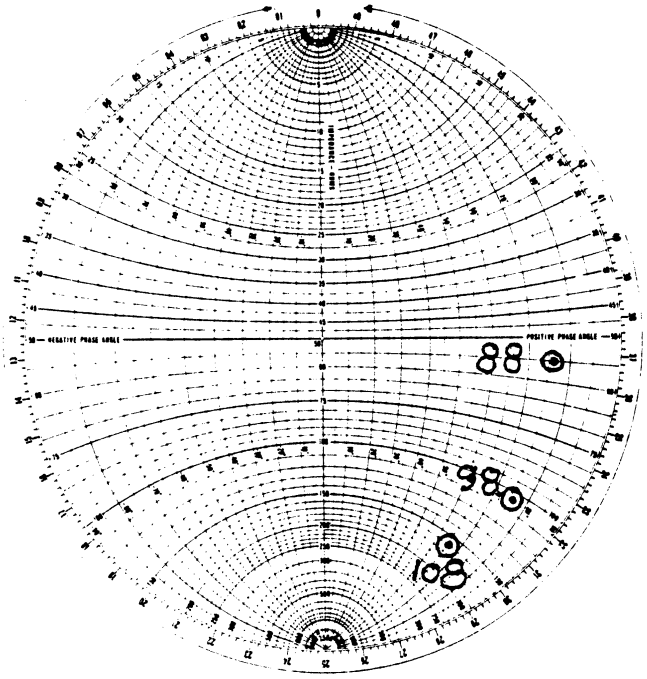
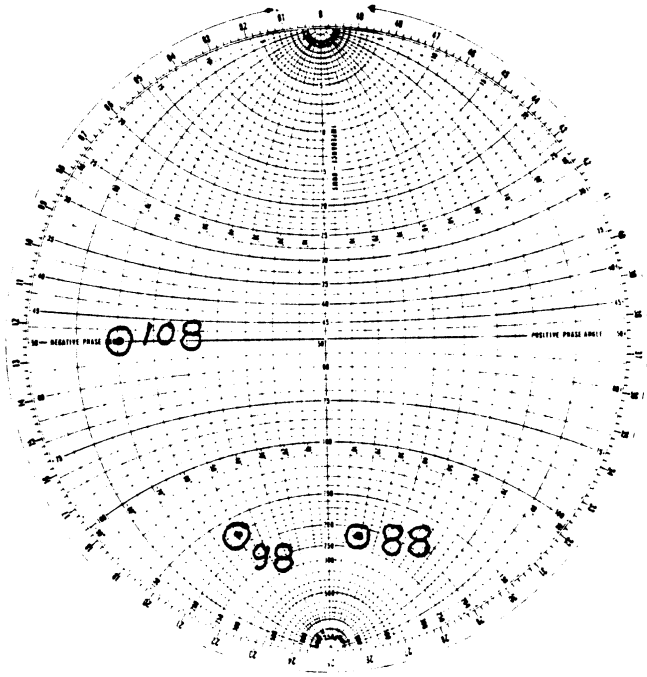


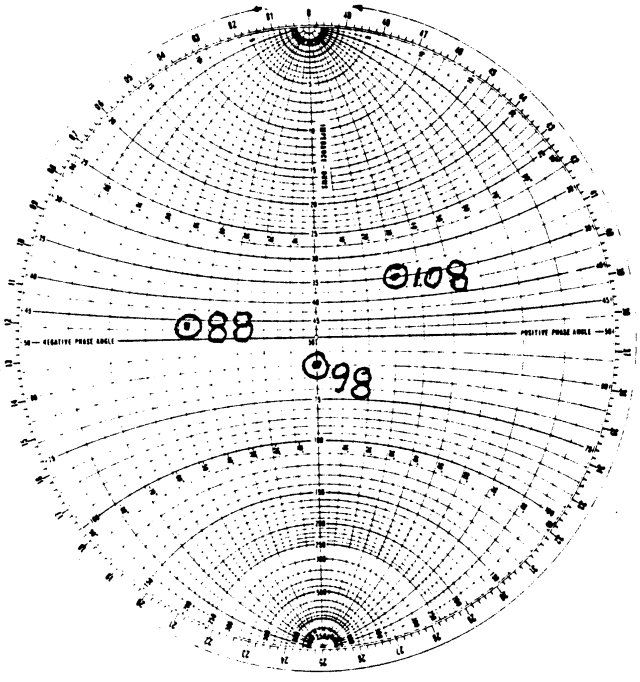
Figure 20. Impedance characteristics at CB Channels 1, 19 and 20 frequencies for test antennas on 1978 Bronco.
(a) EPL-20, (b) RP-111-20 (c) D8TF-18B812-AD, (d) MS-20



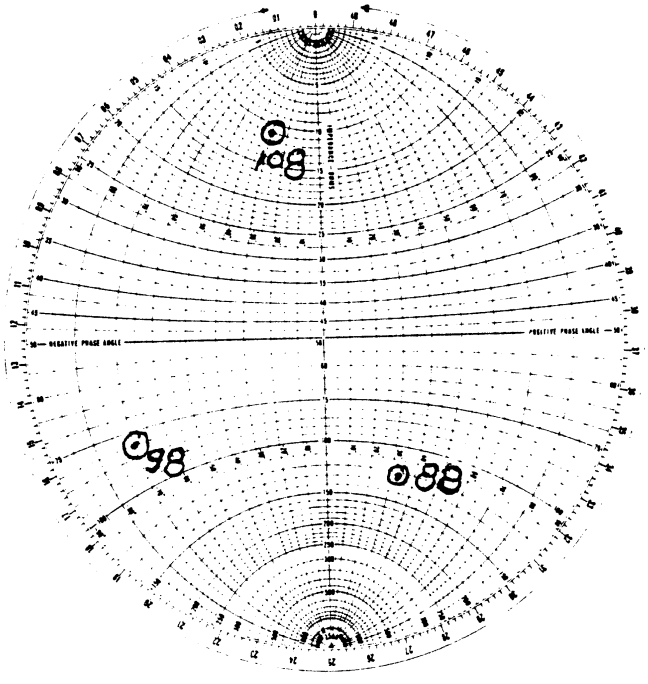
(a)



(b)

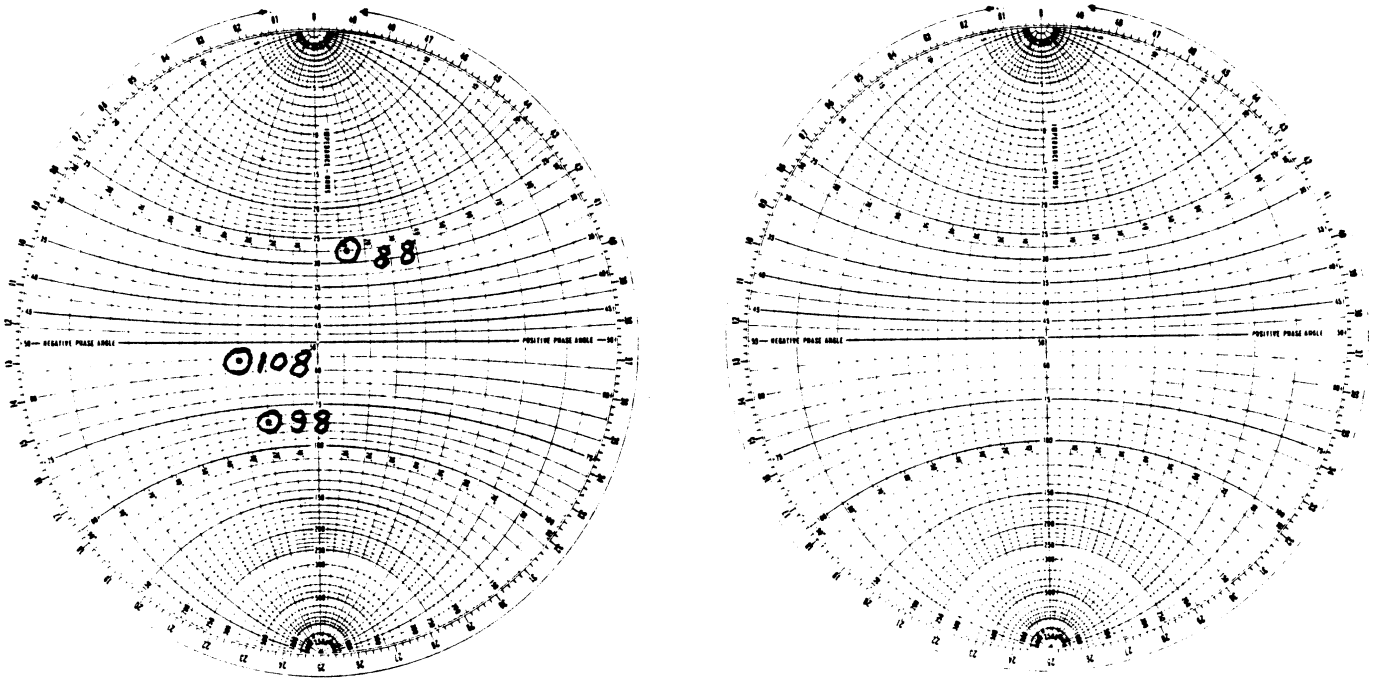


(c)



(d)

Figure 21(a)-(d). Impedance characteristics at 88, 98 and 108 MHz for test antennas on 1978 Bronco.
(a) EPL-20, (b) RP-111-20, (c) D8TF-18B812-AD, (d) MS-20,
(Continued on next page)



(e)

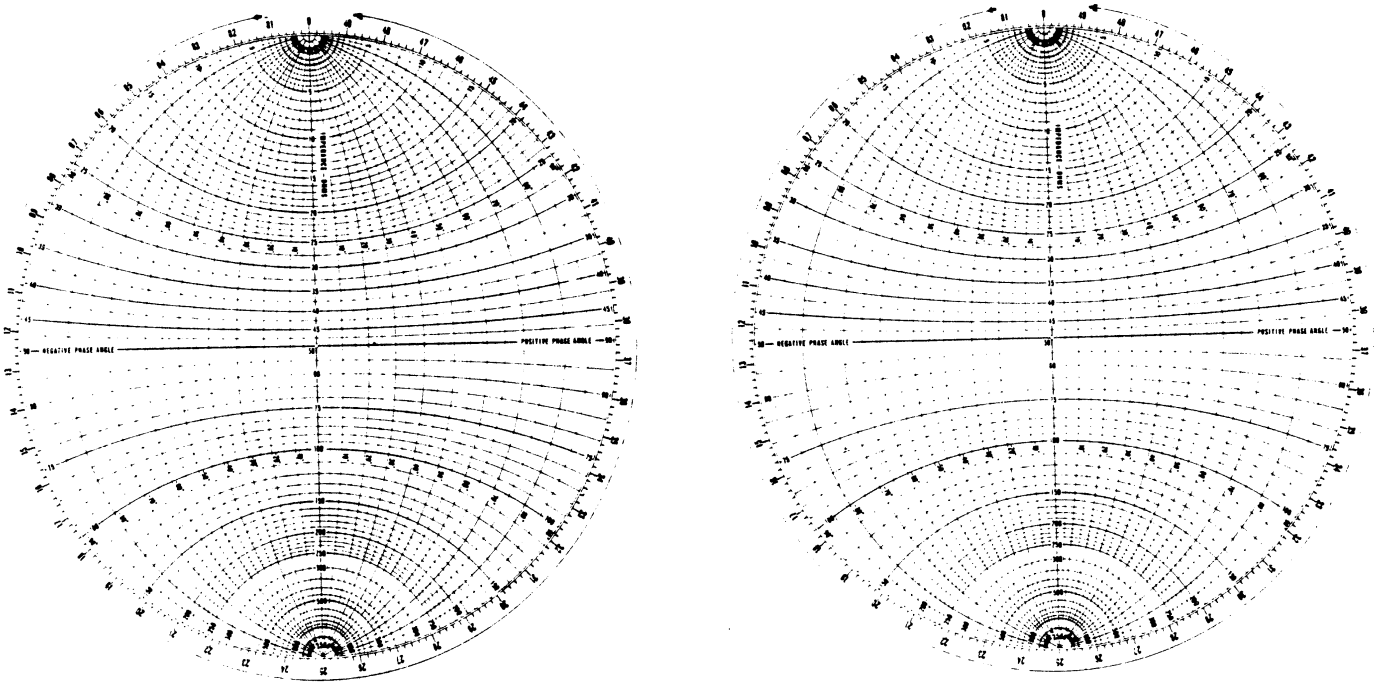


Figure 21(e). Impedance characteristics at 88, 98 and 108 MHz for test antennas on 1978 Bronco.
(e) FM Reference.

TABLE 6. PERFORMANCE DATA FOR TEST ANTENNAS ON 1978 BRONCO.

PERFORMANCE COMPARISON					
PARAMETER	ANTENNA TYPE				
	STD ENT	PRODUCTION	EPL	RP	MS
AM Sensitivity (dB/m)					
0.76 MHz	-61	-66	-61	-63	-69
1.10 MHz	-69	-74	-69	-71	-78
1.60 MHz	-81	-86	-80	-81	-86
Relative FM Sensitivity (dB)					
88.0 MHz	0	-1.0	-4.5	-3.0	0
98.0 MHz	0	+2.0	-7.0	-3.5	-4.5
108.0 MHz	0	+1.0	-5.0	-5.0	-5.0
Relative CB Sensitivity (dB)					
CH 1	0	-11.0	-8.0	-11.0	-15.0
CH 19	0	-9.5	-7.0	-10.0	-12.0
CH 40	0	-10.1	-8.5	-10.5	-14.0
FM VSWR					
88.0 MHz	1.88	2.64	8.47	4.60	3.09
98.0 MHz	1.93	1.19	13.0	6.0	6.85
108.0 MHz	1.76	2.02	8.0	5.93	5.50
CB VSWR					
CH 1		2.44	3.28	2.65	3.77
CH 19		1.38	1.1	1.38	1.14
CH 40		2.44	3.13	2.54	3.43
Isolation (mV)					
CH 1		72	320	280	172
CH 19		105	170	200	218
CH 40		100	285	230	160
AM C(PF)					
0.5 MHz	68	95	68	91	98
1.0 MHz	72	100	71	95	97
1.5 MHz	66	92	67	87	98
AM Q					
0.5 MHz	4724	402	630	286	155
1.0 MHz	2247	380	515	143	72
1.5 MHz	714	985	440	212	78

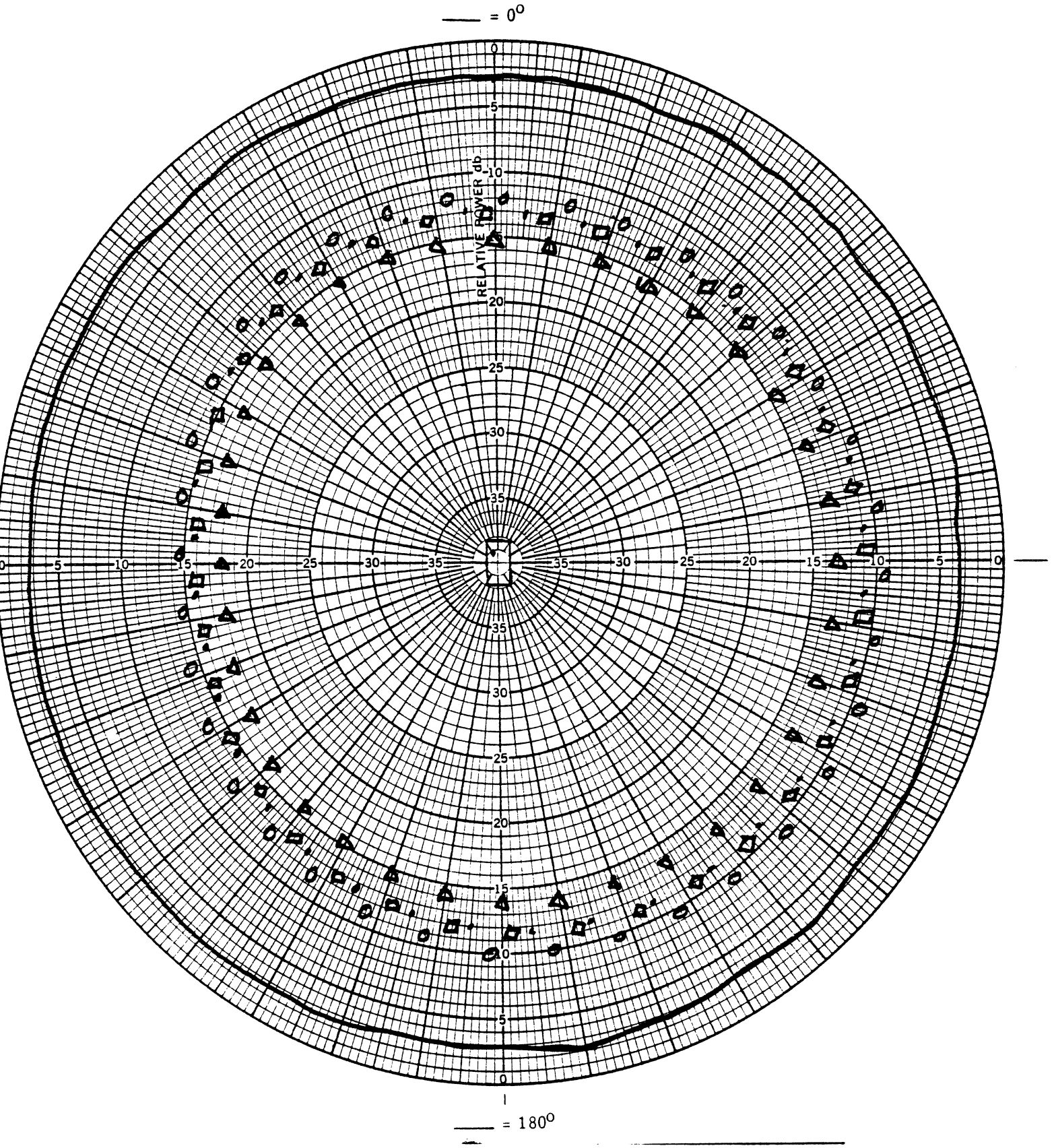


Figure 22(a). Radiation patterns at CB Channel 1 for test and reference antennas on 1978 Fiesta.

—— CB Reference, ▫ ▫ ▫ EPL-20, ... RP-111-20, ○○○○ D8TF-18B812-AD, ΔΔΔΔ MS-20.

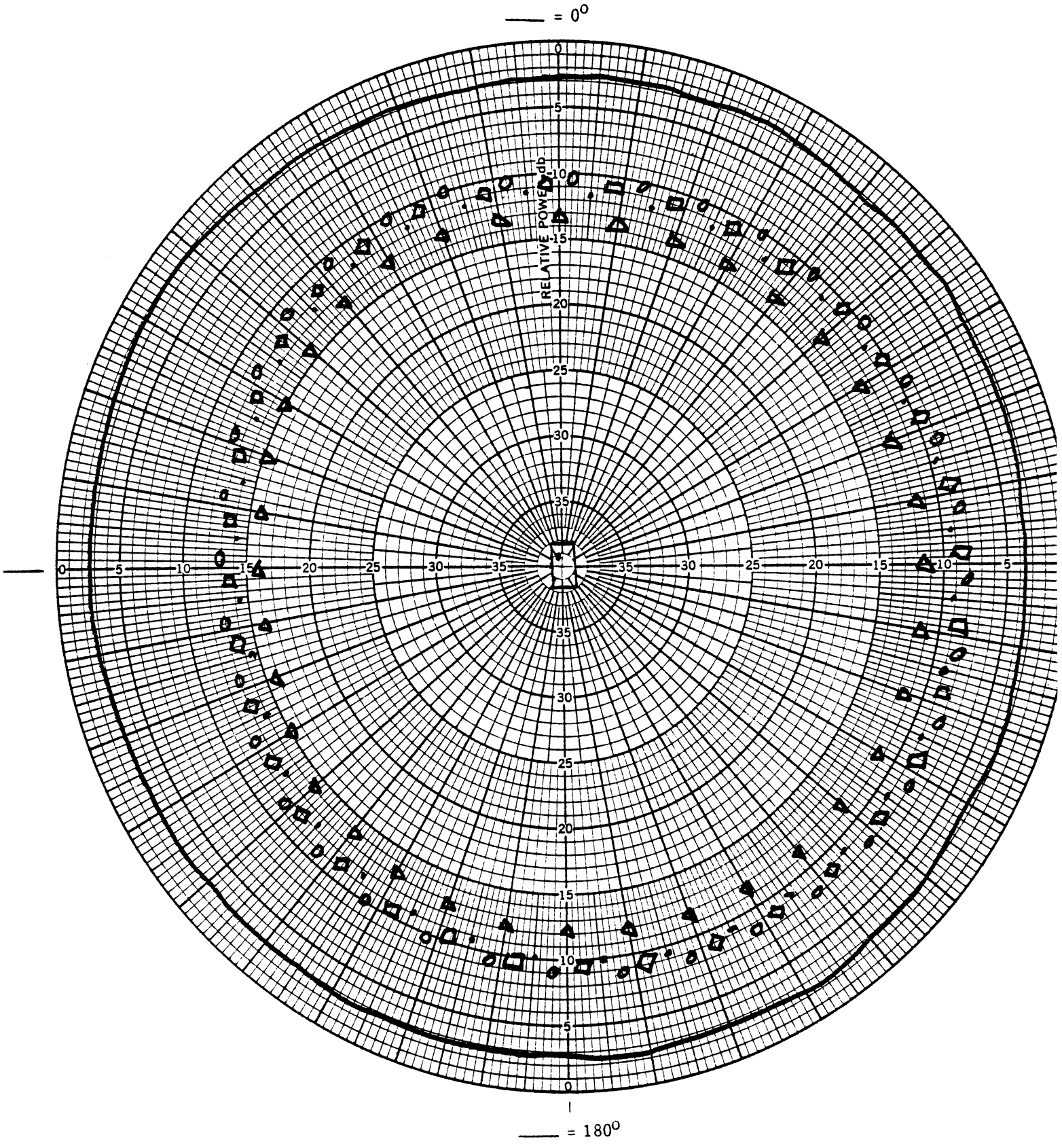


Figure 22(b). Radiation patterns at CB Channel 19 for test and reference antennas on 1978 Fiesta.

—— CB Reference, □ □ □ EPL-20, ···· RP-111-20, ○○○○ D8TF-18B812-AD, ΔΔΔΔ MS-20.

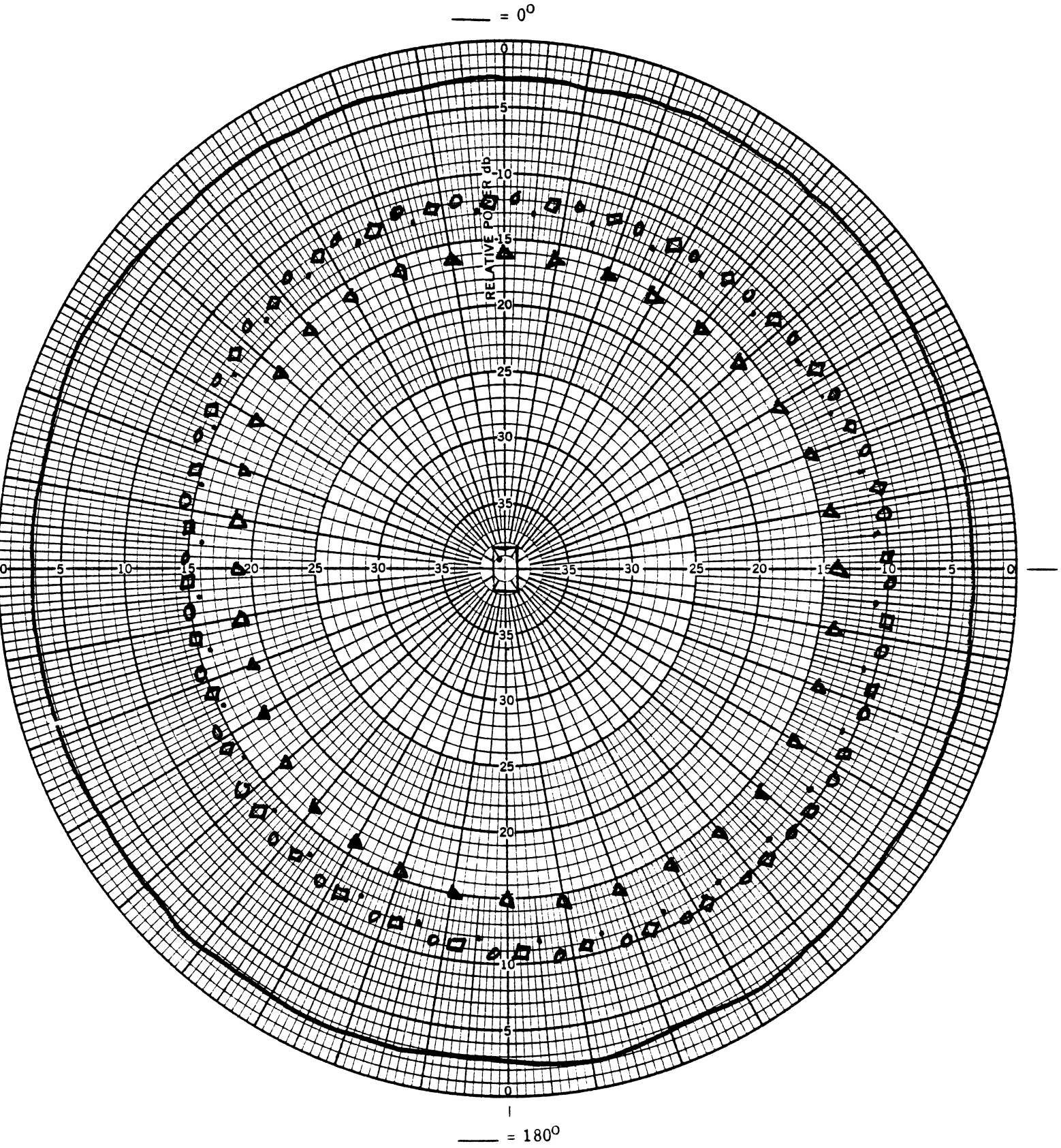


Figure 22(c). Radiation patterns at CB Channel 40 for test and reference antennas on 1978 Fiesta.

—— CB Reference, □ □ □ EPL-20, ... RP-111-20, ∘∘∘∘ D8TF-18B812-AD.

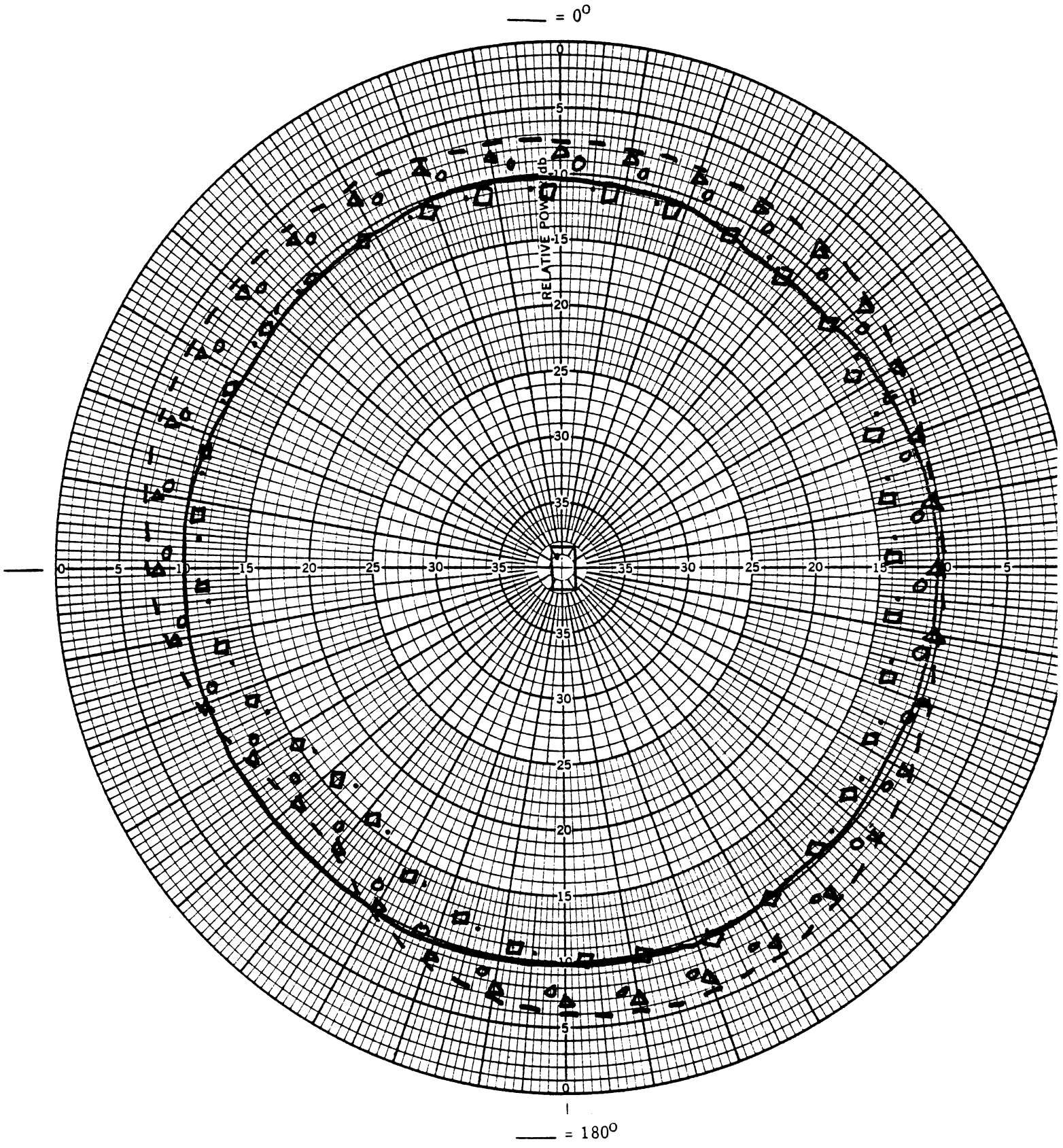


Figure 23(a). Radiation patterns at 88 MHz for test and reference antennas on 1978 Fiesta.

—— λ/4 Reference, ---- FM Reference, □ □ □ EPL-20, ···· RP-111-20, ○○○○ D8TF-18B812-AD, ΔΔΔΔ MS-20.

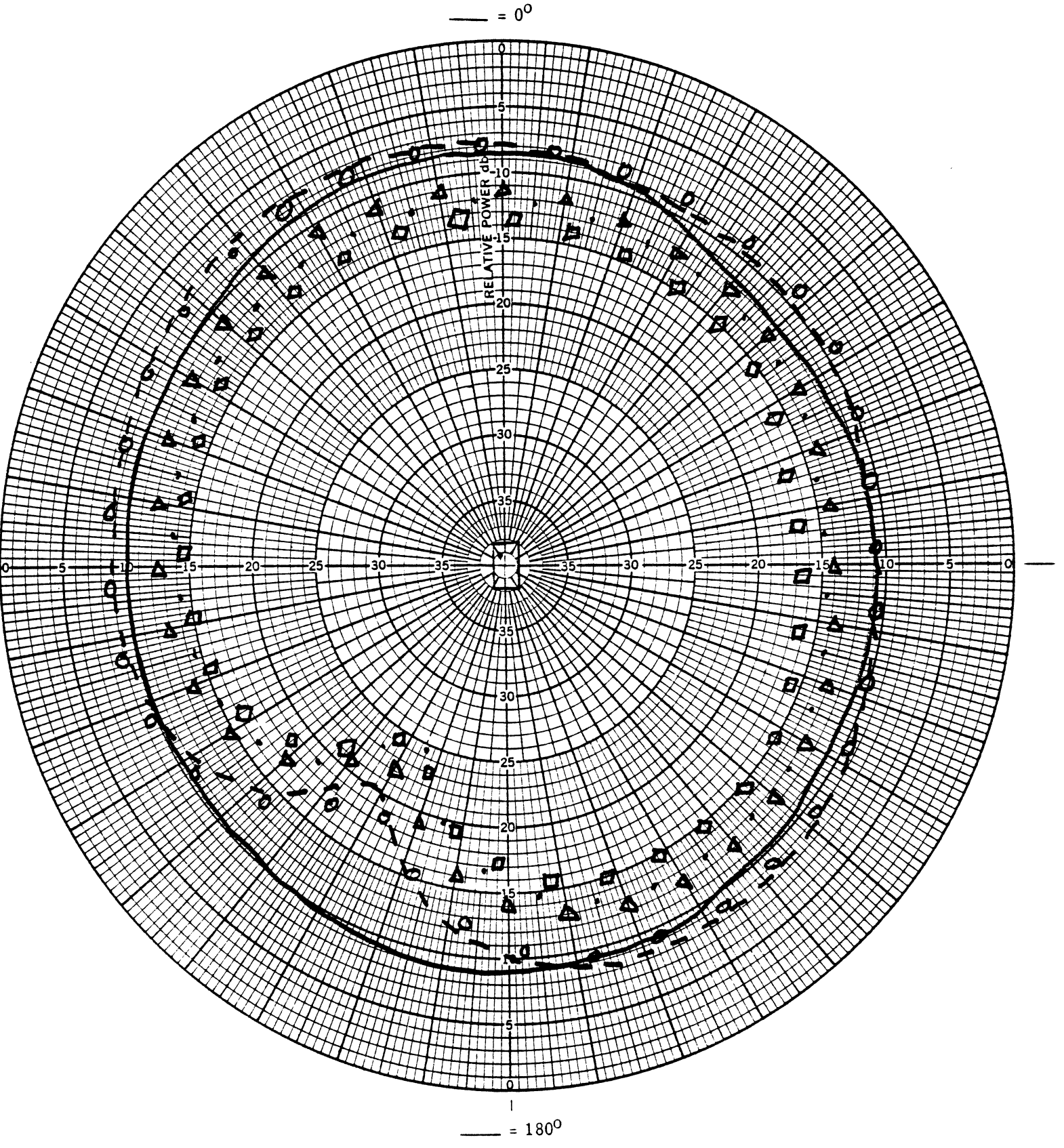


Figure 23(b). Radiation patterns at 98 MHz for test and FM reference antennas on 1978 Fiesta.

—— λ/4 Reference, ---- FM Reference, □ □ □ EPL-20, ···· RP-111-20, ○○○○ D8TF-18B812-AD, ΔΔΔΔ MS-20.

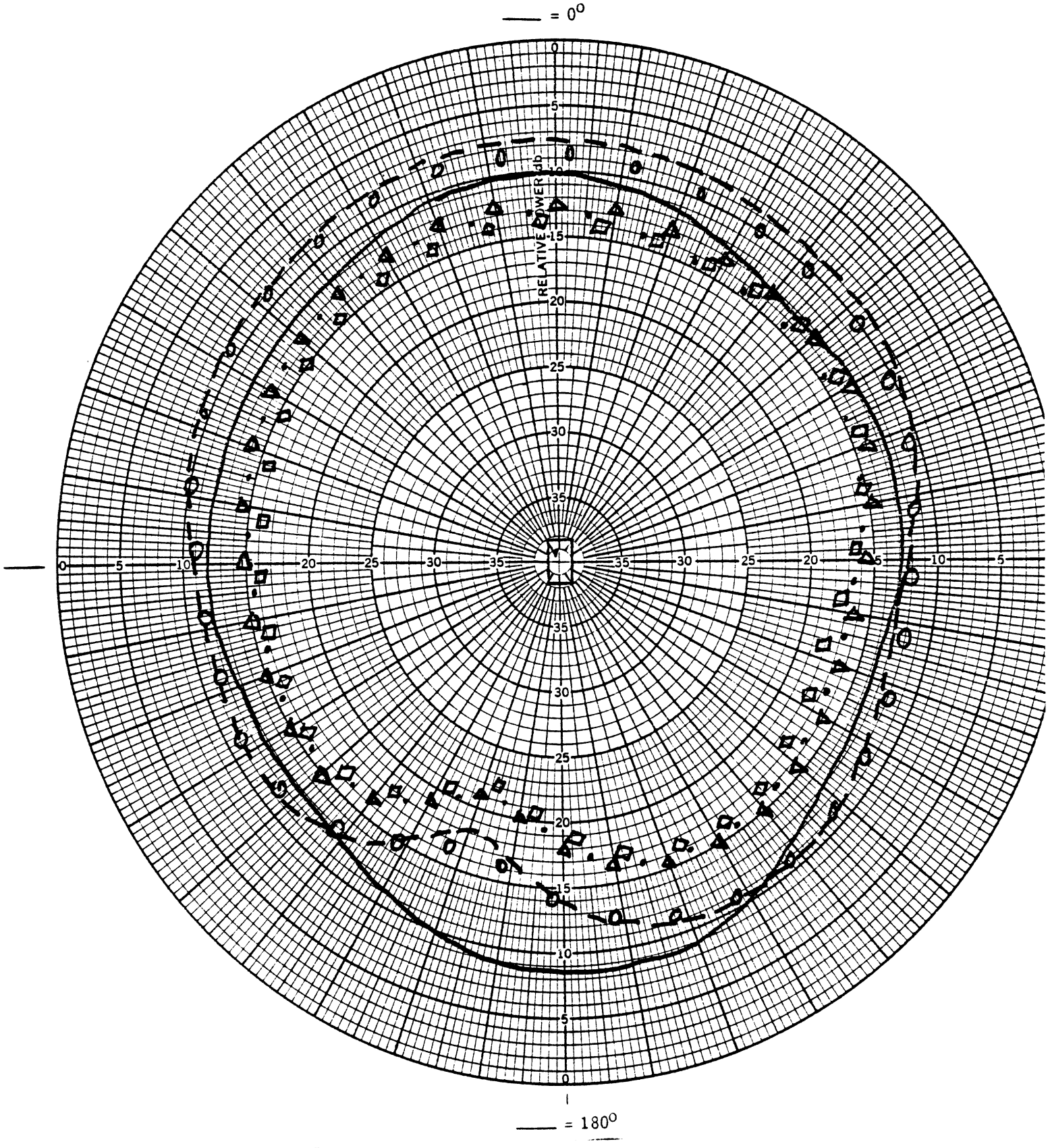


Figure 23(c). Radiation patterns at 108 MHz for test and FM reference antennas on 1978 Fiesta.

—— λ/4 Reference, ---- FM Reference, □□□ EPL-20, ···· RP-111-20, ○○○○D8TF-18B812-AD, ΔΔΔΔ MS-20.

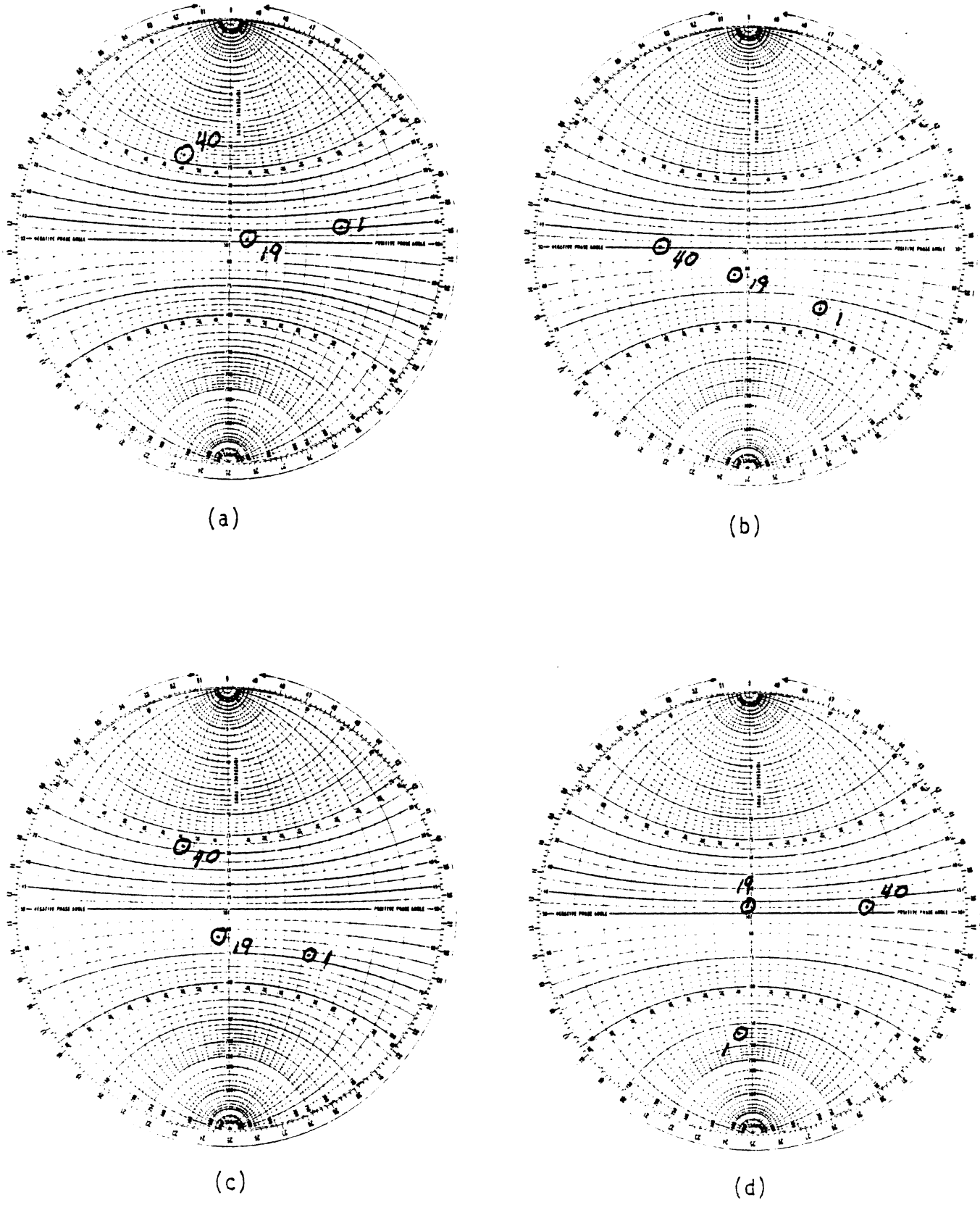
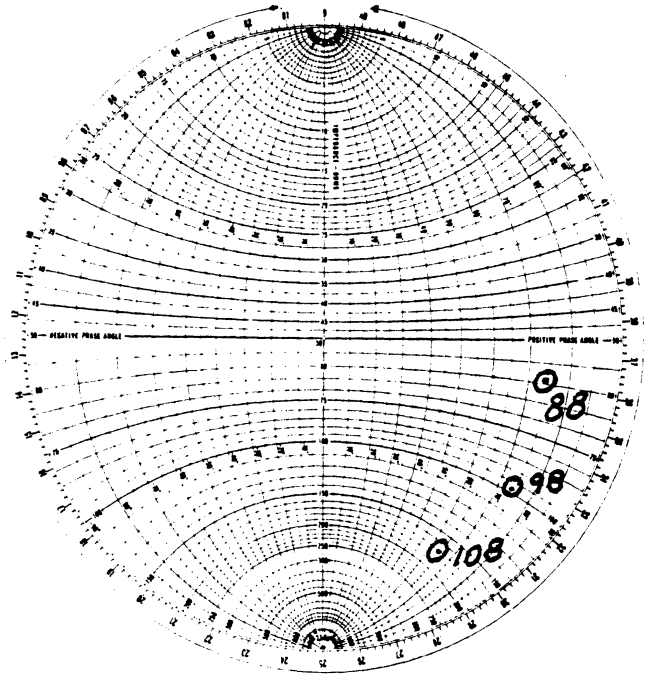
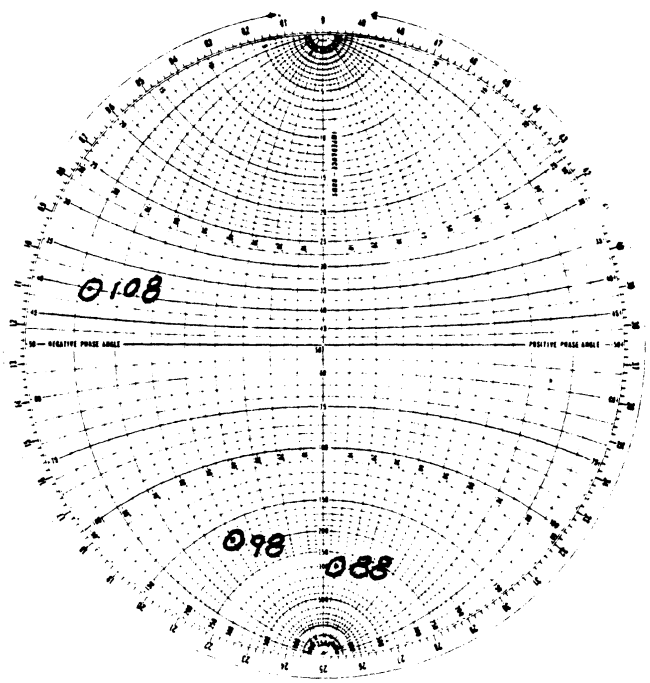


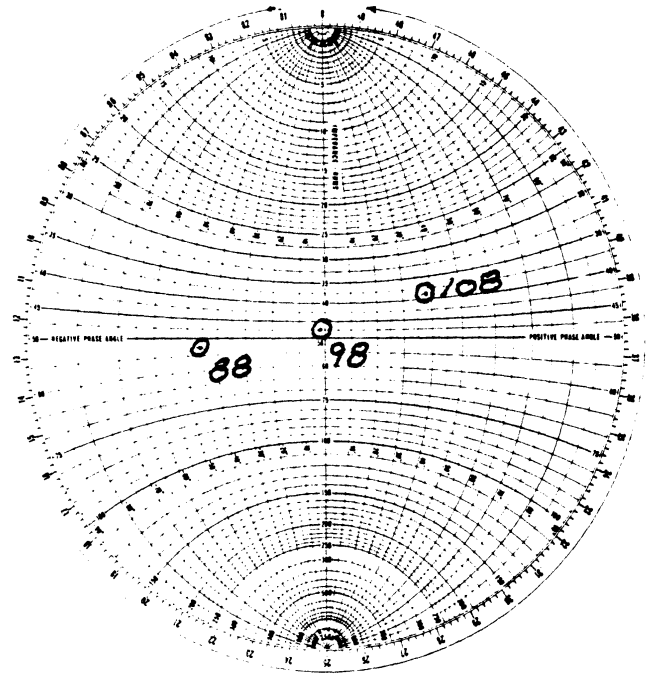
Figure 24. Impedance characteristics at CB Channels 1, 9 and 40 for the test antennas on 1978 Fiesta.
(a) EPL-20, (b) RP-111-20, (c) D8TF-18B812-AD, (d) MS-20.



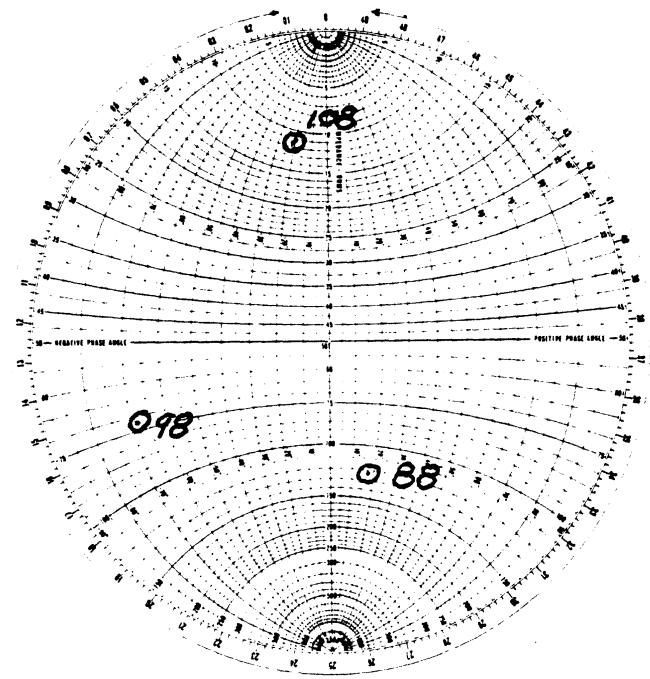
(a)



(b)

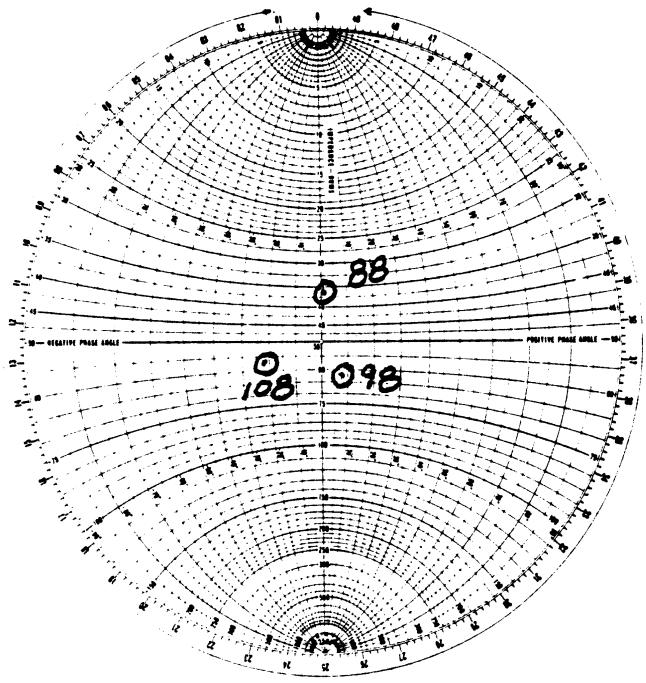


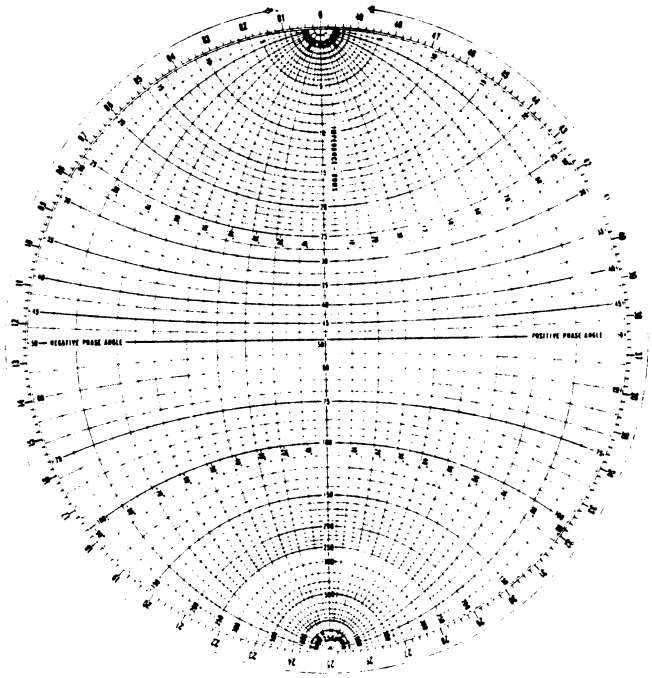
(c)



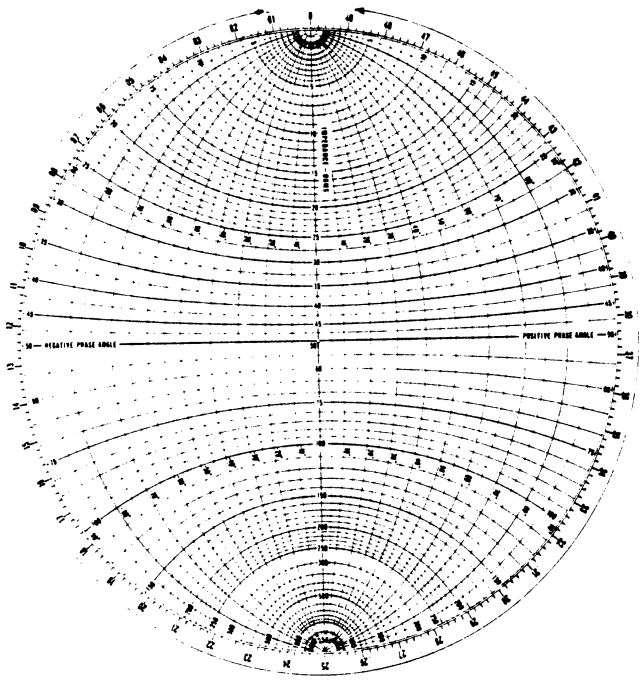
(d)

Figure 25(a)-(d). Impedance characteristics at 88, 98 and 108 MHz for test antennas on 1978 Fiesta.
(a) EPL-20, (b) RP-111-20, (c) D8TF-18B812-AD, (d) MS-20,
(Continued on next page)





(e)



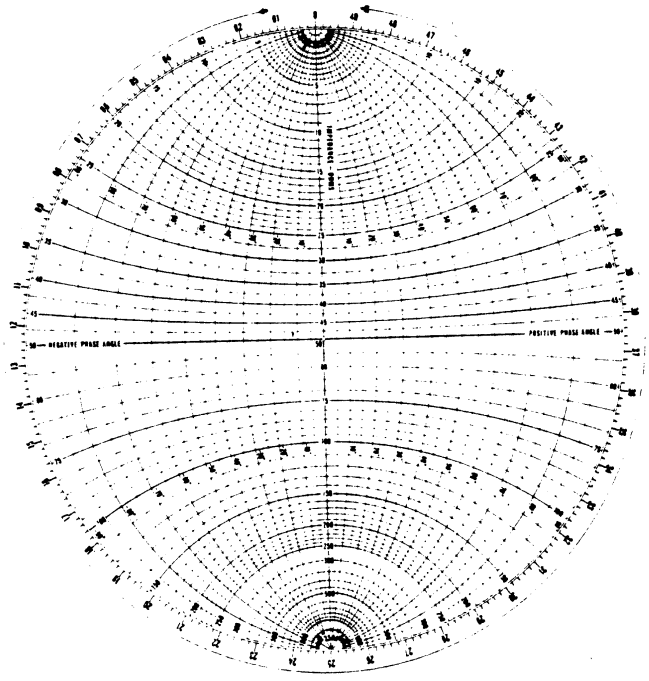


Figure 25(e). Impedance characteristics at 88, 98 and 108 MHz for test antennas on 1978 Fiesta.
(e) FM Reference.

TABLE 7. PERFORMANCE DATA FOR TEST ANTENNAS ON 1978 FIESTA.

PERFORMANCE COMPARISON					
PARAMETER	ANTENNA TYPE				
	STD ENT	PRODUCTION	EPL	RP	MS
AM Sensitivity (dB/m)					
0.76 MHz	-61	-64	-61	-63	-70
1.10 MHz	-70	-74	-70	-73	-78
1.60 MHz	-81	-84	-80	-81	-86
Relative FM Sensitivity (dB)					
88.0 MHz	0	-1.5	-4.0	-3.5	-0.5
98.0 MHz	0	0	-5.5	-4.0	-3.5
108.0 MHz	0	-5.0	-5.5	-6.5	-1.0
Relative CB Sensitivity (dB)					
CH 1	0	-9.0	-9.0	-10.0	-14.0
CH 19	0	-7.5	-8.0	-9.0	-11.0
CH 40	0	-9.0	-9.0	-10.0	-14.0
FM VSWR					
88.0 MHz	1.39	2.66	8.11	5.96	2.66
98.0 MHz	1.39	1.11	11.0	5.96	5.86
108.0 MHz	1.58	2.21	7.91	9.75	5.13
CB VSWR					
CH 1		2.52	3.14	2.58	3.46
CH 19		1.32	1.15	1.36	1.07
CH 40		2.22	2.63	2.37	3.45
Isolation (mV)					
CH 1		400	225	172	270
CH 19		215	160	200	235
CH 40		235	270	135	155
AM C(PF)					
0.5 MHz	68	95	68	91	98
1.0 MHz	72	100	71	95	97
1.5 MHz	66	92	67	87	98
AM Q					
0.5 MHz	4724	402	630	286	155
1.0 MHz	2247	380	515	143	72
1.5 MHz	714	985	440	212	38

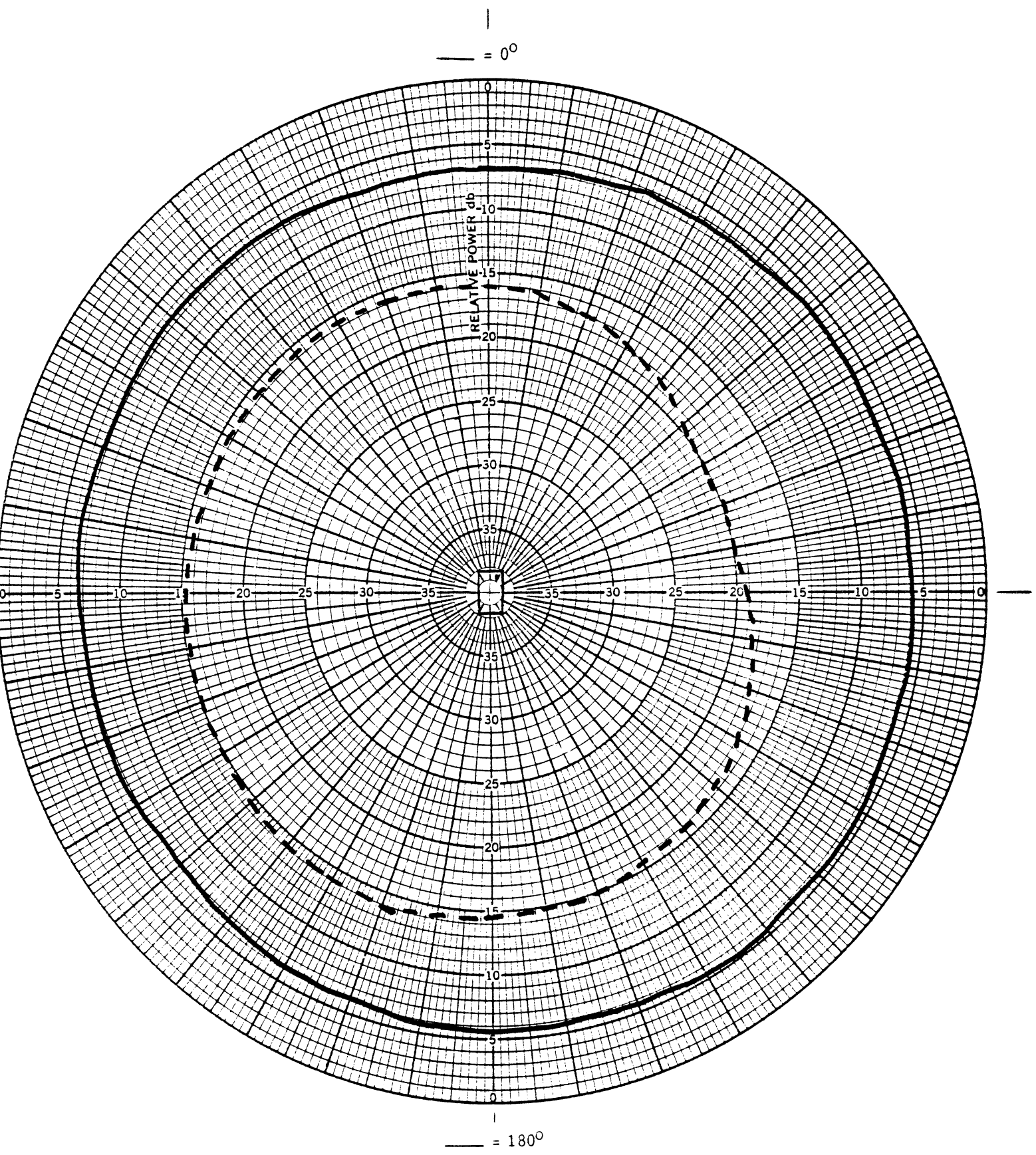


Figure 26(a). Radiation patterns at CB Channel 1 for test and reference antennas on 1978 Granada/Monarch.

—— CB Reference, ----- D8DF-18B812-AC.

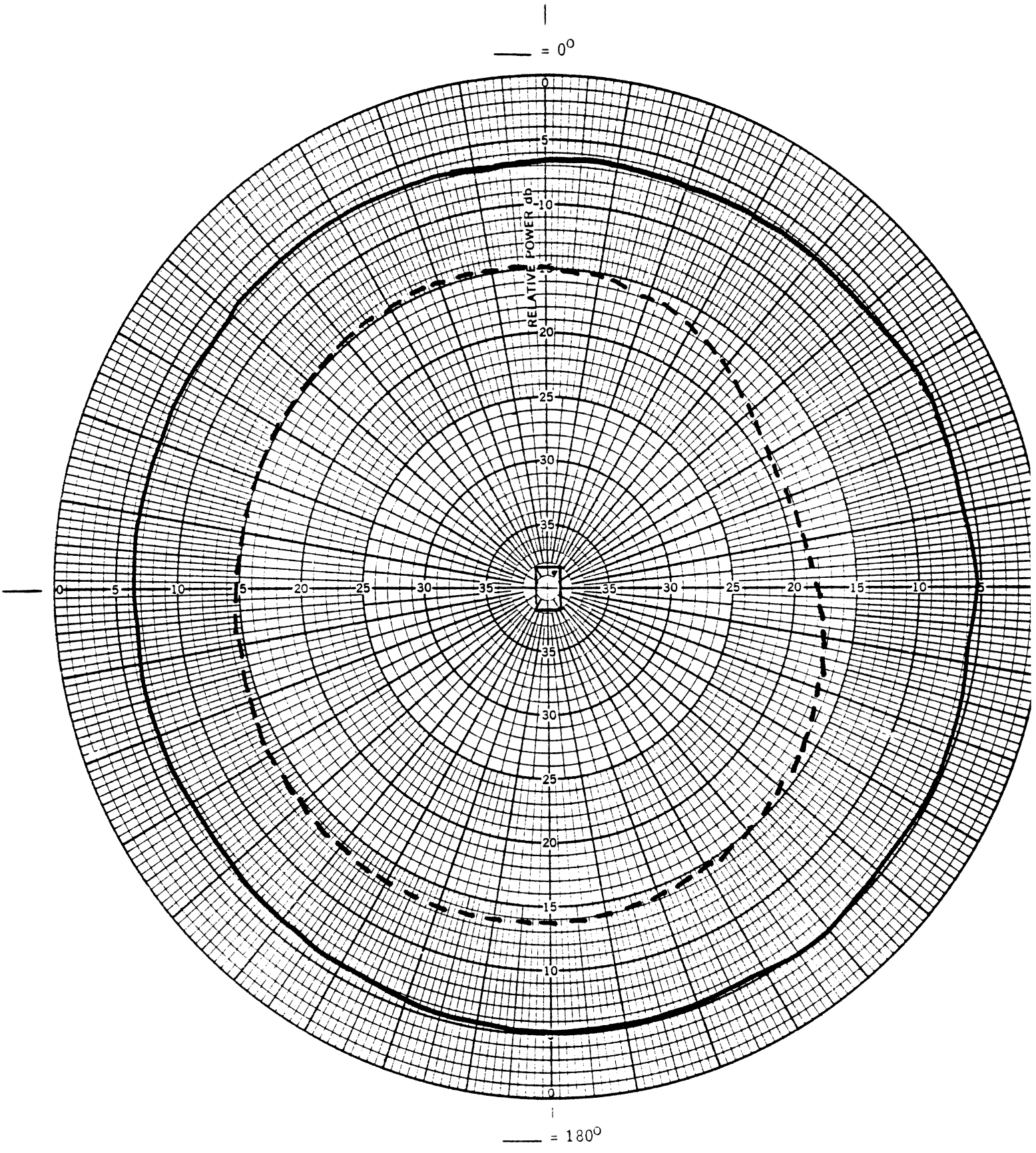


Figure 26(b). Radiation patterns at CB Channel 19 for test and reference antennas on 1978 Granada/Monarch.

—— CB Reference, ----- D8DF-18B812-AC.

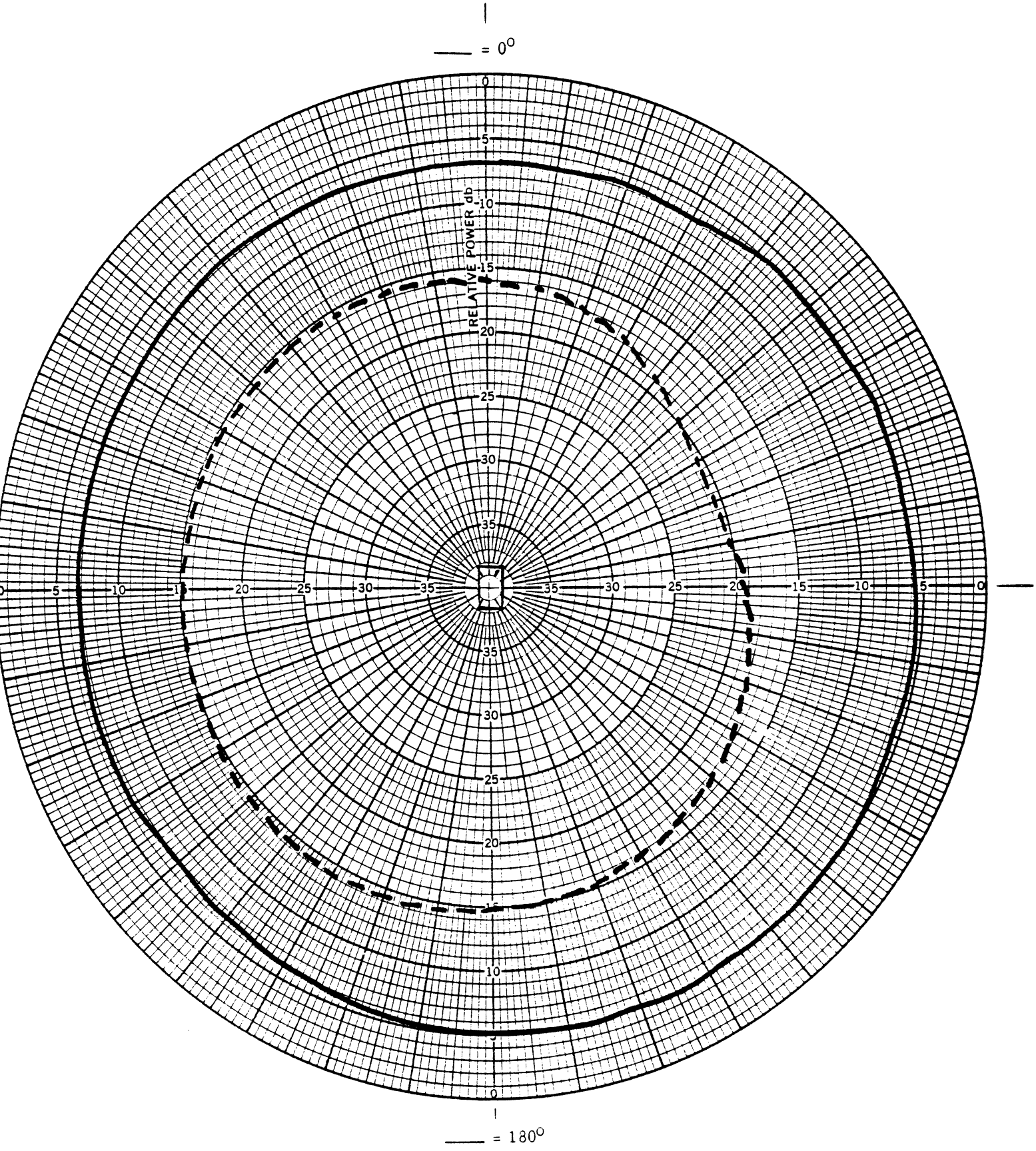


Figure 26(c). Radiation patterns at CB Channel 40 for test and reference antennas on 1978 Granada/Monarch.

—— CB Reference, ----- D8DF-18B812-AC.

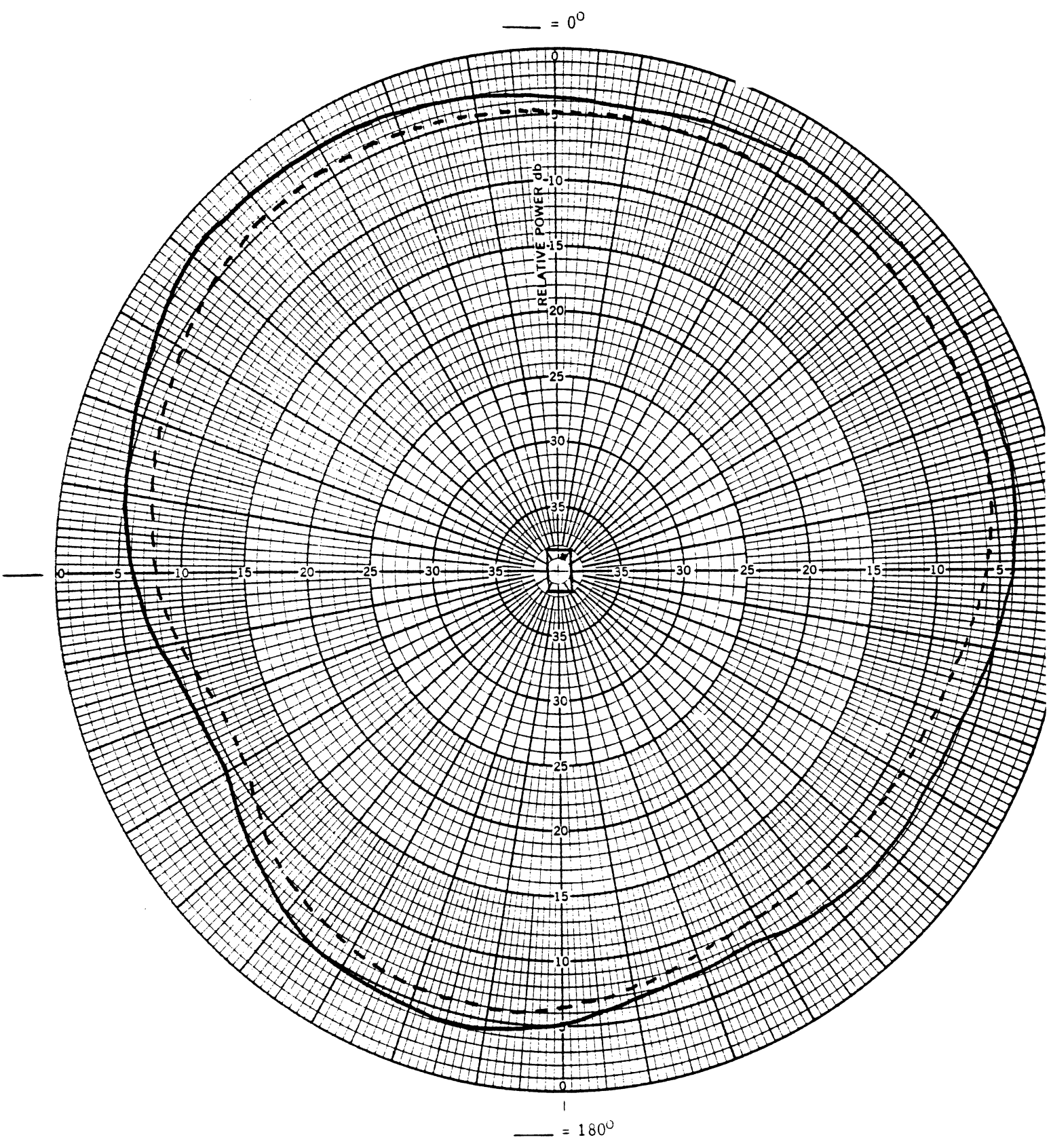


Figure 27(a). Radiation patterns at 88 MHz for test and FM reference antennas on 1978 Granada/Monarch.

—— FM Reference, ---- D8DF-18B812-AC.

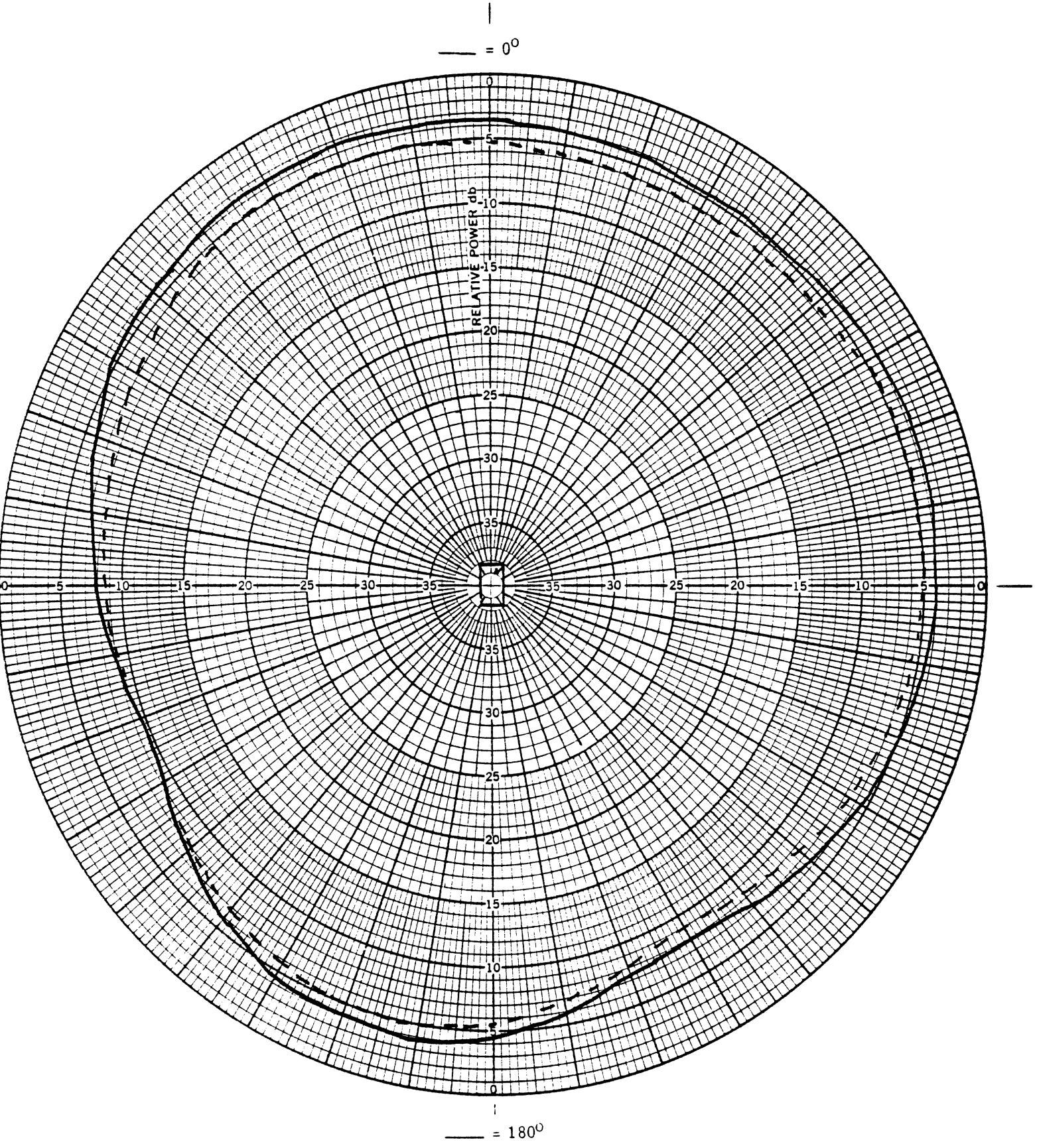


Figure 27(b). Radiation patterns at 98 MHz for test and FM reference antennas on 1978 Granada/Monarch.

—— FM Reference, ---- D8DF-18B812-AC.

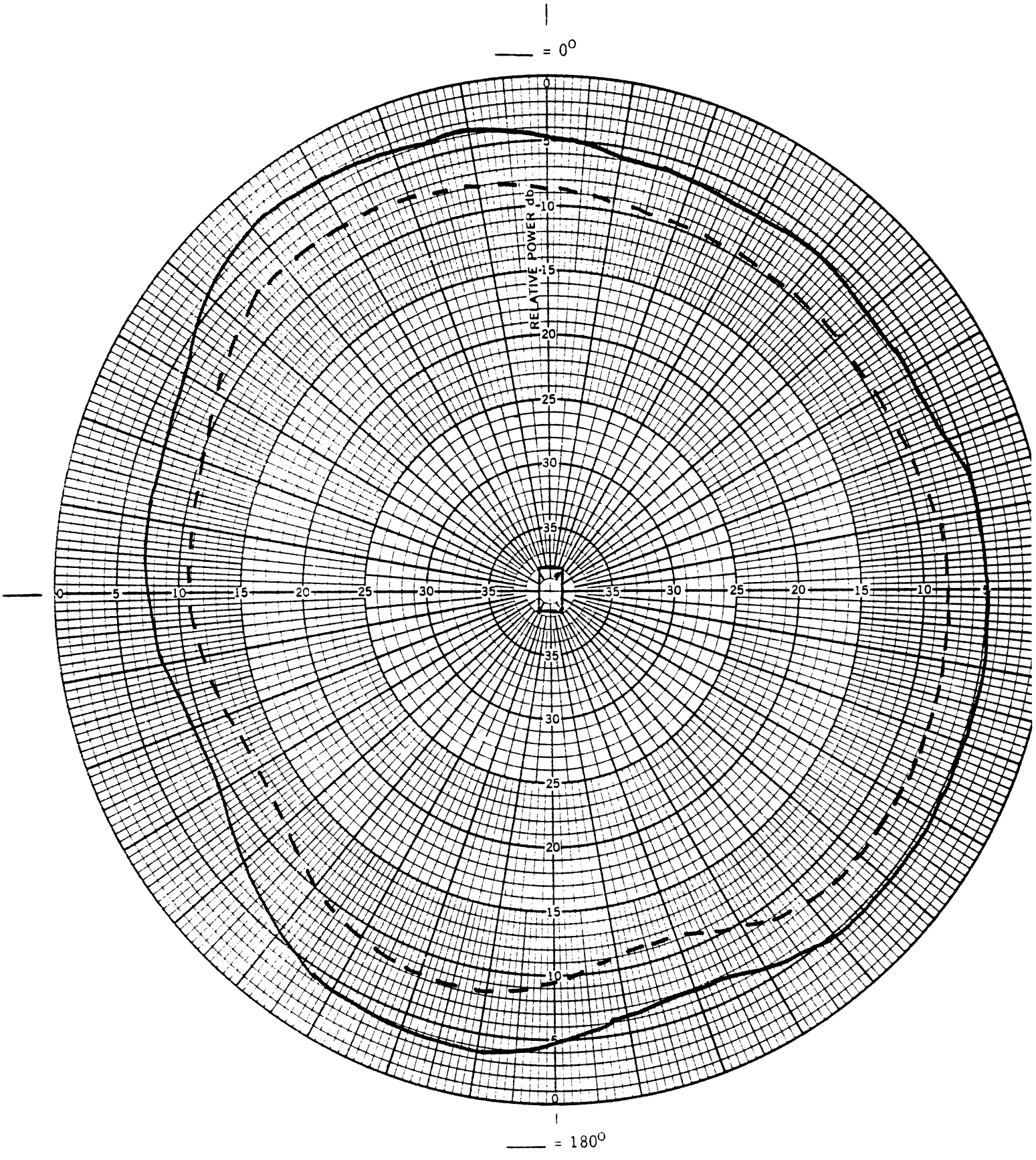
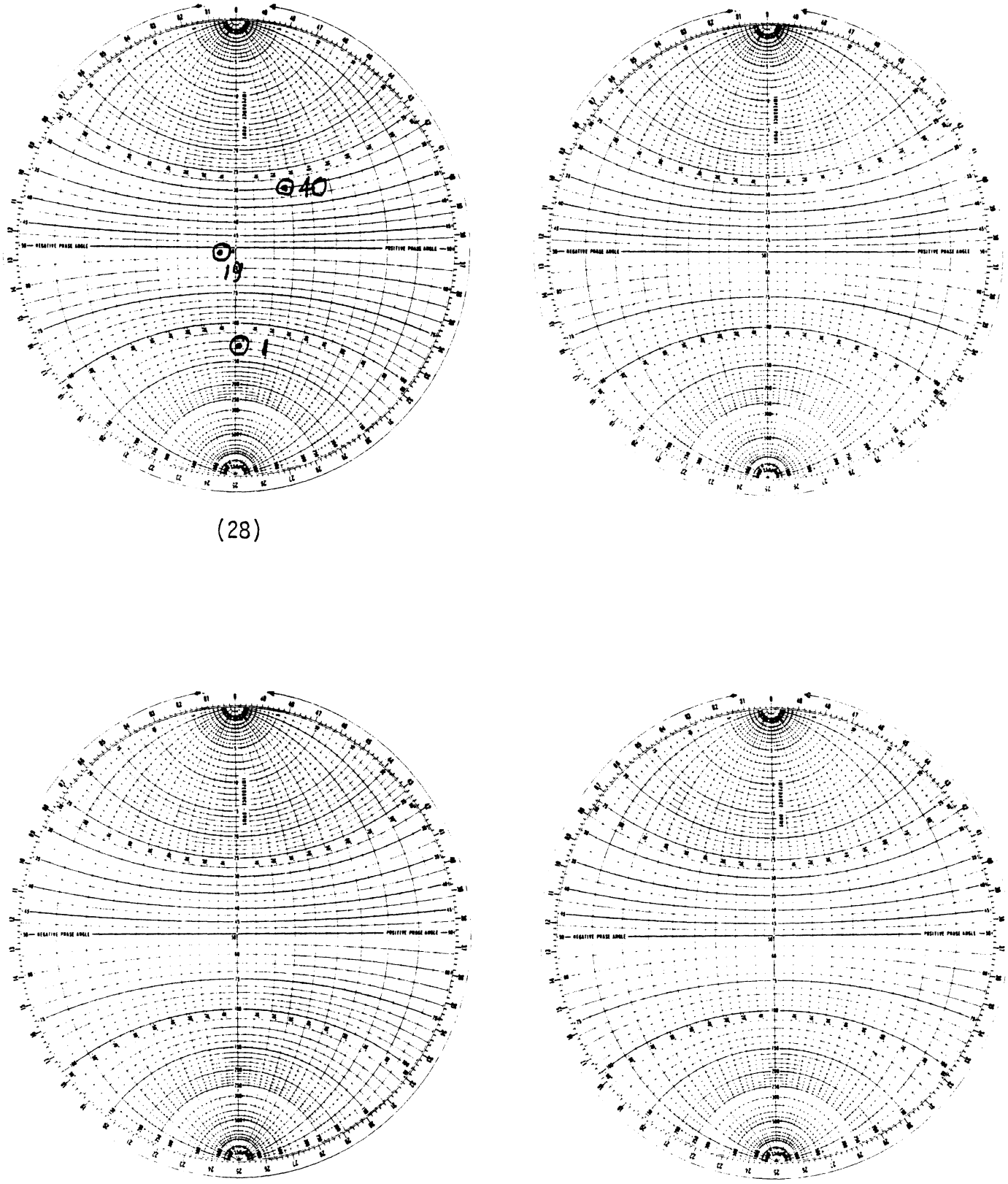


Figure 27(c). Radiation patterns at 108 MHz for test and FM reference antennas on 1978 Granada/Monarch.

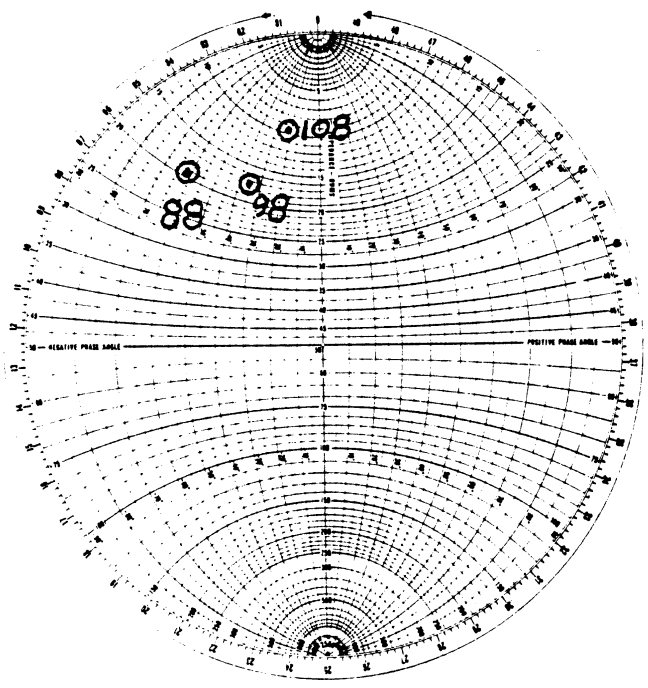
—— FM Reference, ---- D8DF-18B812-AC.



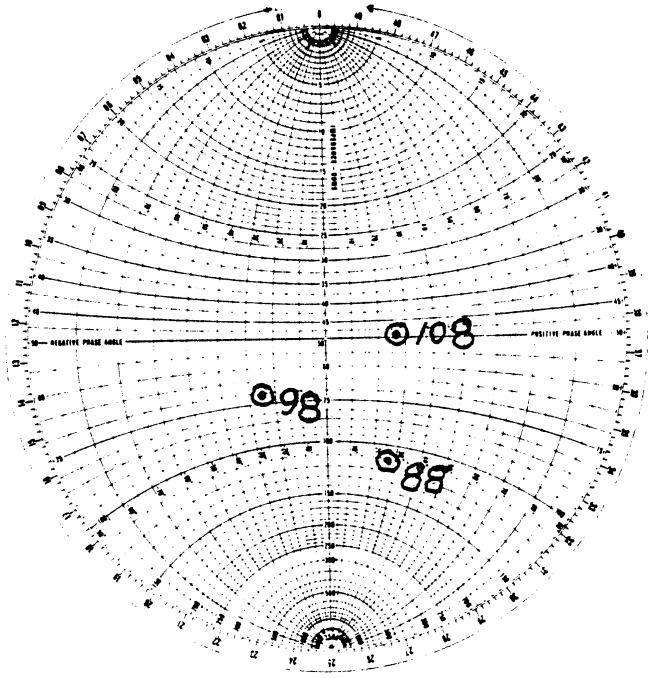
(28)

Figure 28. Impedance characteristics at CB Channel 1, 19 and 40 frequencies for the test antenna on 1978 Granada/Monarch.

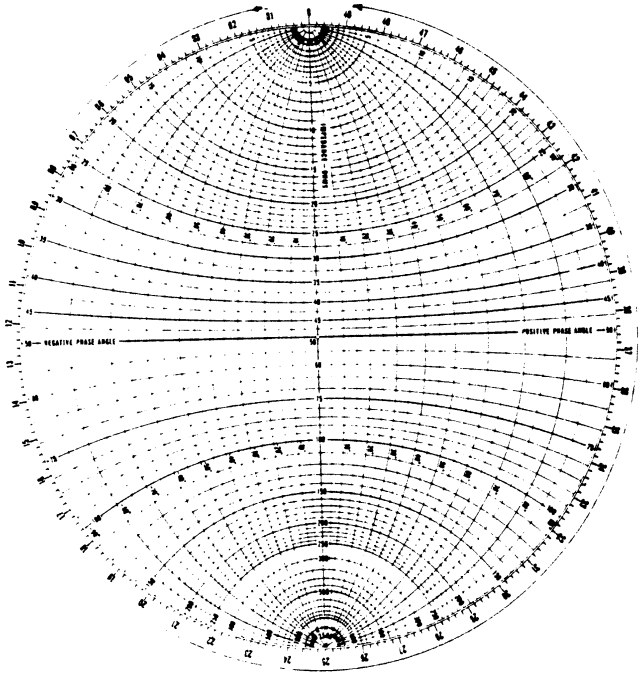
D8DF-18B812-AC.



(a)



(b)



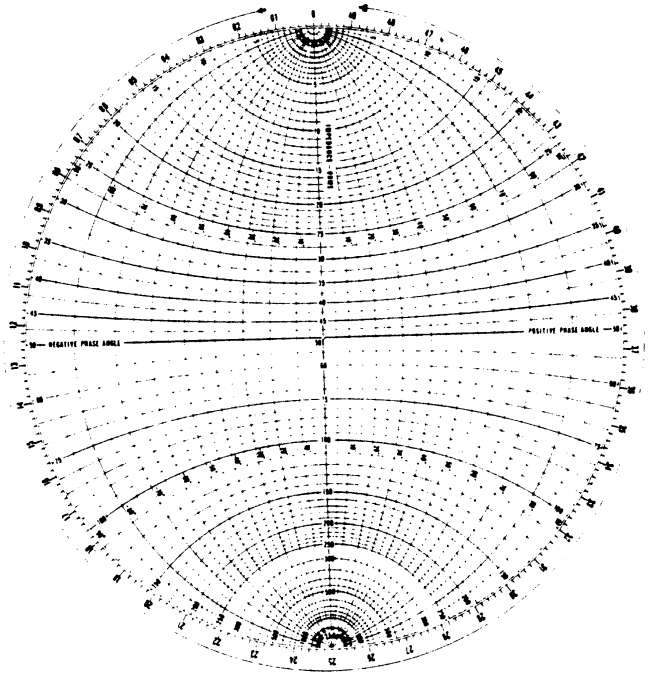


Figure 29. Impedance characteristics at 88, 98 and 108 MHz for test antennas on 1978 Granada/Monarch.
(a) D8DF-18B812-AC, (b) FM Reference.

TABLE 8. PERFORMANCE DATA FOR TEST ANTENNAS ON 1978 GRANADA/MONARCH

PERFORMANCE COMPARISON					
PARAMETER	ANTENNA TYPE				
	STD ENT	PRODUCTION	EPL	RP	MS
AM Sensitivity (dB/m)					
0.76 MHz	-64	-68			
1.10 MHz	---	---			
1.60 MHz	---	---			
Relative FM Sensitivity (dB)					
88.0 MHz	0	-1.78			
98.0 MHz	0	-1.10			
108.0 MHz	0	-3.60			
Relative CB Sensitivity (dB)					
CH 1	0	-9.70			
CH 19	0	-9.10			
CH 40	0	-9.60			
FM VSWR					
88.0 MHz	2.71	1.20			
98.0 MHz	1.79	2.67			
108.0 MHz	1.66	5.71			
CB VSWR					
CH 1		2.43			
CH 19		1.19			
CH 40		2.04			
Isolation (mV)					
CH 1		315			
CH 19		172			
CH 40		250			
AM C(PF)					
0.5 MHz	96	97			
1.0 MHz	102	103			
1.5 MHz	93	96			
AM Q					
0.5 MHz	1635	507			
1.0 MHz	1553	391			
1.5 MHz	1697	232			

rules by which all the performance criteria of the antenna are affected by the test vehicle. On the basis of the results discussed in the previous sections we make the following comments on the general performance of the various test antennas:

(i) AM Sensitivity

The test vehicles have appreciable effects on the AM sensitivity of each test antenna; except for the van, the vehicle can cause a total variation of 2 - 4 dB in the observed sensitivity. When mounted on the van, each antenna maintains its largest sensitivity and the EPL antenna then has a maximum sensitivity of 12 dB. The MS antenna has the poorest sensitivity with all vehicles. In order of decreasing AM sensitivity, the antennas are: EPL, RP, Production and MS.

(ii) FM Sensitivity

The vehicle effects cause a maximum variation of 5.5 dB in the FM sensitivity of the MS antenna, and variations between 2-3 dB for the other antennas. The production antenna has the largest FM sensitivity. All the test antennas except the RP have the largest sensitivity when mounted on the LTD II.

(iii) CB Sensitivity

Vehicle effects may cause a maximum variation of about 5 dB in the sensitivity of each antenna. The lowest sensitivity of the MS-antenna is about -12 dB; the other antennas have comparable sensitivities, the least value being about -9 dB. All antennas have largest sensitivity with the LTD II.

(iv) FM VSWR

The production antenna maintains a VSWR < 3 with all vehicles; the other antennas generally have large VSWR (>4) with all vehicles. The vehicle effects on the VSWR are insignificant.

(v) CB VSWR

The test antennas, being tuned to CB channel 19, maintain VSWR ≤ 1.5 at channel 19 with all vehicles. The vehicle effects on the VSWR are insignificant for antennas tuned on individual cars.

(vi) CB Isolation

The production antenna has the best isolation characteristics.

On the basis of the above comments, and the results discussed earlier, it is concluded that of all the antennas tested the Production antenna has the best, and the MS antenna the worst, overall performance.

V. REAR TRI-BAND ANTENNAS WITH IN-LINE CAPACITORS

The short loading coil (SLC) power tri-band antennas using a padder capacitor at the AM/FM input line of the radio (Figure 5) is compared with production antennas with padder capacitors in the splitter box. Some of the production series (i.e. D-series) antennas use conventional loading coils to obtain better CB-isolation characteristics, and have the CB and AM/FM branches within the splitter box shielded from each other by using a metallic barrier A---A as shown in Figure 5. The latter are referred to as improved production series or improved isolation antennas and will be denoted by an appropriate D-number without padder capacitor. The present chapter discusses the results obtained with SLC and improved production series antennas mounted on a variety of 1978 model cars. The test vehicles were Lincoln Mark V, Lincoln, Cougar and Versailles.

5.1. Mark V

Figures 30 and 31 show the CB and FM band horizontal plane patterns obtained with SLC and improved production series antennas, along with the corresponding patterns for the standard antennas. As seen from Figure 30 both test antennas perform similarly in the CB-band of frequencies, although the improved production series antenna does appear to have slightly less sensitivity at the highest CB channel frequency. The improved isolation antenna has less sensitivity than the SLC antenna at 88 and 98 MHz (Figures 31a and 31b), but more at 108 MHz (Figure 31c). The difference is due to the short loading coil used, not because of the capacitor. Note that at both CB and FM band frequencies the two test antennas have sensitivities less than the corresponding standard antennas. The impedances of the two antennas at CB frequencies are shown in Figure 32. The FM band impedances of the

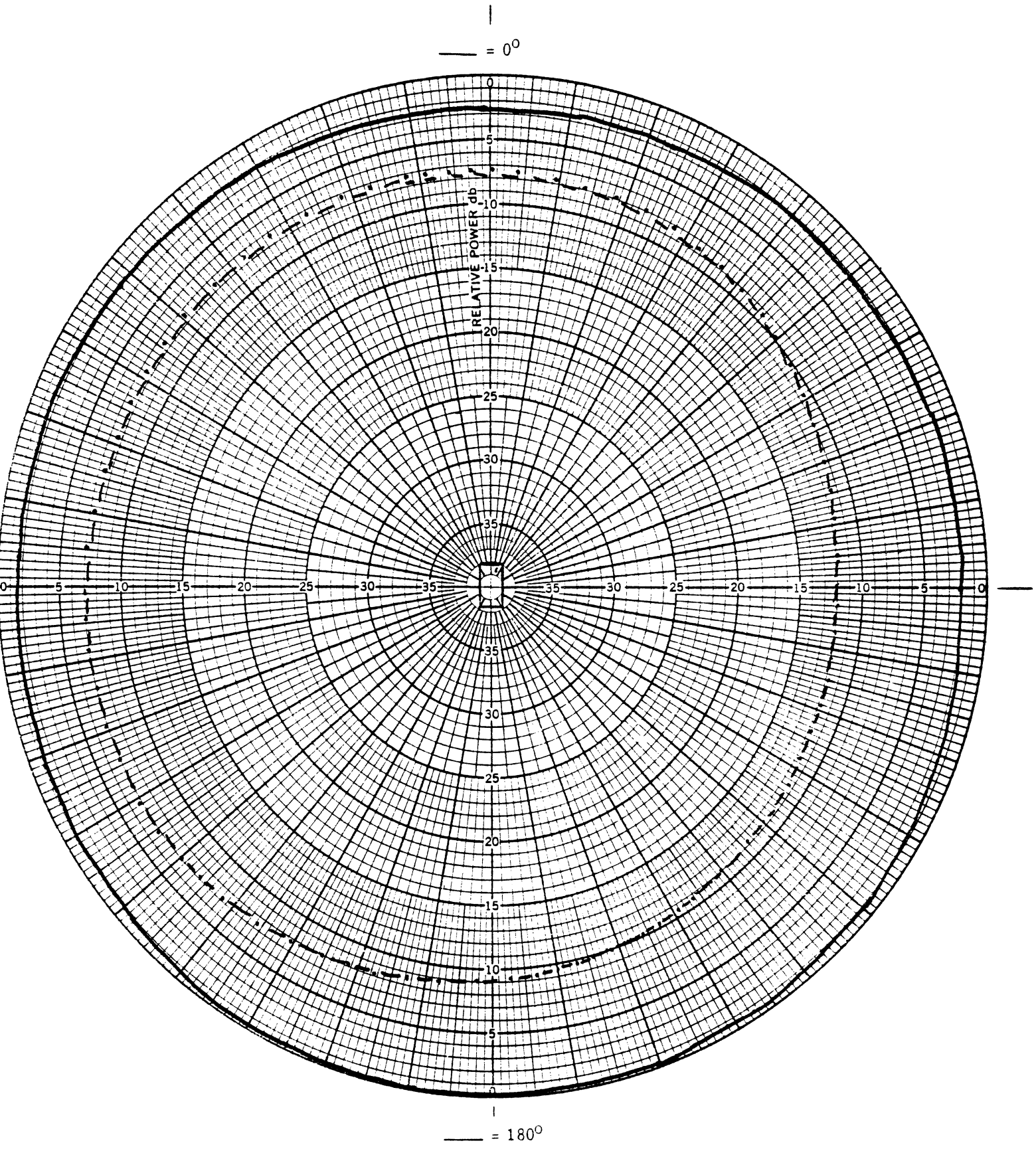


Figure 30(a). Radiation patterns at CB Channel 1 for SLC and reference antennas on 1978 Mark V.

—— CB Reference, ---- D8LF-18B812-AC with padder capacitor
···· D8LF-18B812-AC without padder capacitor.

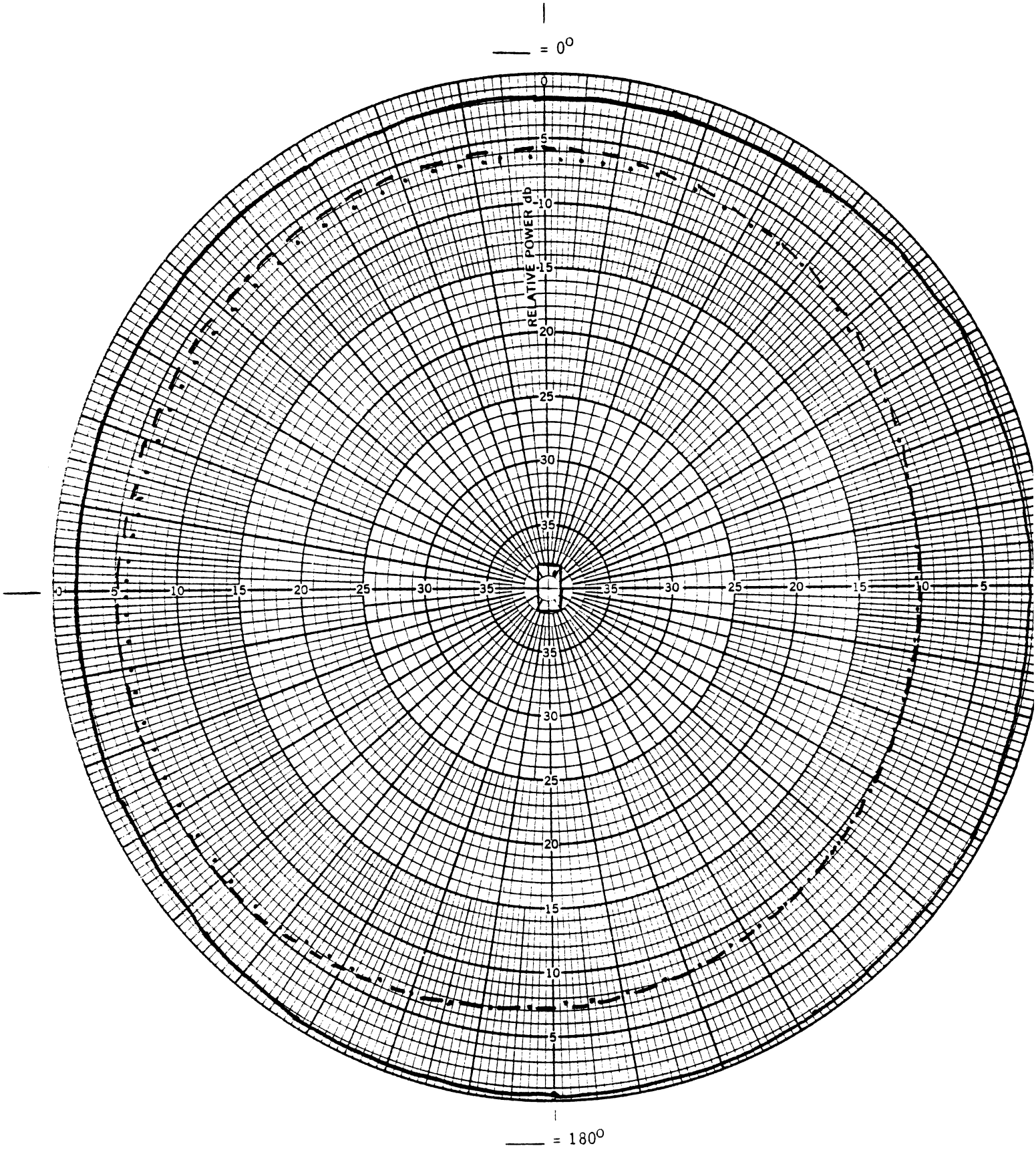


Figure 30(b). Radiation patterns at CB Channel 19 for SLC and reference antennas on 1978 Mark V.

—— CB Reference, ---- D8LF-18B812-AC with padder capacitor, ···· D8LF-18B812-AC without padder capacitor.

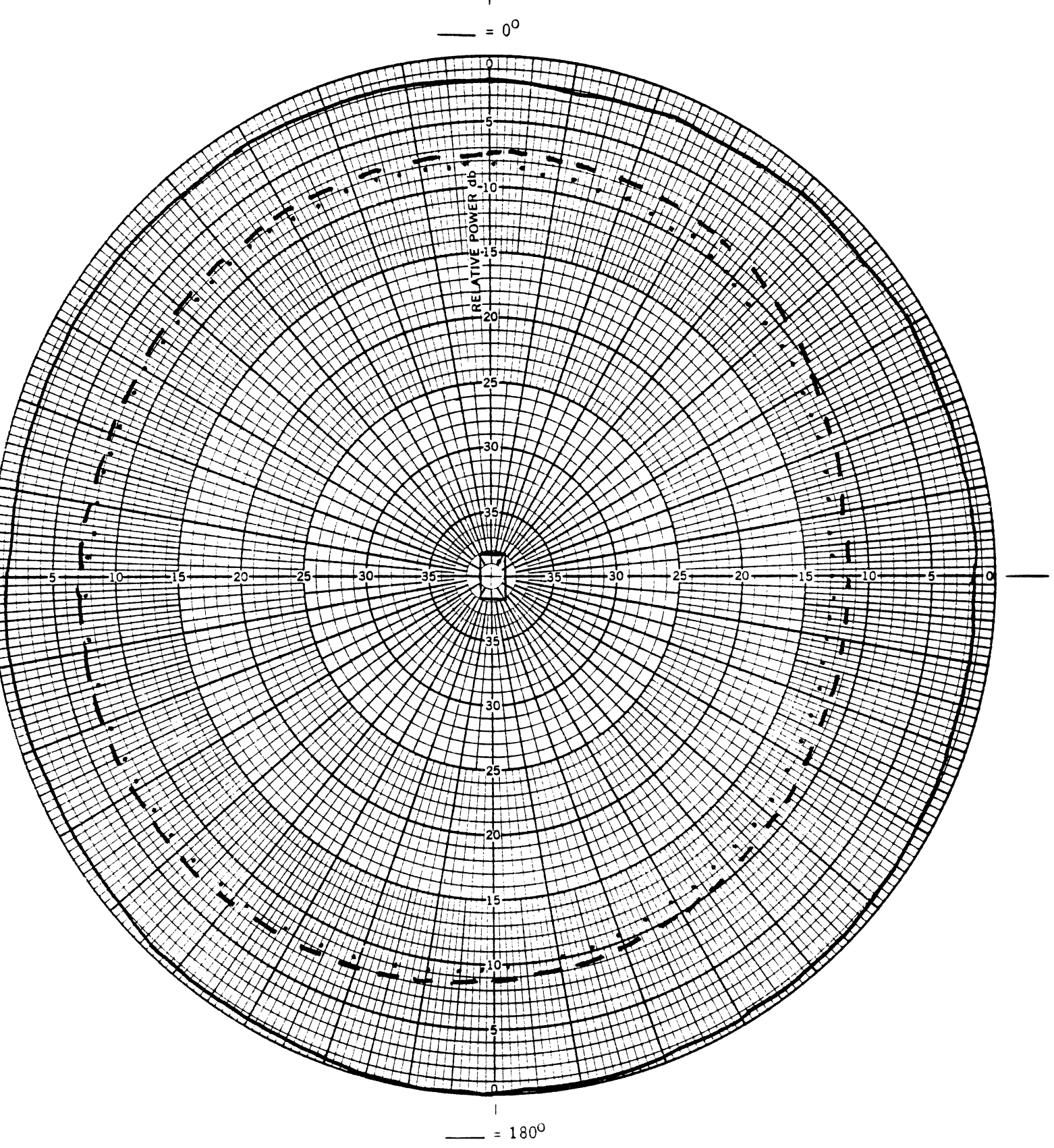


Figure 30(c). Radiation patterns at CB Channel 40 for SLC and reference antennas on 1978 Mark V.

—— CB Reference, ---- D8LF-18B812-AC with padder capacitor, ... D8LF-18B812-AC without padder capacitor.

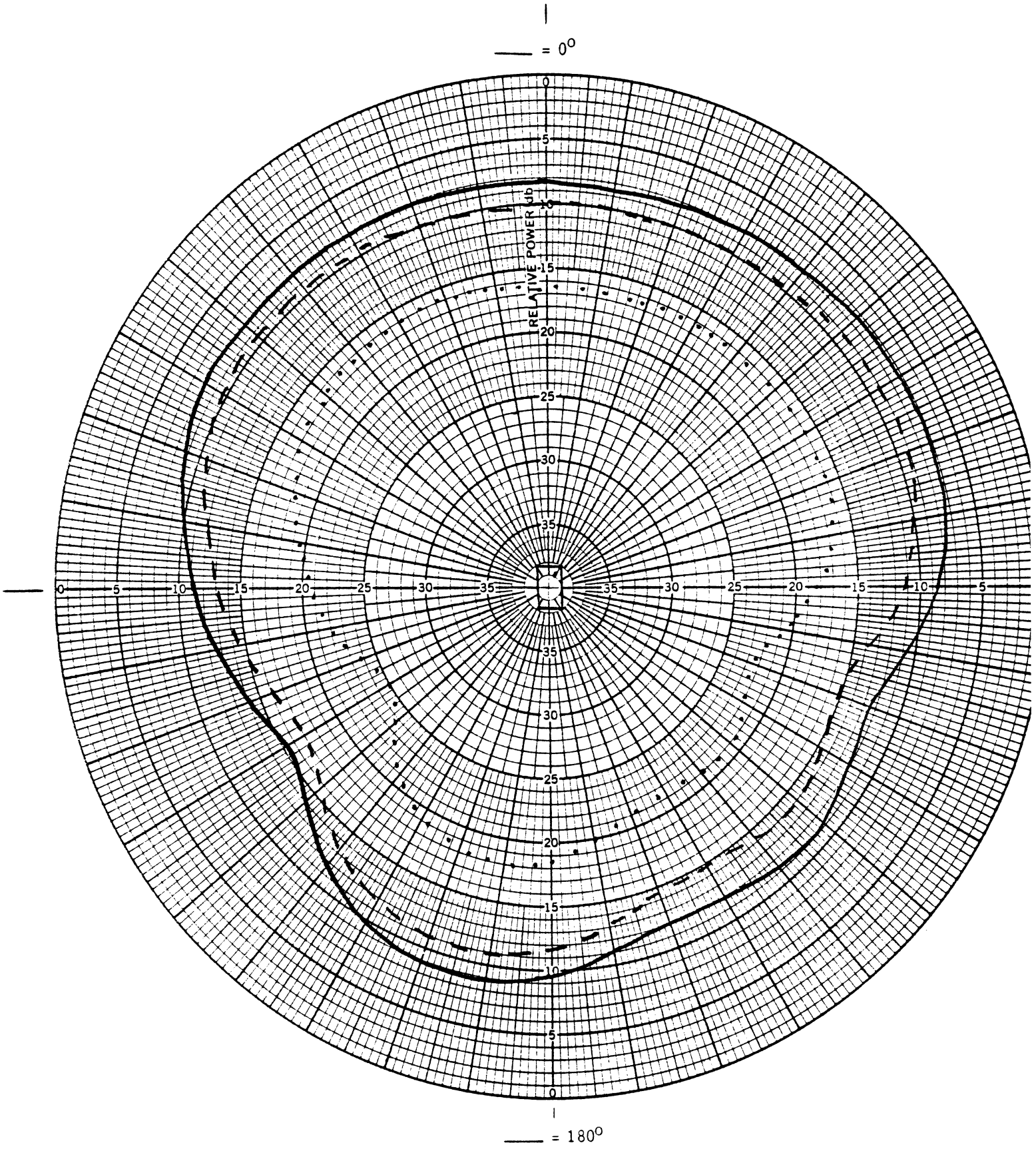


Figure 31(a). Radiation patterns at 88 MHz for SLC and FM reference antennas on 1978 Mark V.

—— FM Reference, ---- D8LF-18B812-AC with padder capacitor, ... D8LF-18B812-AC without padder capacitor.

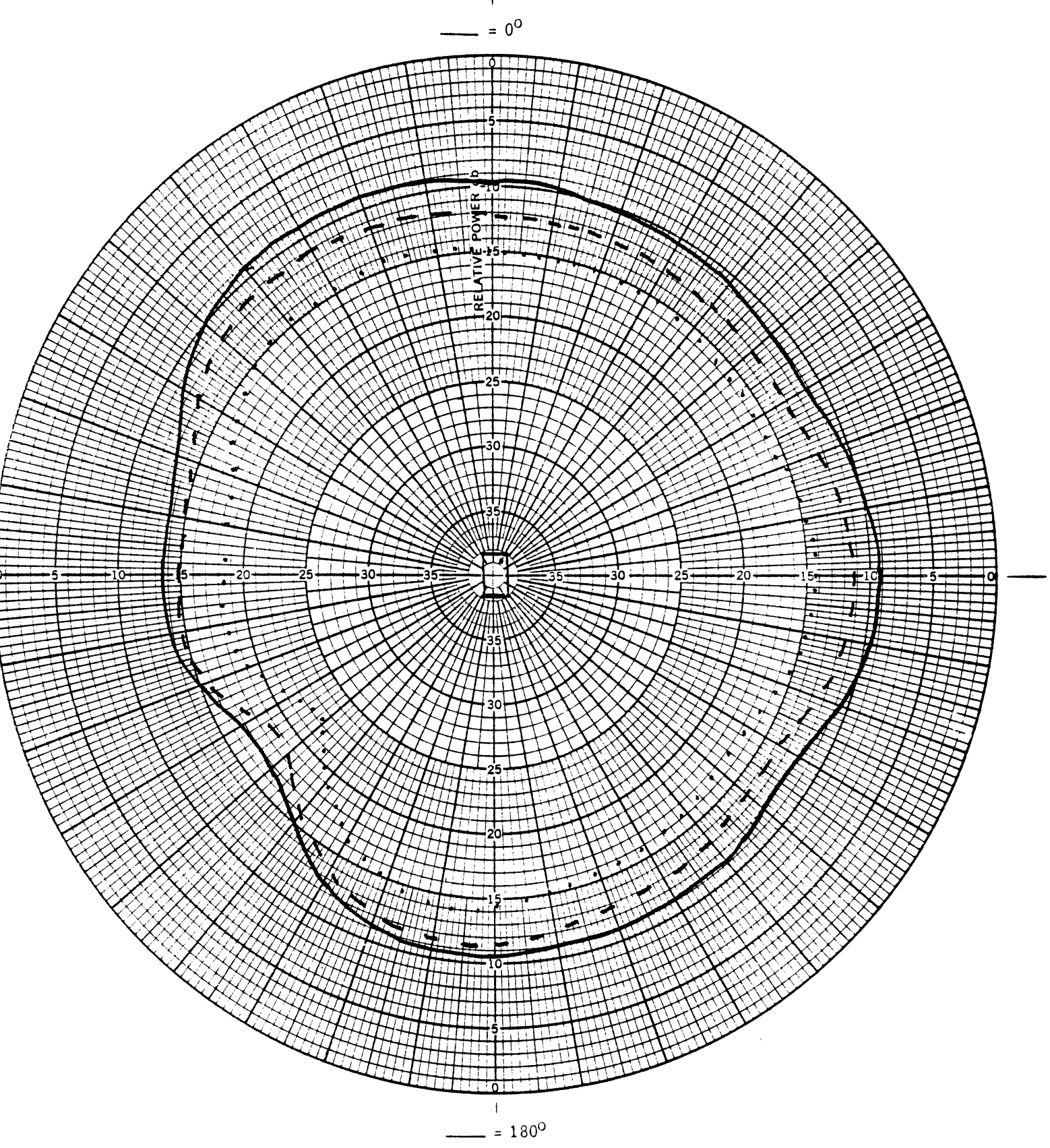


Figure 31(b). Radiation patterns at 98 MHz for SLC and FM reference antennas on 1978 Mark V.

—— FM Reference, ---- D8LF-18B812-AC with padder capacitor, ···· D8LF-18B812-AC without padder capacitor.

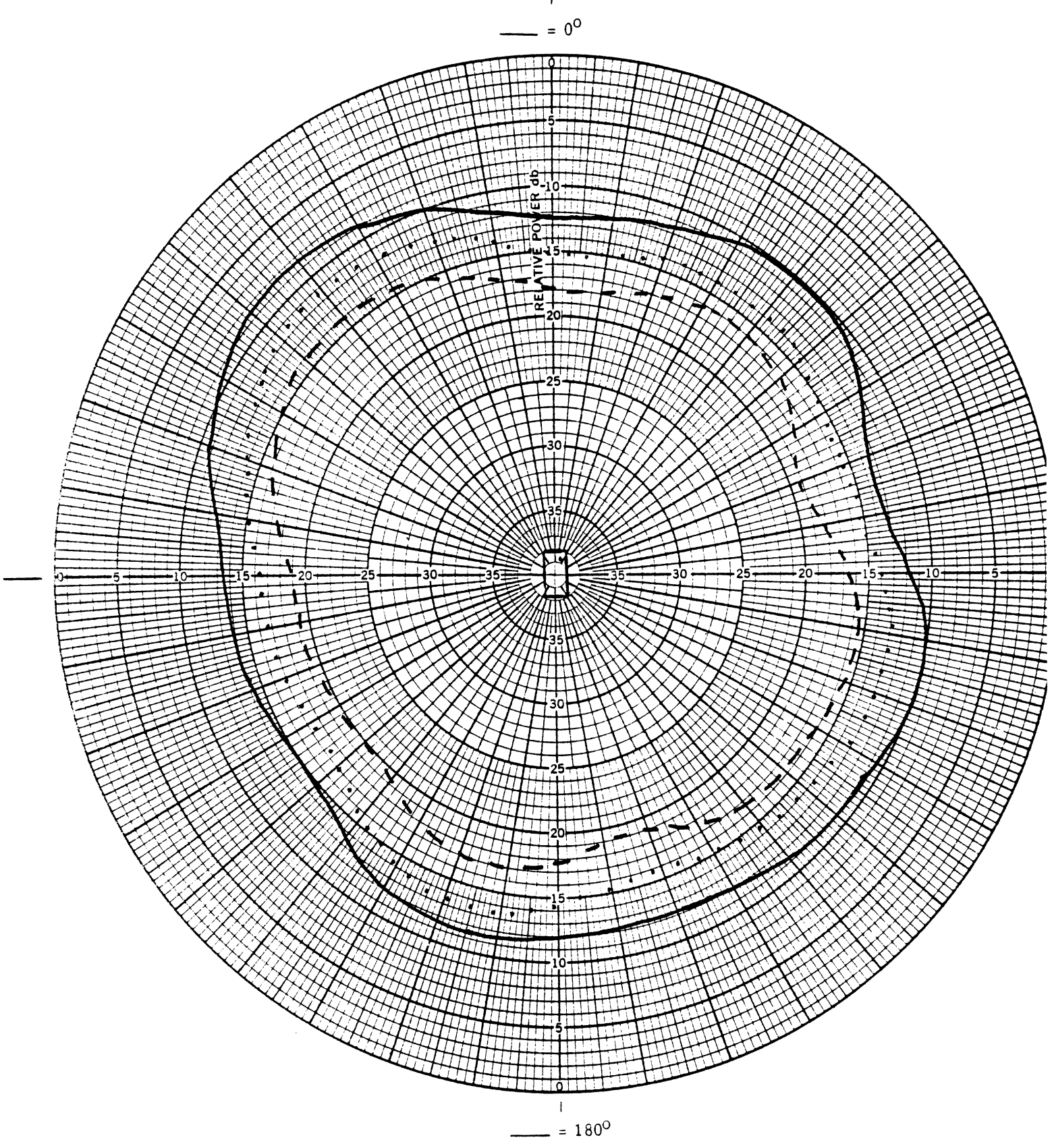
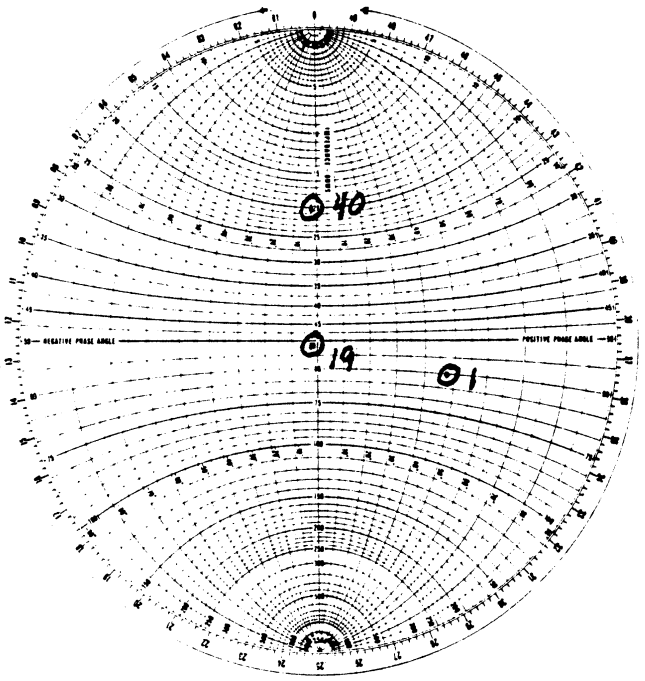
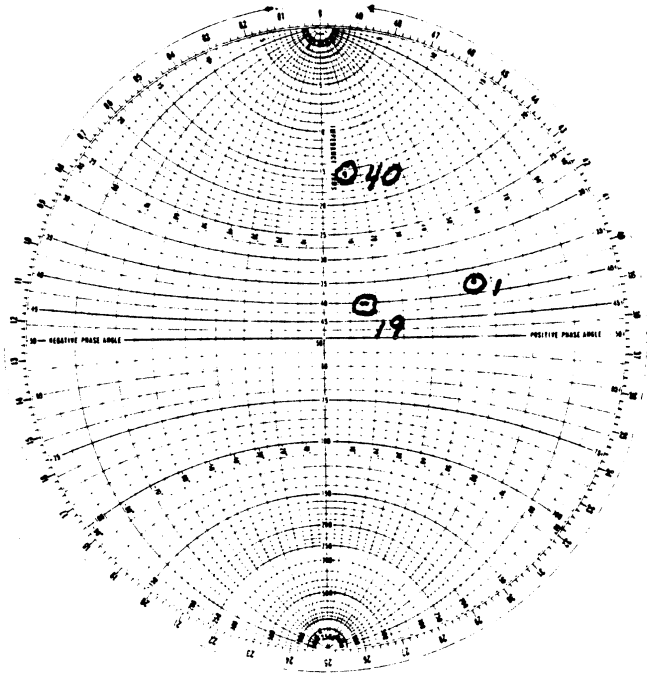


Figure 31(c). Radiation patterns at 108 MHz for SLC and FM reference antennas on 1978 Mark V.

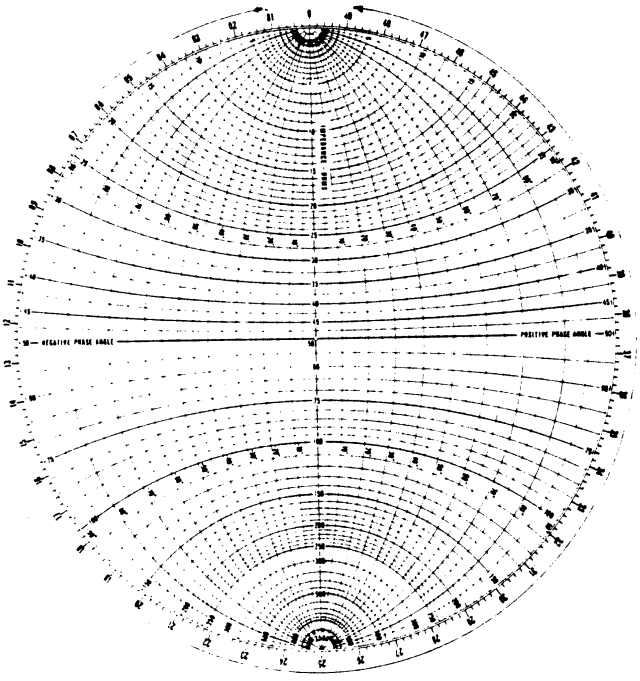
—— FM Reference, ---- D8LF-18B812-AC with padder capacitor, ... D8LF-18B812-AC without padder capacitor.



(a)



(b)



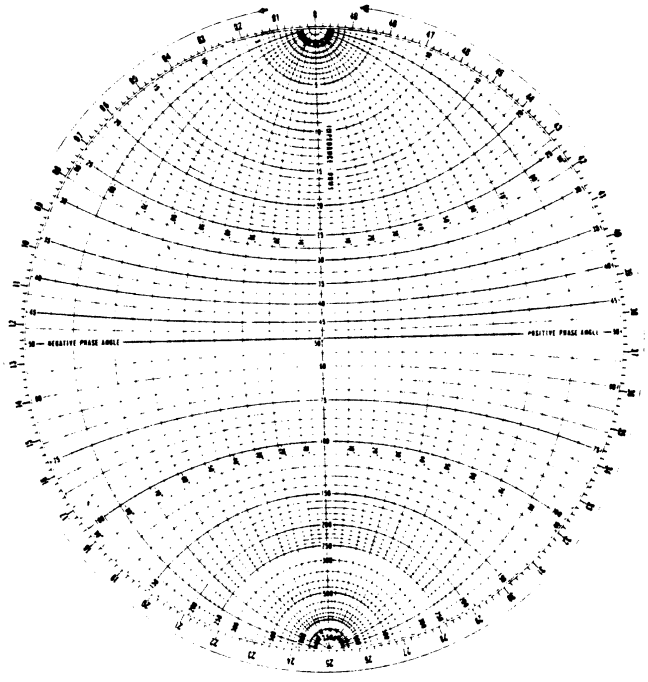


Figure 32. Impedance characteristics at CB Channel 1, 19 and 40 frequencies for the SLC antennas on 1978 Mark V.
(a) D8LF-18B812-AC with padder capacitor, (b) D8LF-18B812-AC without padder capacitor.

AM/FM standard and the two test antennas are shown in Figure 33.

5.2. Lincoln

The CB and FM-band horizontal plane patterns obtained for the test and standard antennas are shown in Figures 34 and 35. Observe the CB sensitivities of the two test antennas in the 90° and 270° directions of Figures 34(a)-(c) and compare them with those in Figures 30(a)-(c). It is found that the directions of minimum sensitivity are interchanged. It thus appears that reduced sensitivity occurs along the 90° - 270° direction, with the minimum occuring on the side where the antenna is located.

The results of Figure 34 indicate no significant difference in the performance of the two antennas at the CB frequencies.

At FM band frequencies the SLC antenna appears to have equal or more sensitivity than the reference antenna (Figure 35). The improved isolation antenna is found to be less sensitive than the SLC antenna at 88 and 98 MHz (Figure 35a-b), but at 108 MHz both antennas have approximately the same sensitivity, larger than that of the reference antenna.

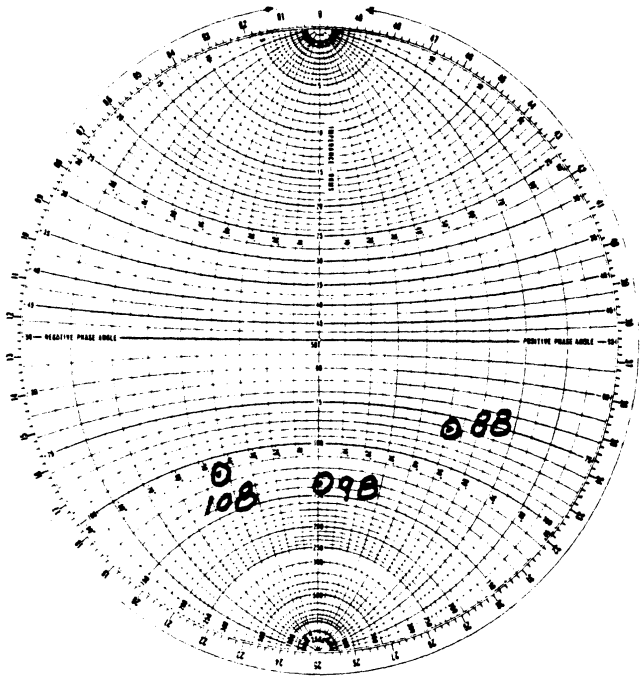
The corresponding impedance results are shown in Figures 36 and 37.

5.3. Cougar

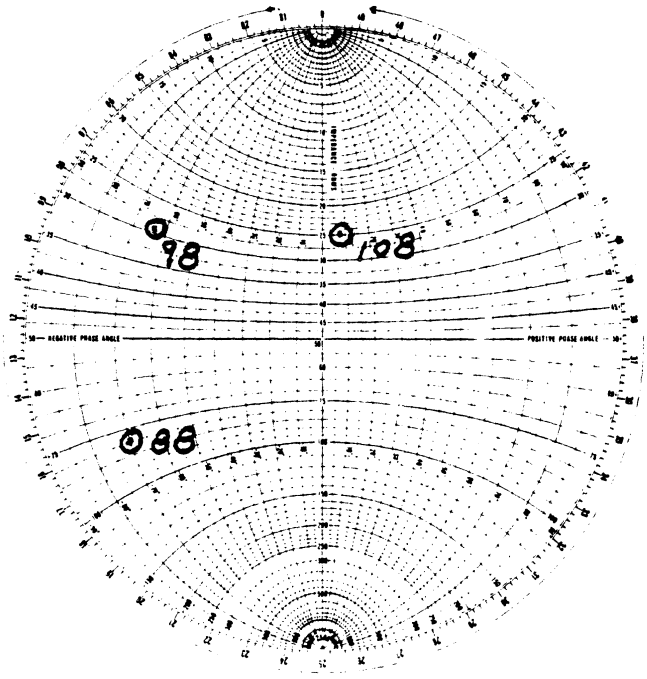
Figures 38-41 show the appropriate radiation patterns and impedances for the two test antennas mounted on the Cougar. Figure 38 indicates that the SLC antenna has less sensitivity than the improved isolation antenna at all CB freqencies. At FM band frequencies the improved isolation antenna appears less sensitive than the SLC antenna.

5.4. Versailles

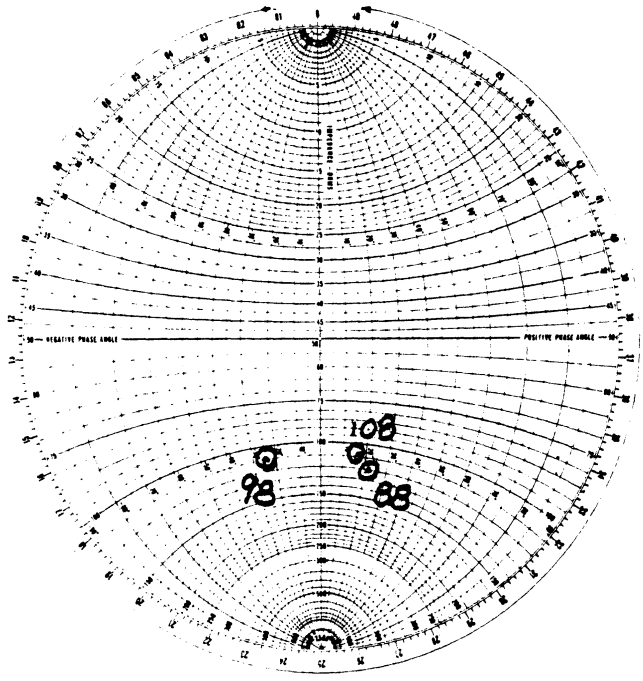
Results for the test antennas mounted on the Versailles are shown in Figures 42-45. The CB performances of the two antennas are about the same (Figure 42). At 88 and 98 MHz the improved isolation antenna is somewhat less sensitive (Figure 43a-b), but at 108 MHz the two antennas have about



(a)



(b)



(c)

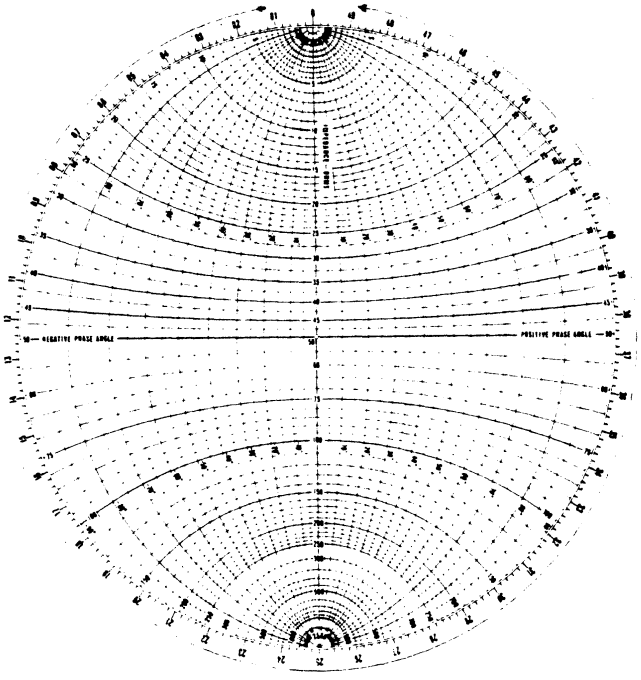


Figure 33. Impedance characteristics at 88, 98 and 108 MHz for SLC and FM reference antennas on 1978 Mark V.
(a) D8LF-18B812-AC with padder capacitor, (b) D8LF-18B812-AC without padder capacitor, (c) FM Reference.

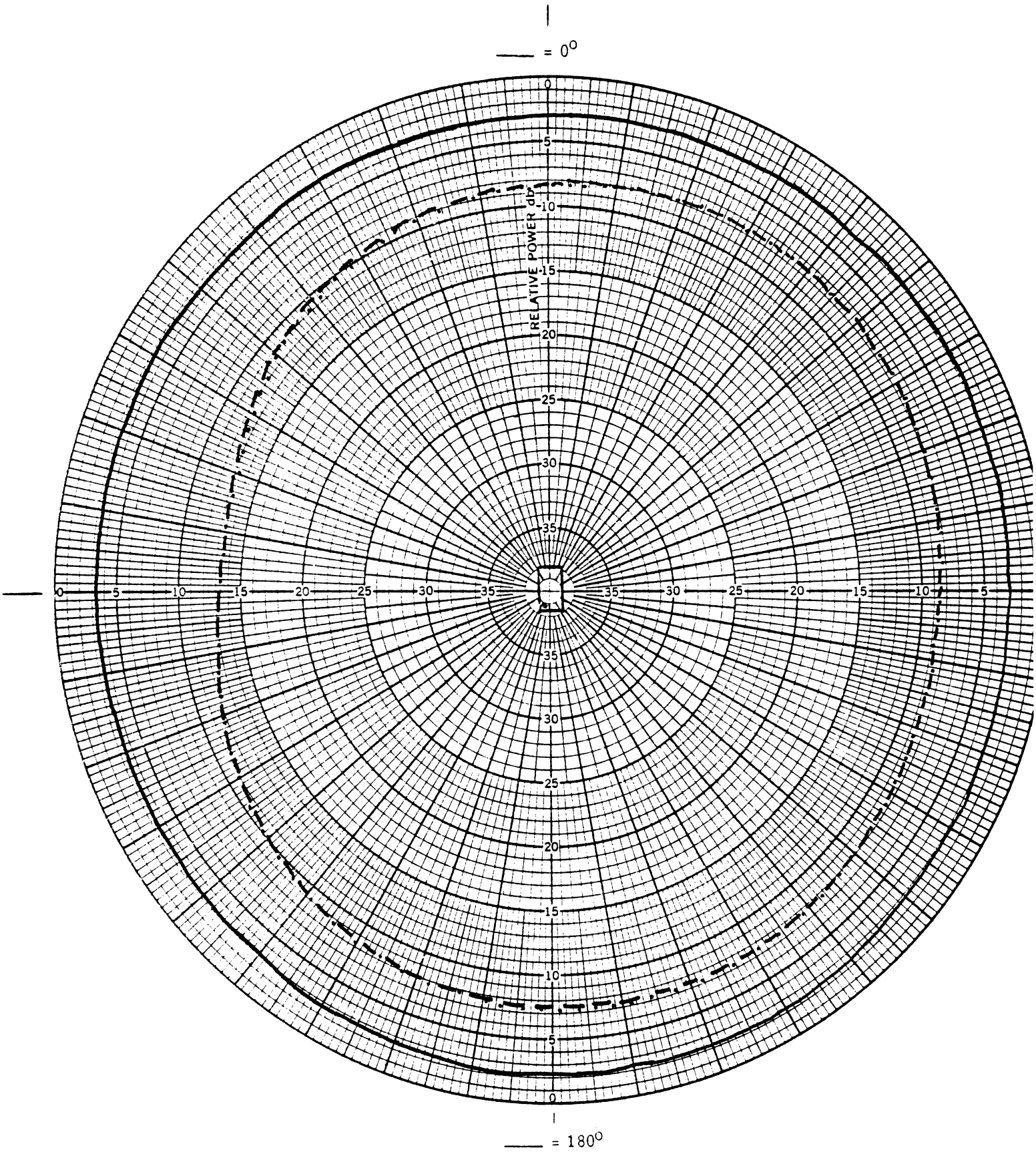


Figure 34(a). Radiation patterns at CB Channel 1 for SLC and reference antennas on 1978 Lincoln.

—— CB Reference, ---- D8VF-18B812-AC with padder capacitor, ···· D8VF-18B812-AC without padder capacitor.

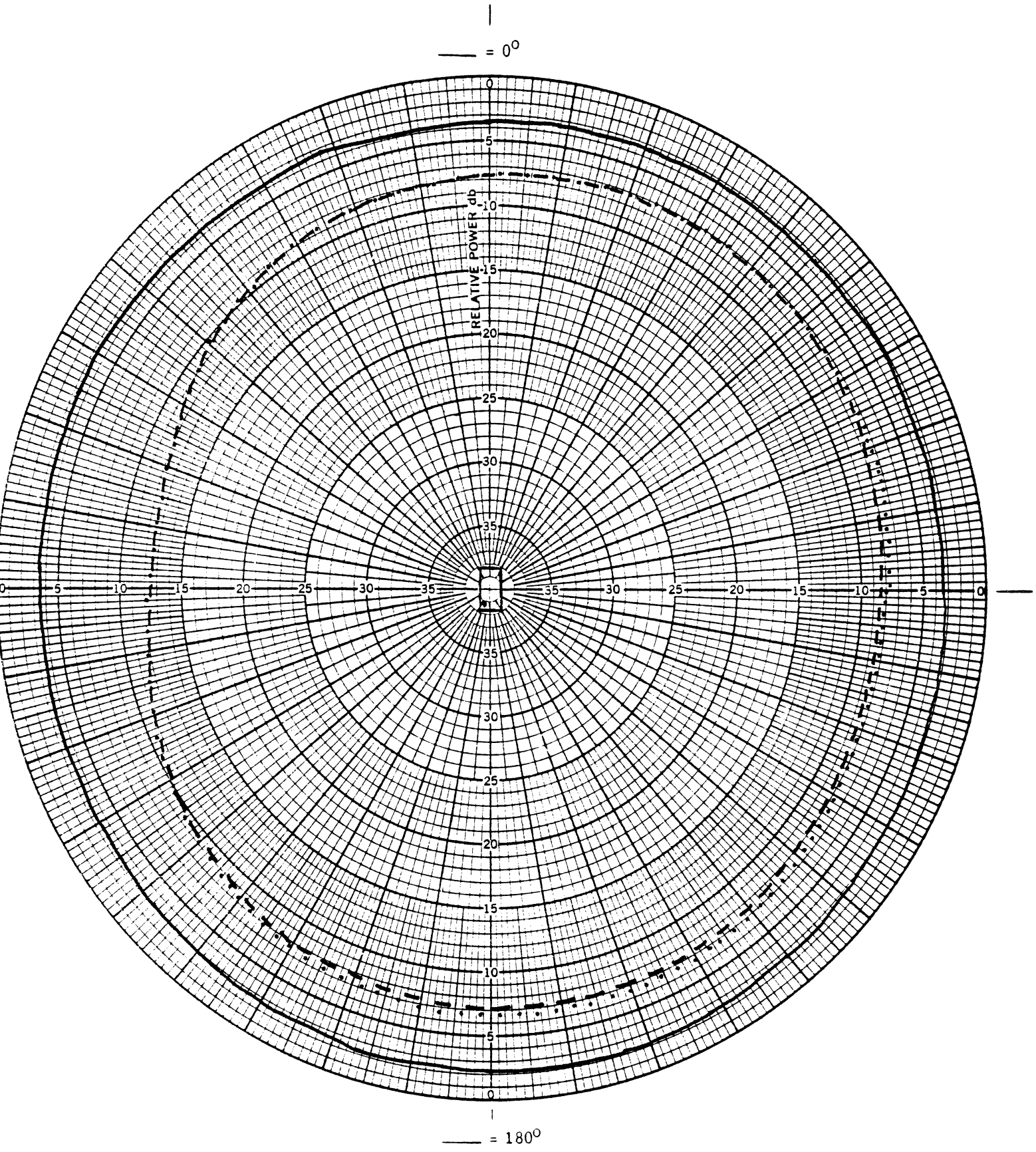


Figure 34(b). Radiation patterns at CB Channel 19 for SLC and reference antennas on 1978 Lincoln.

—— CB Reference, ---- D8VF-18B812-AC with padder capacitor, ···· D8VF-18B812-AC without padder capacitor.

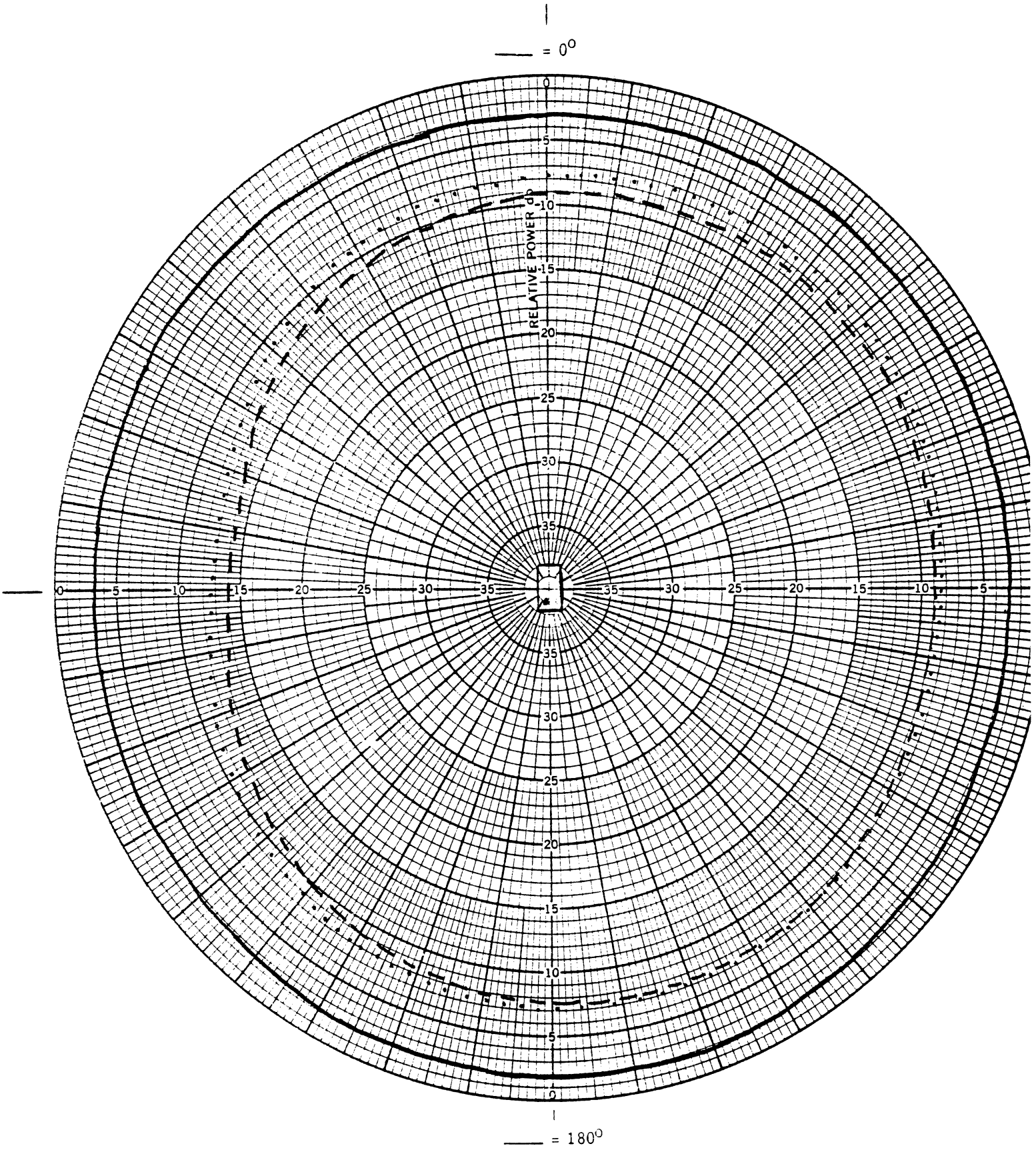


Figure 34(c). Radiation patterns at CB Channel 40 for SLC and reference antennas on 1978 Lincoln.

—— CB Reference, ---- D8VF-18B812-AC with padder capacitor, ... D8VF-18B812-AC without padder capacitor.

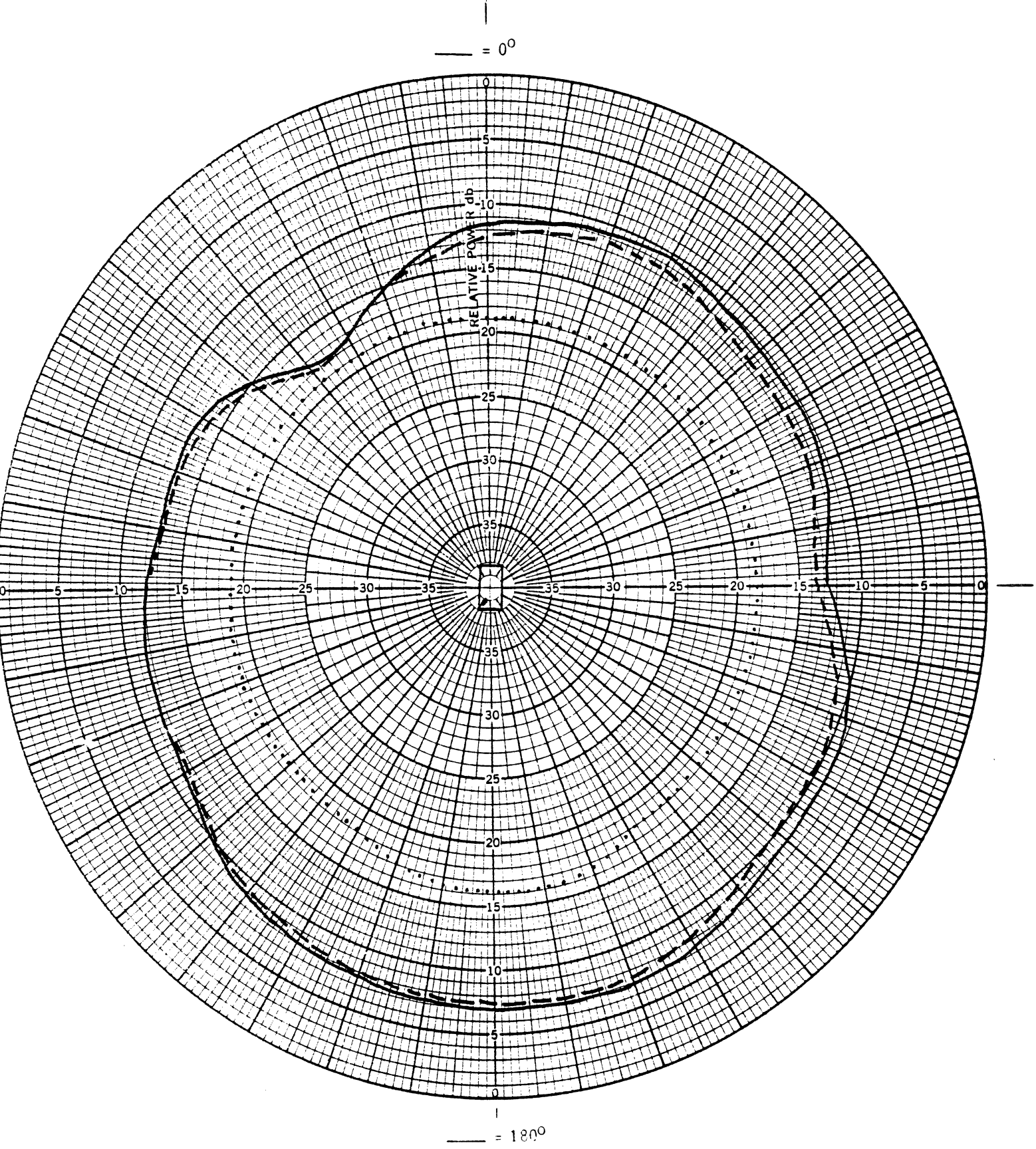


Figure 35(a). Radiation patterns at 88 MHz for SLC and reference antennas on 1978 Lincoln.

—— FM Reference, ---- D8VF-18B812-AC with padder capacitor, ···· D8VF-18B812-AC without padder capacitor.

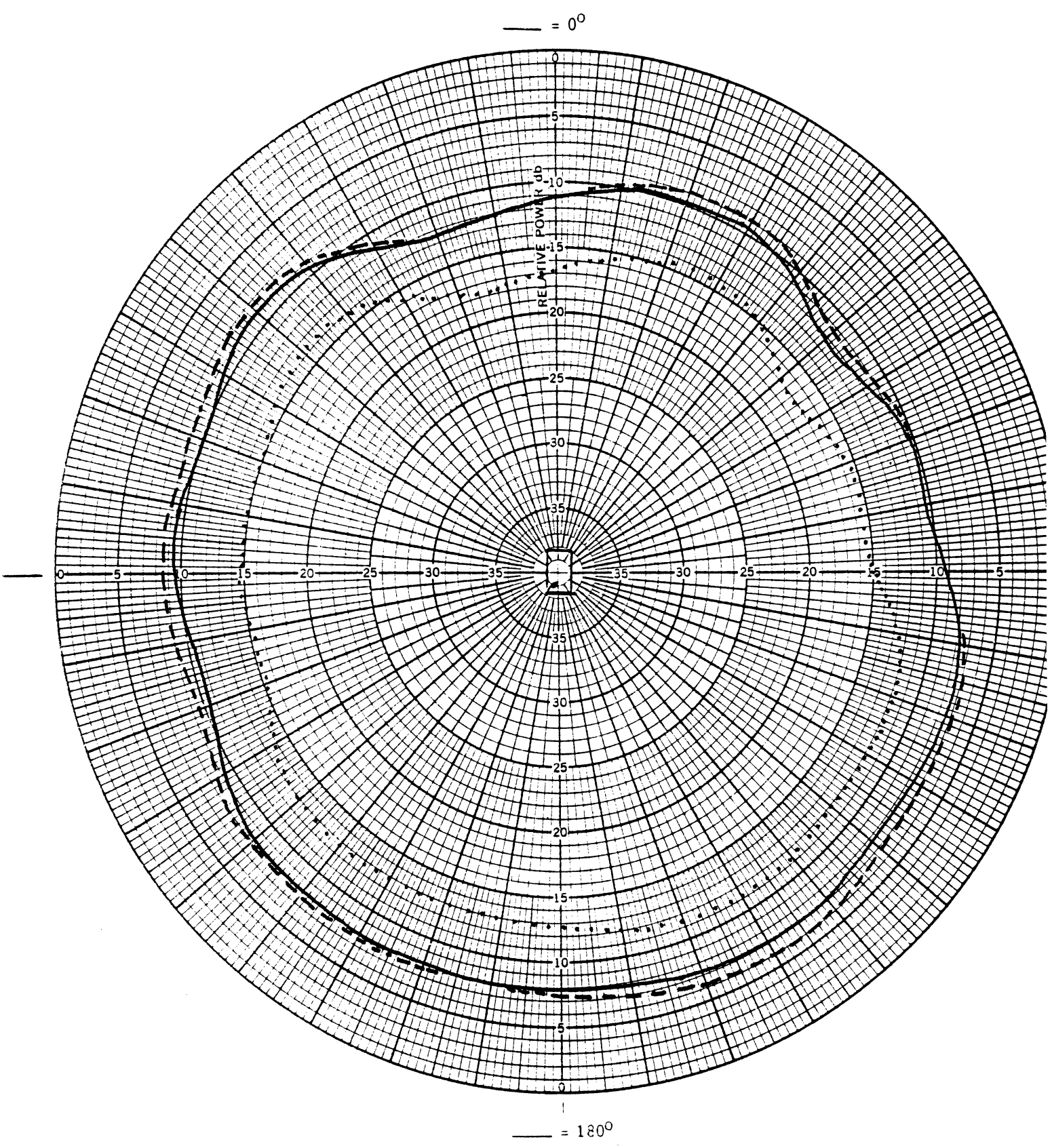


Figure 35(b). Radiation patterns at 98 MHz for SLC and reference antennas on 1978 Lincoln.

—— FM Reference, ---- D8VF-18B812-AC with padder capacitor, ... D8VF-18B812-AC without padder capacitor.

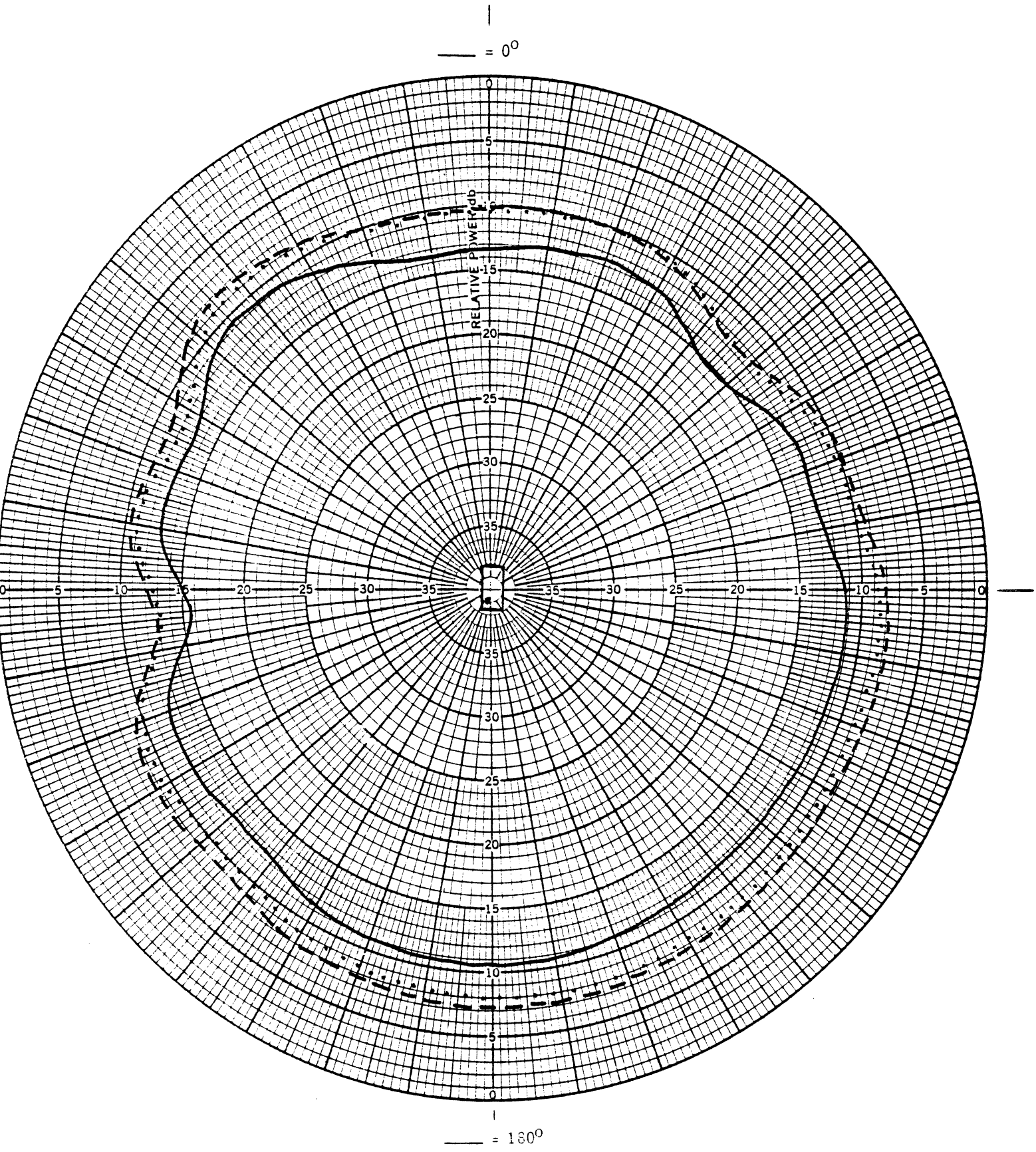
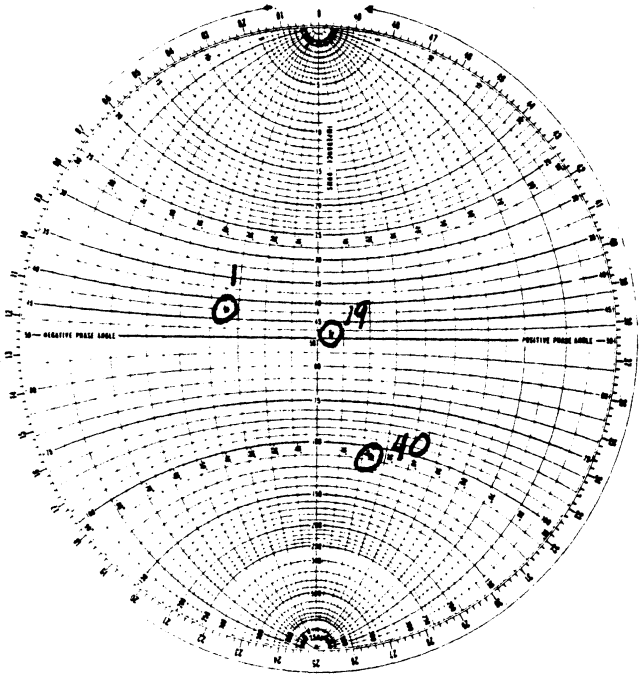
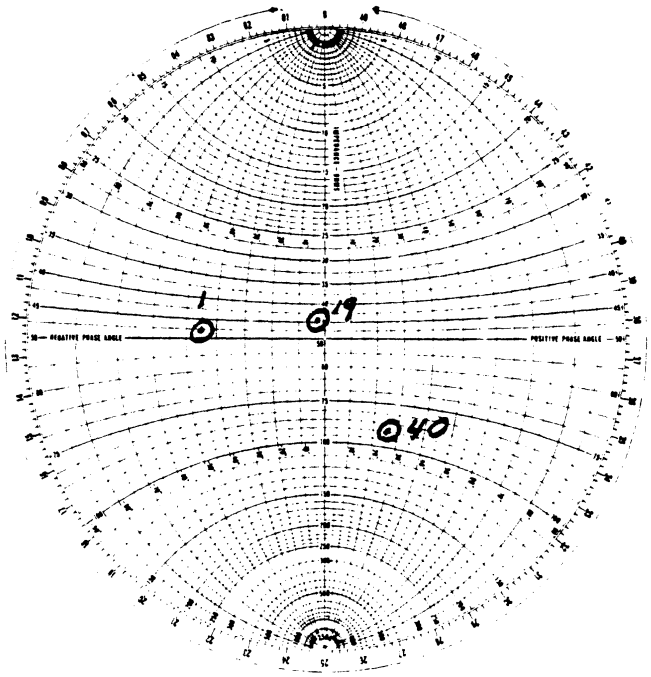


Figure 35(c). Radiation patterns at 108 MHz for SLC and reference antennas on 1978 Lincoln.

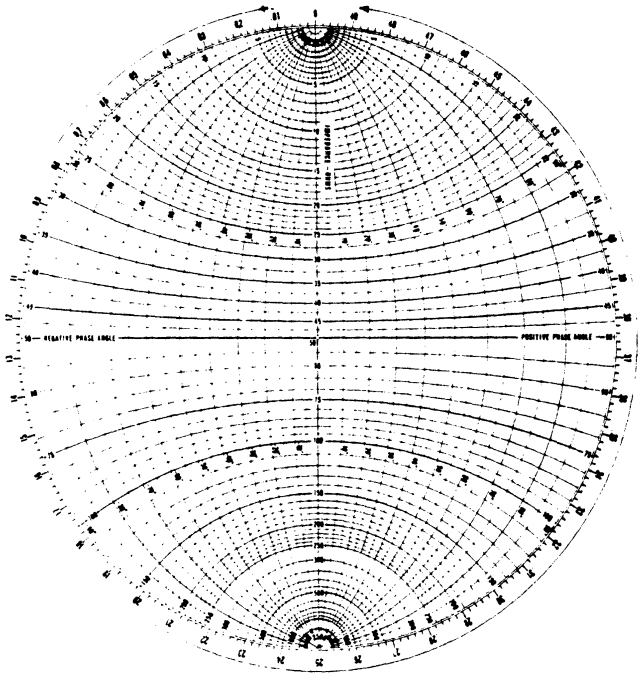
—— FM Reference, ---- D8VF-18B812-AC with padder capacitor, ... D8VF-18B812-AC without padder capacitor.



(a)



(b)



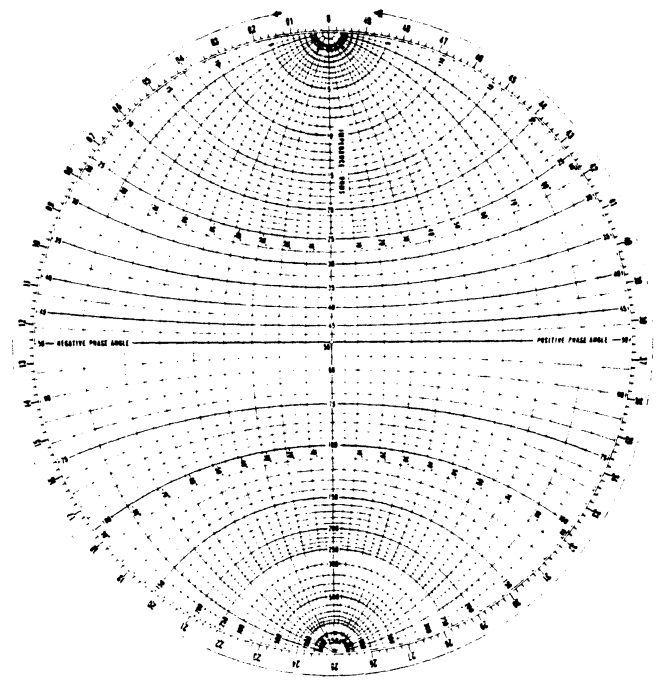
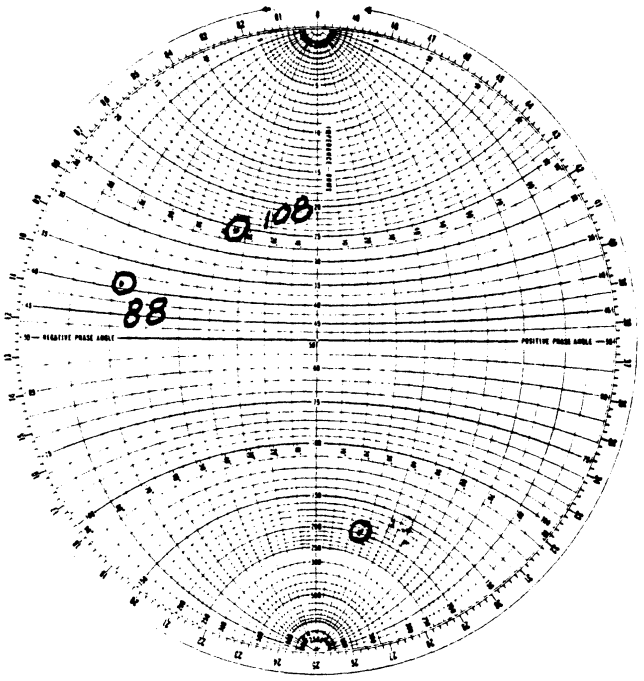
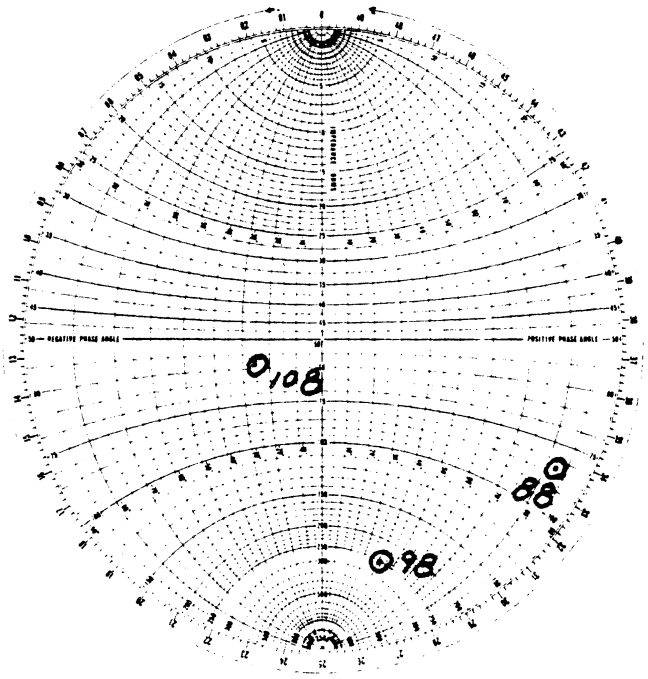


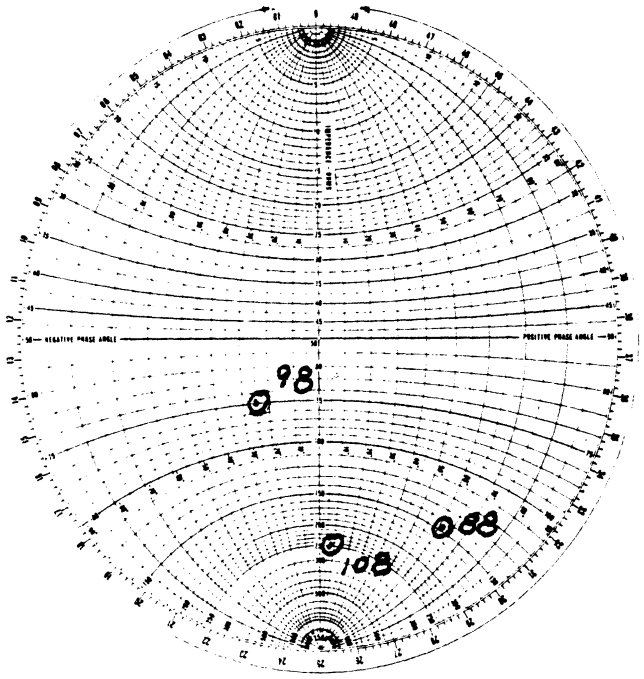
Figure 36. Impedance characteristics at CB Channels 1, 19 and 40 for the SLC antennas on 1978 Lincoln.
(a) D8VF-18B812-AC with padder capacitor, (b) D8VF-18B812-AC without padder capacitor.



(a)



(b)



(c)

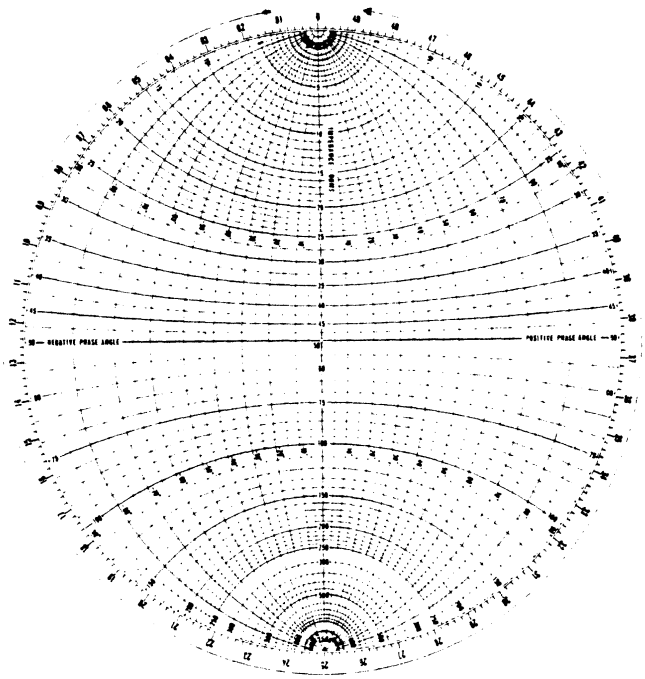


Figure 37. Impedance characteristics at 88, 98 and 108 MHz for the SLC and FM reference antennas on 1978 Lincoln.
(a) D8VF-18B812-AC with padder capacitor (b) D8VF-18B812-AC without padder capacitor (c) FM Reference.

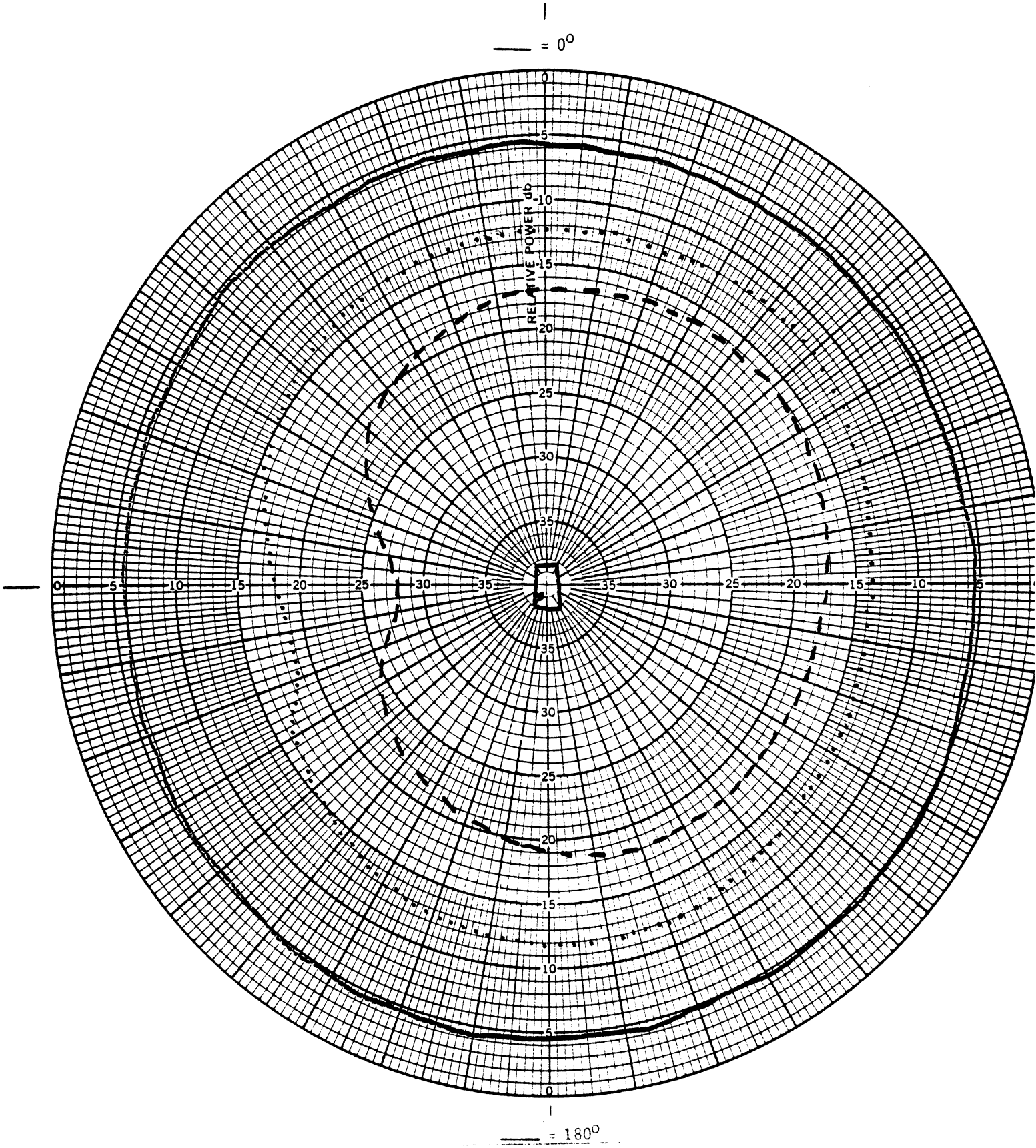


Figure 38(a). Radiation patterns at CB Channel 1 for test and reference antennas on 1978 Cougar.

—— CB Reference, ---- D8SF-18B812-AA with padder capacitor, ... D8SF-18B812-AA without padder capacitor.

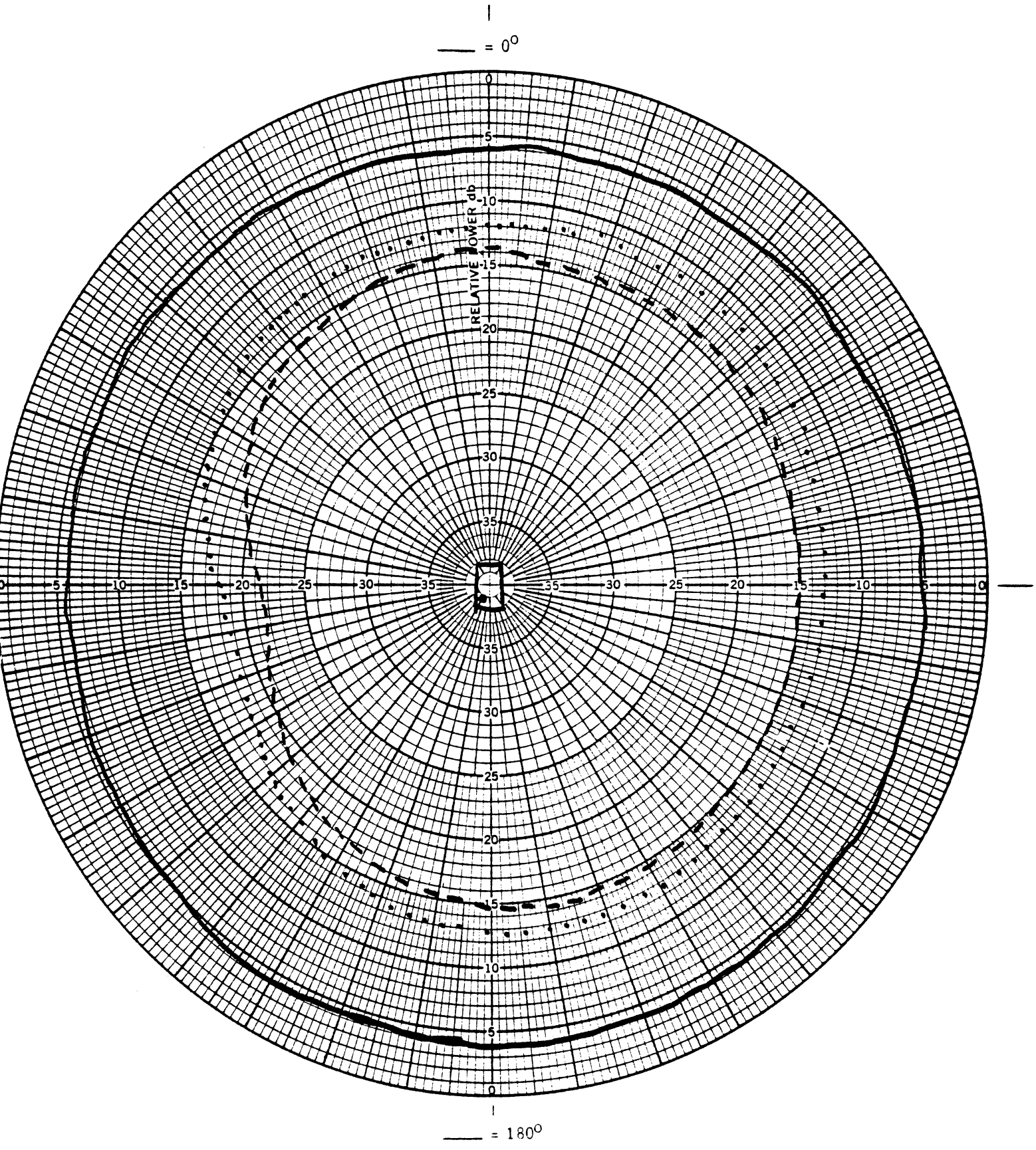


Figure 38(b). Radiation patterns at CB Channel 19 for test and reference antennas on 1978 Cougar.

—— CB Reference, ---- D8SF-18B812-AA with padder capacitor, ···· D8SF-18B812-AA without padder capacitor.

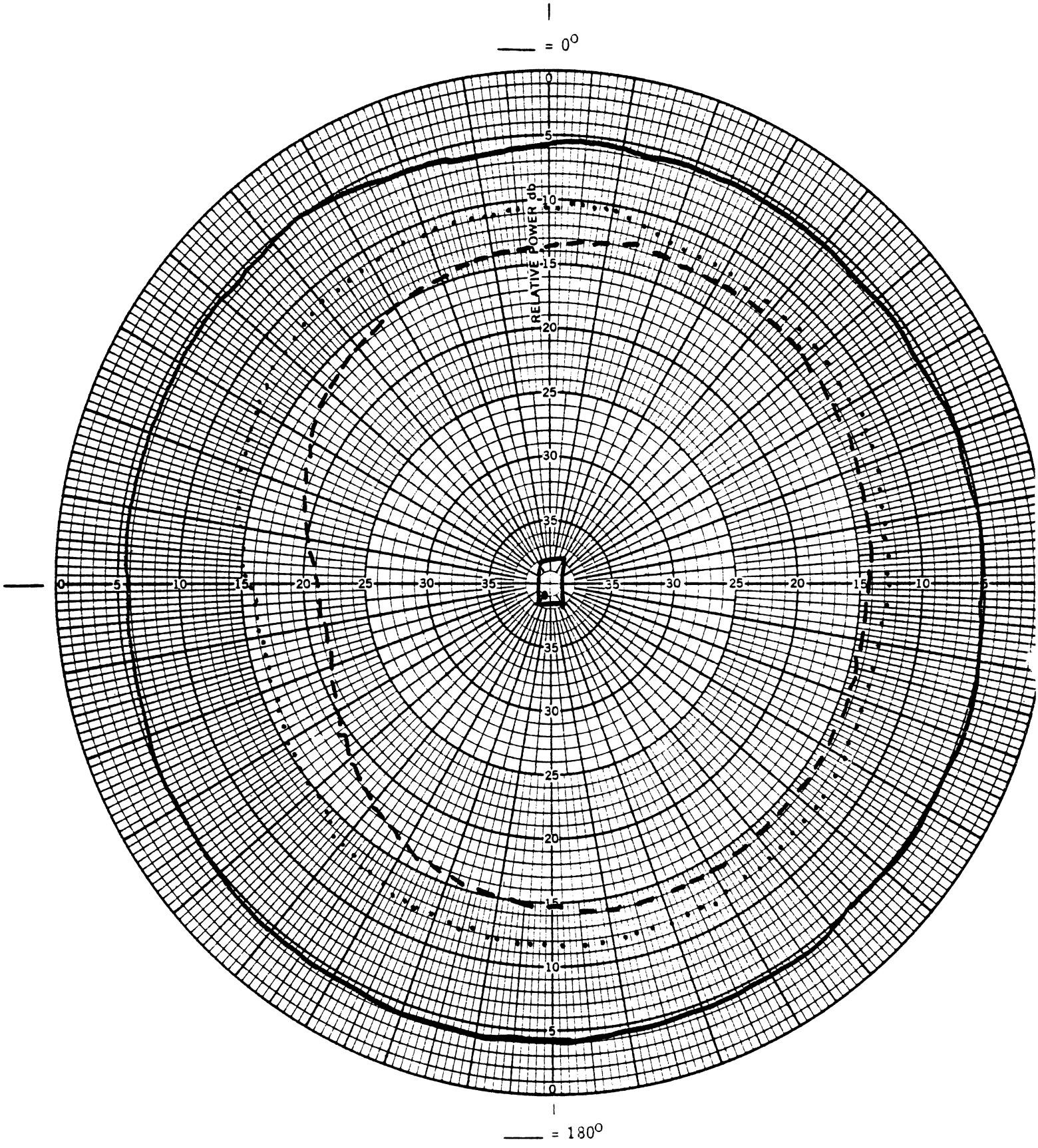


Figure 38(c). Radiation patterns at CB Channel 40 for test and reference antennas on 1978 Cougar.

—— CB Reference, ---- D8SF-18B812-AA with padder capacitor, ···· D8SF-18B812-AA without padder capacitor.

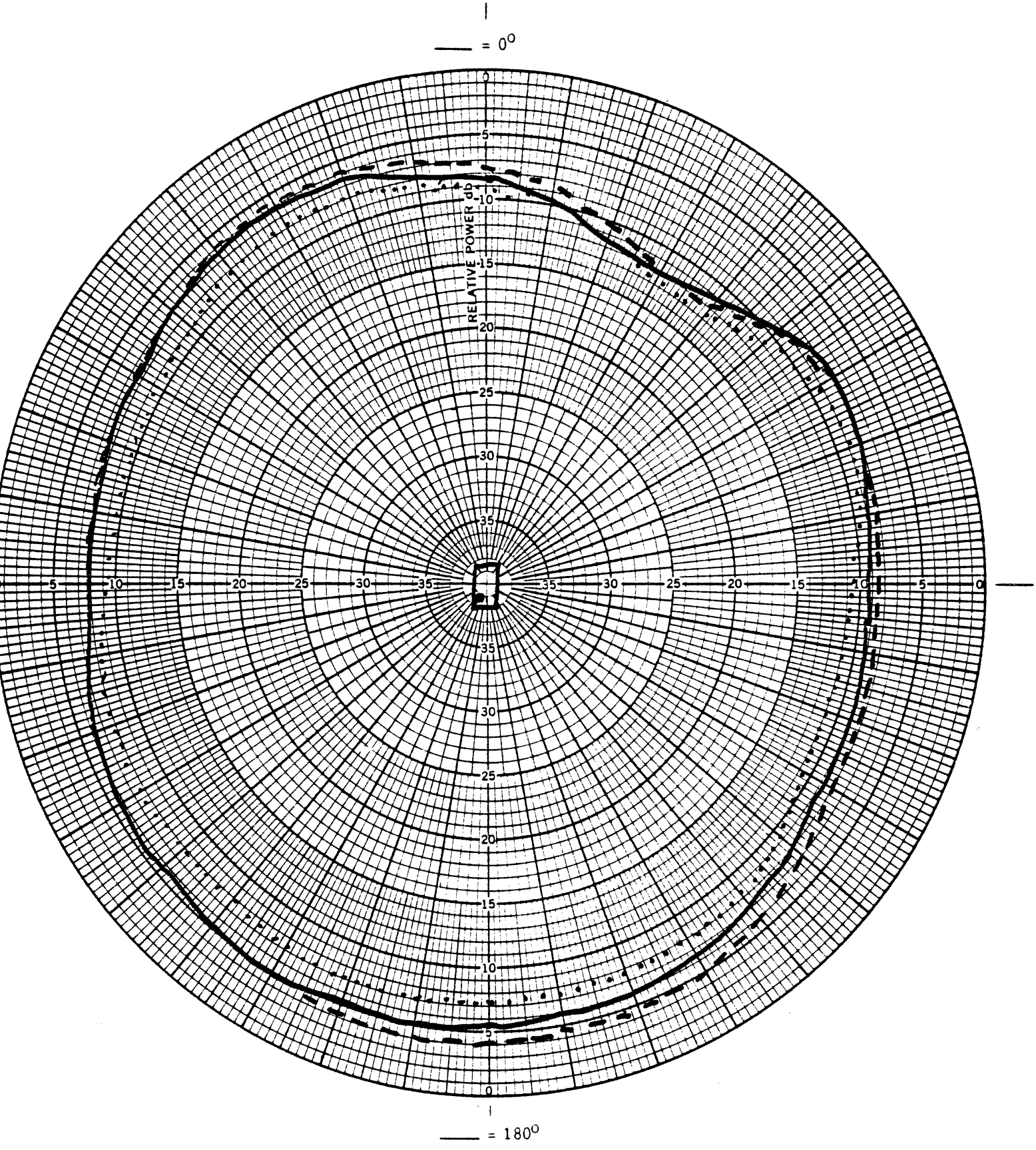


Figure 39(a). Radiation patterns at 88 MHz for test and FM reference antennas on 1978 Cougar.

—— FM Reference, ---- D8SF-18B812-AA with padder capacitor, ... D8SF-18B812-AA without padder capacitor.

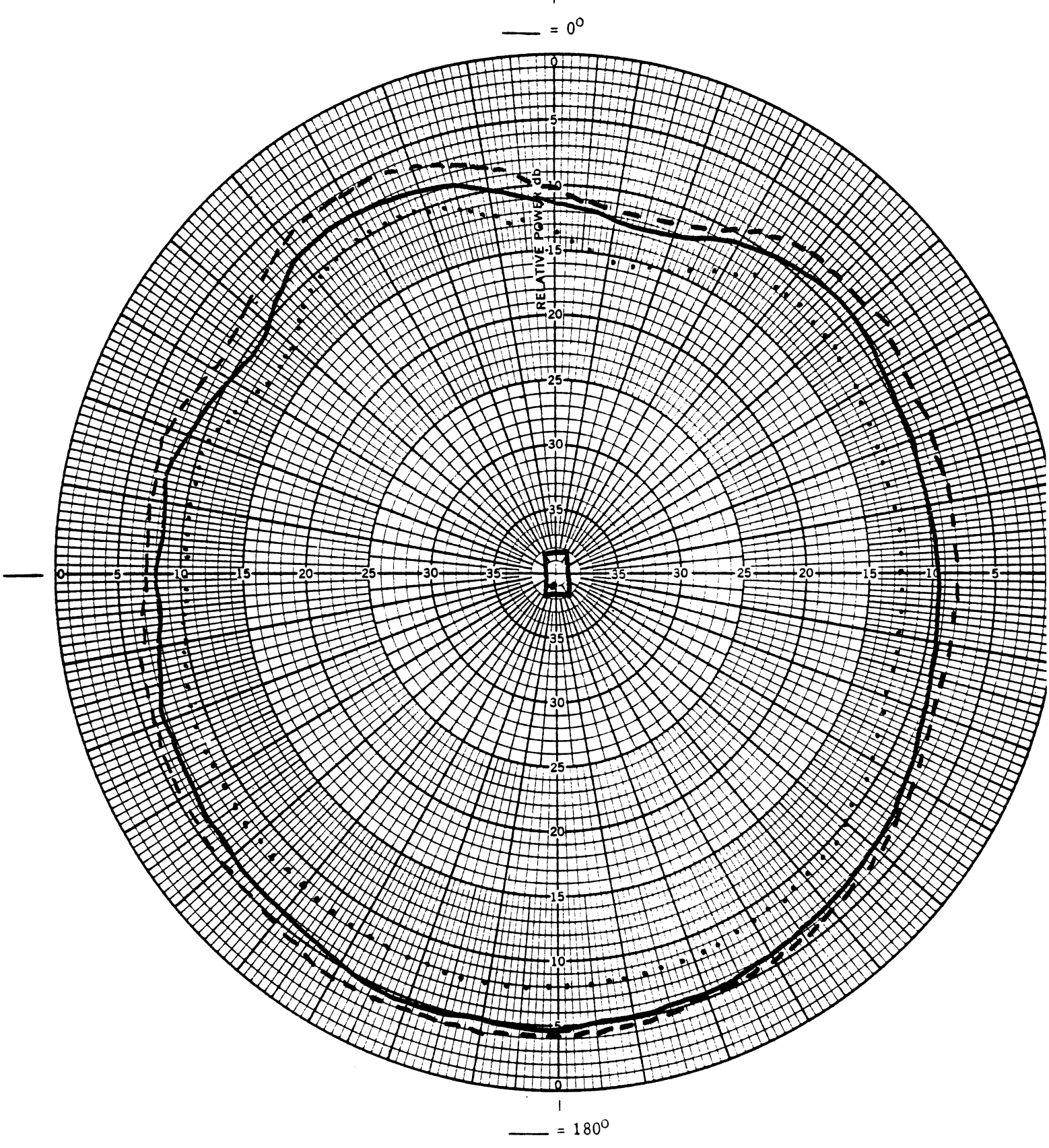


Figure 39(b). Radiation patterns at 98 MHz for test and FM reference antennas on 1978 Cougar.

—— FM Reference, ---- D8SF-18B812-AA with padder capacitor, ···· D8SF-18B812-AA without padder capacitor.

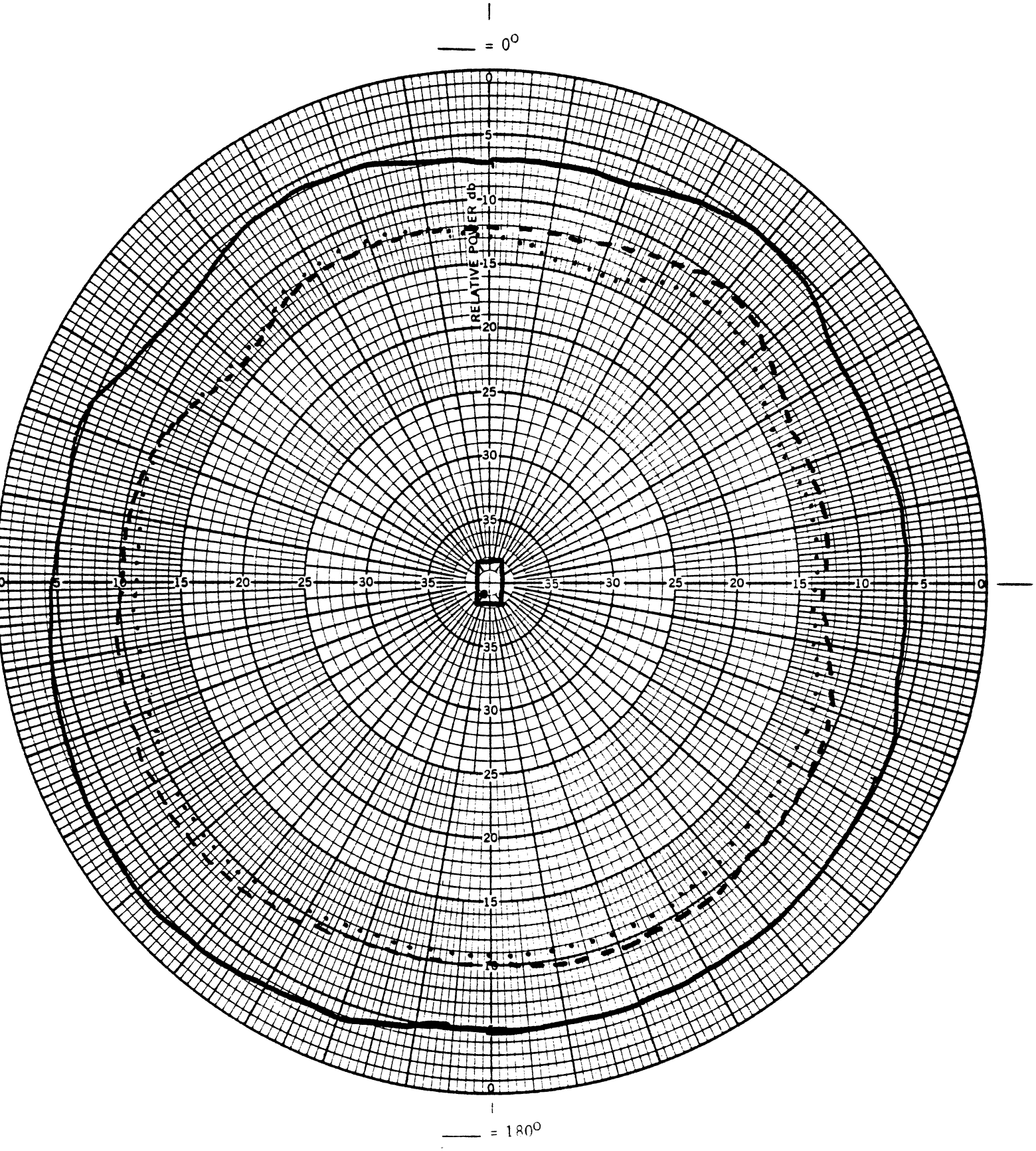


Figure 39(c). Radiation patterns at 108 MHz for test and FM reference antennas on 1978 Cougar.

——— FM Reference, ----- D8SF-18B812-AA with padder capacitor,
····· D8SF-18B812-AA without padder capacitor.

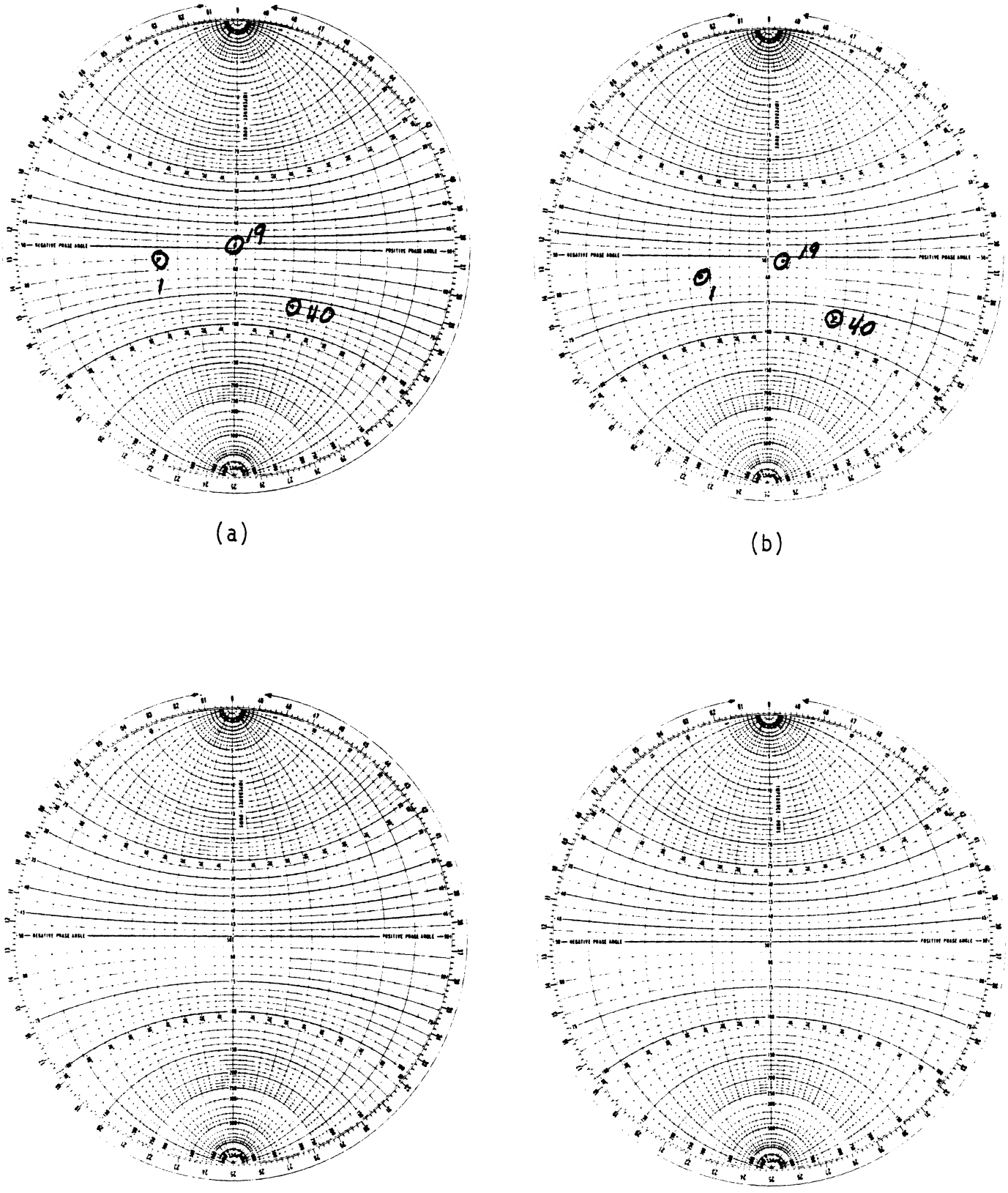
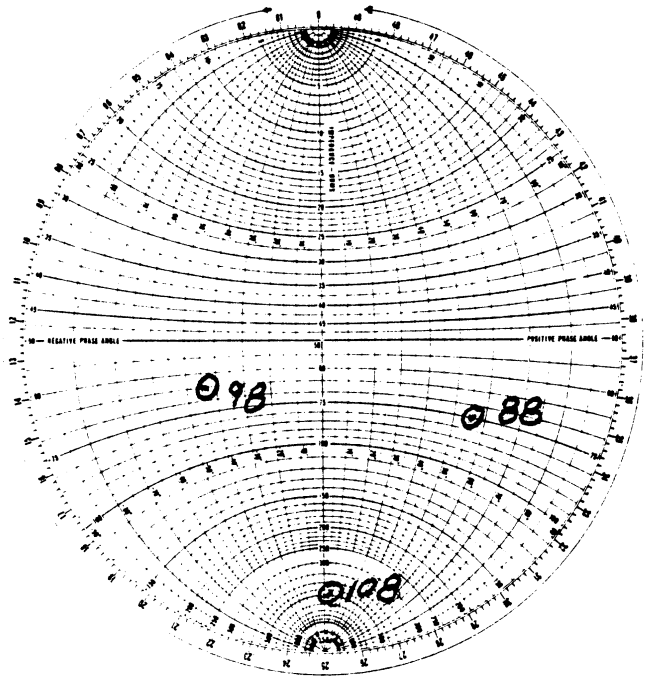
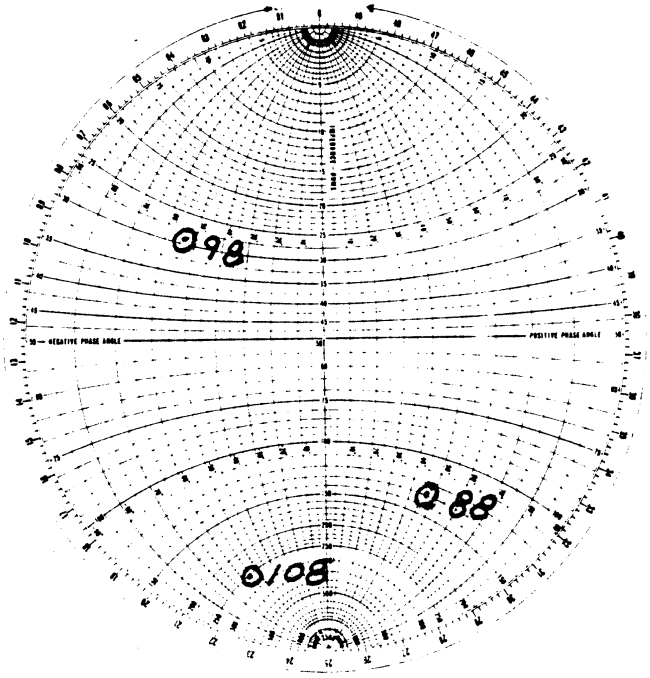


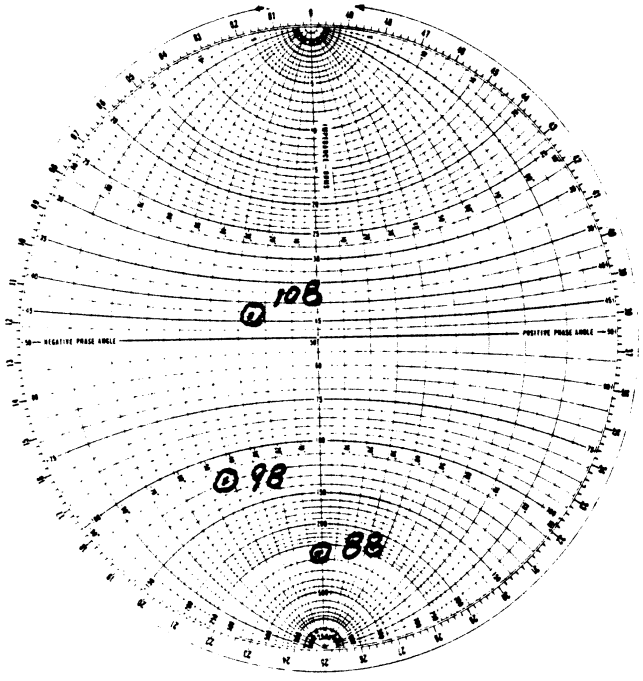
Figure 40. Impedance characteristics at CB channels 1, 19, and 40 frequencies for test antennas on 1978 Cougar. (a) D8SF-18B812-AA with padder capacitor (b) D8SF-18B812-AA without padder capacitor.



(a)



(b)



(c)

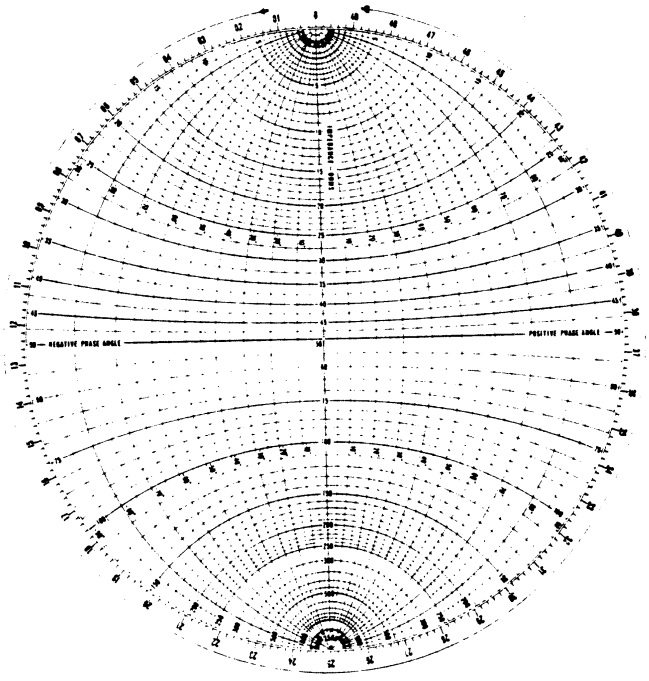


Figure 41. Impedance charactistics at 88, 98 and 108 MHz for test and FM reference antennas on 1978 Cougar. (a) D8SF-18B812-AA with padder capacitor (b) D8SF-18B812-AA without padder capacitor (c) FM reference (PE).

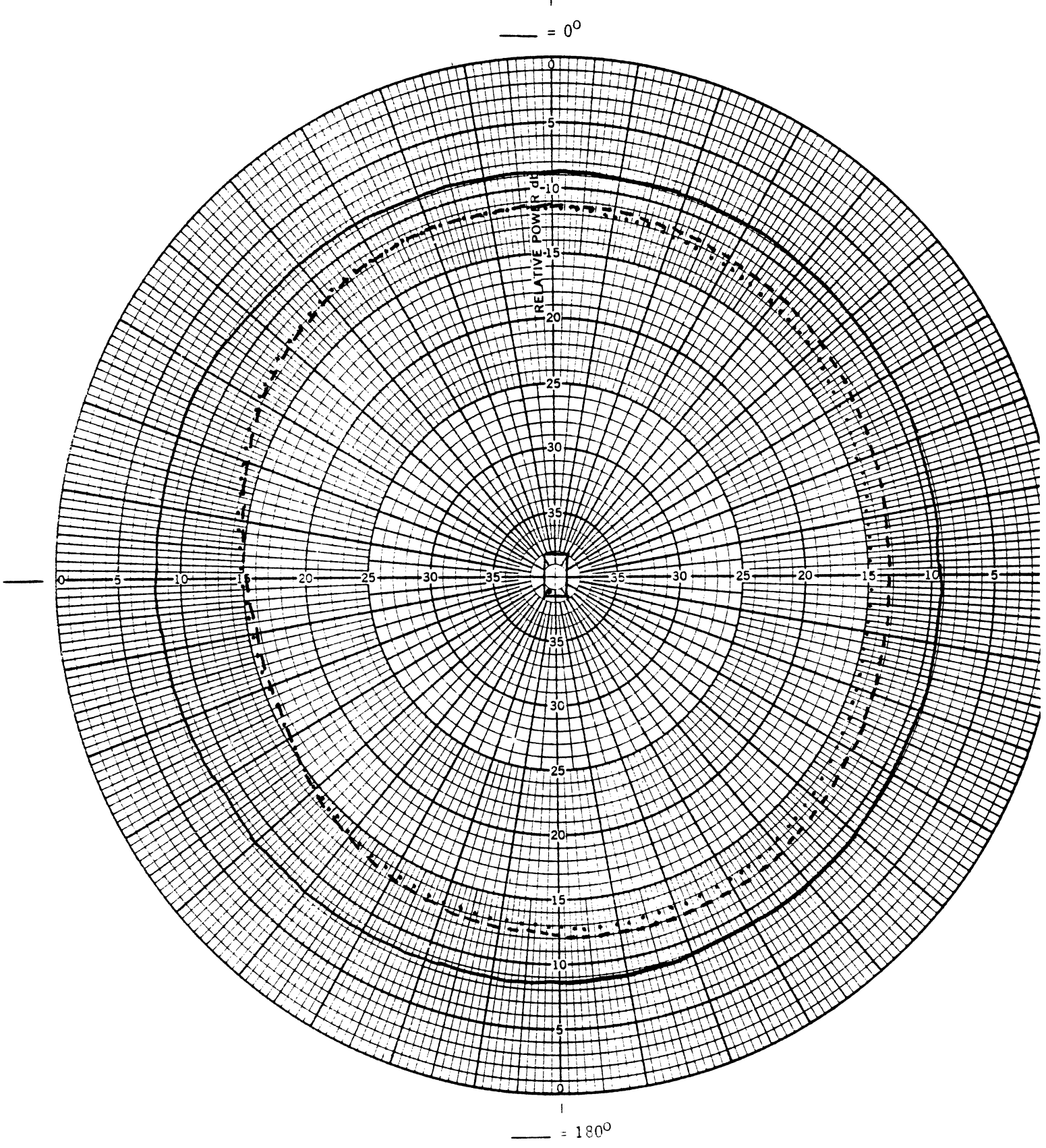


Figure 42(a). Radiation patterns at CB channel 1 for test and reference antennas on 1978 Versailles.

——CB reference, ----D84F-18B812-AC with padder capacitor, ···· D84F-18B812-AC without padder capacitor.

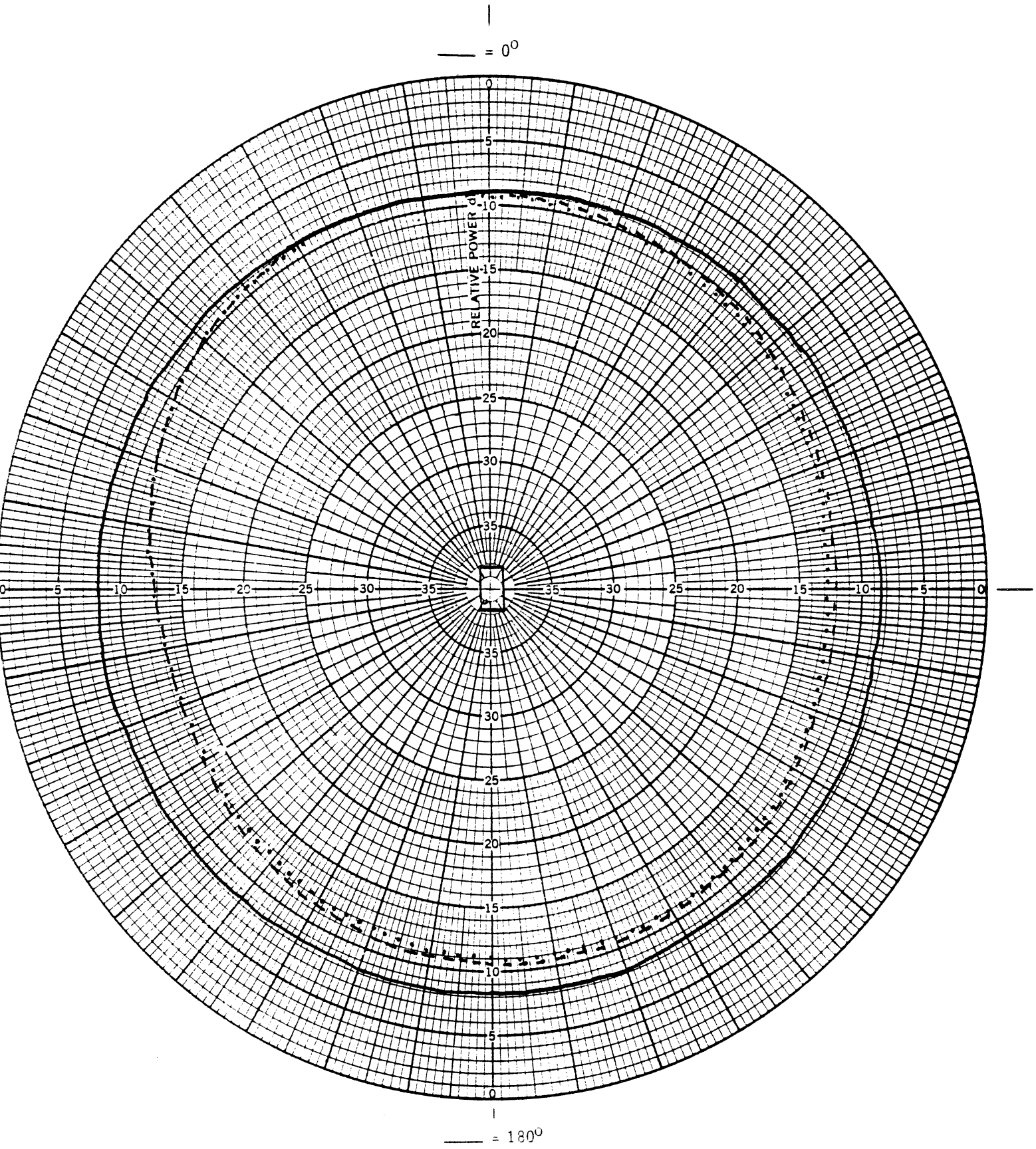


Figure 42(b). Radiation patterns at CB channel 19 for test and reference antennas on 1978 Versailles.

—— CB reference, ---- D84F-18B812-AC with padder capacitor, ····· D84F-18B812-AC without padder capacitor.

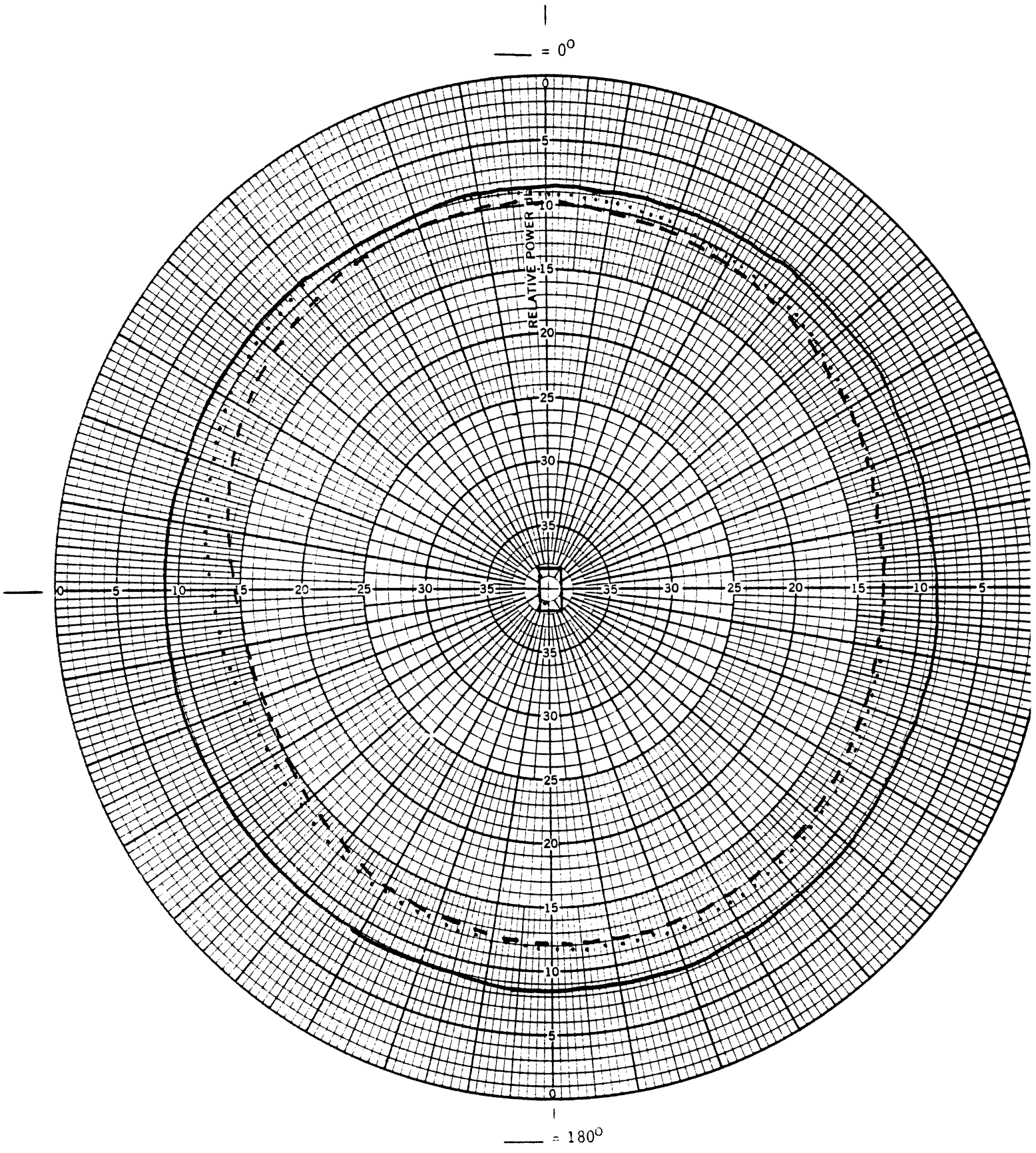


Figure 42(c). Radiation patterns at CB channel 40 for test and reference antennas on 1978 Versailles.

—— CB reference, ---- D84F-18B812-AC with padder capacitor, ····· D84F-18B812-AC without padder capacitor.

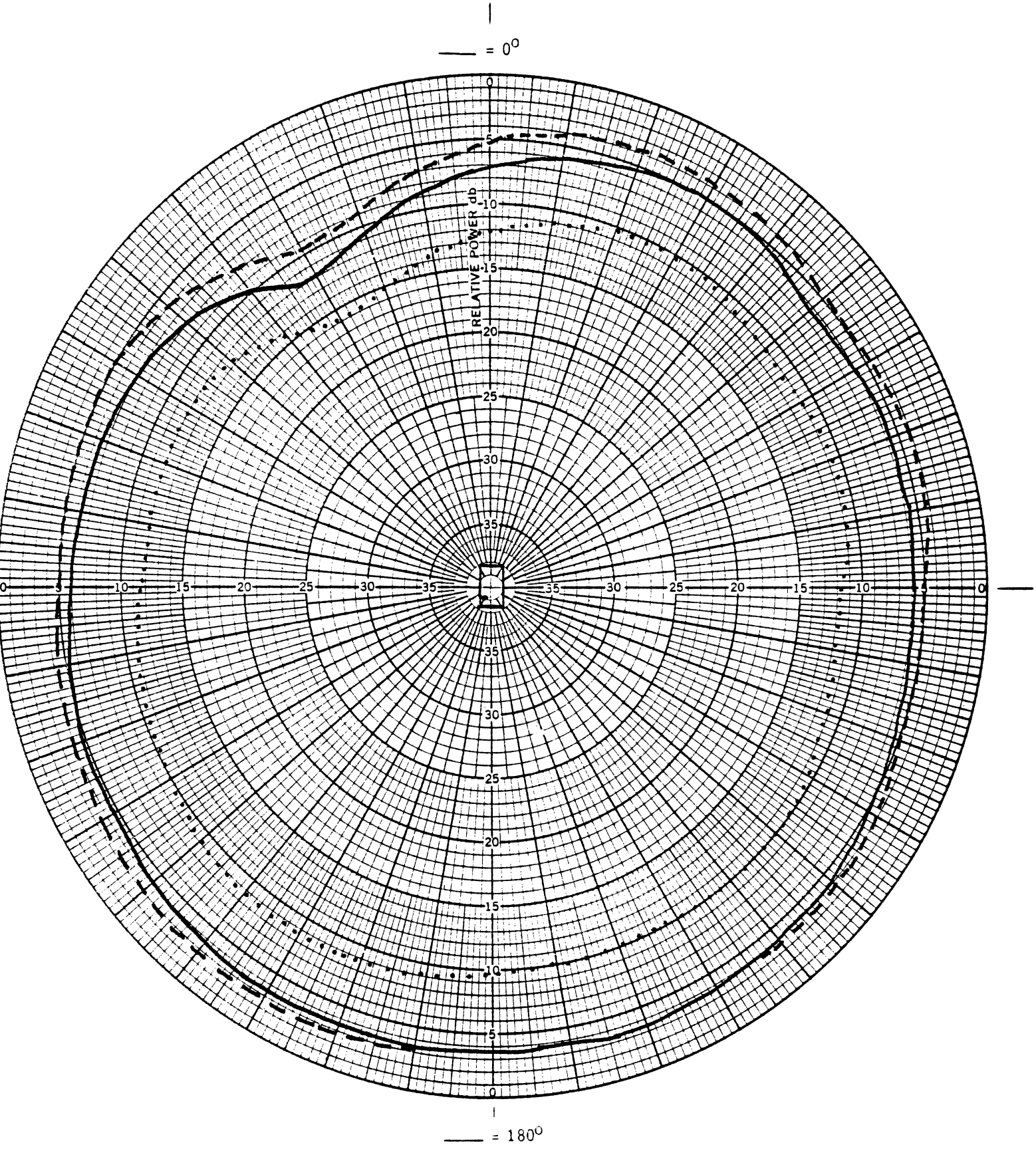


Figure 43(a). Radiation patterns at 88 MHz for test and FM reference antennas on 1978 Versailles.

—— FM reference, ---- D84F-18B812-AC with padder capacitor, ····· D84F-18B812-AC without padder capacitor.

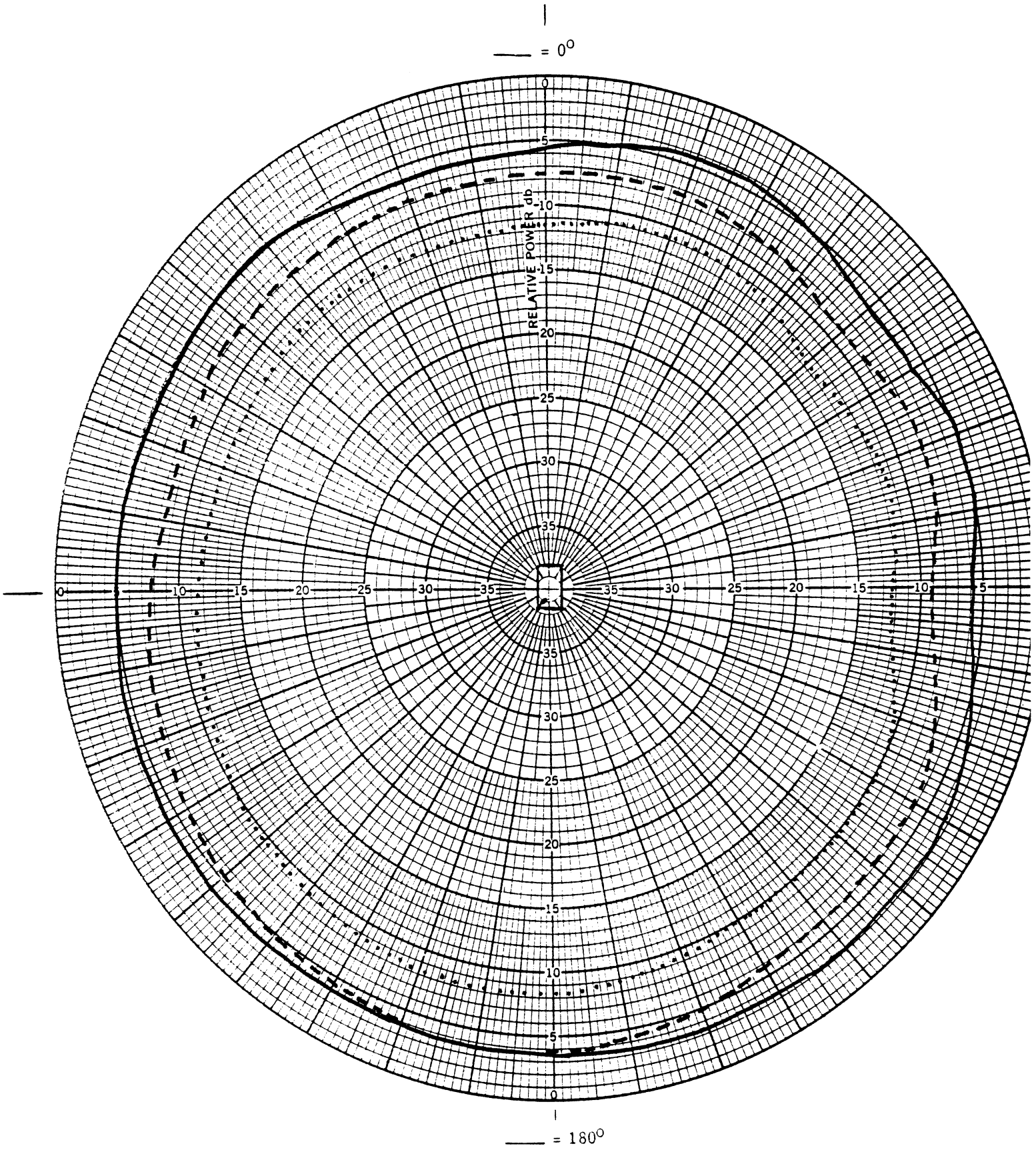


Figure 43(b). Radiation patterns at 98 Mhz for test and FM reference antennas on 1978 Versailles.

—— FM reference, ---- D84F-18B812-AC with padder capacitor, ····· D84F-18B812-AC without padder capacitor.

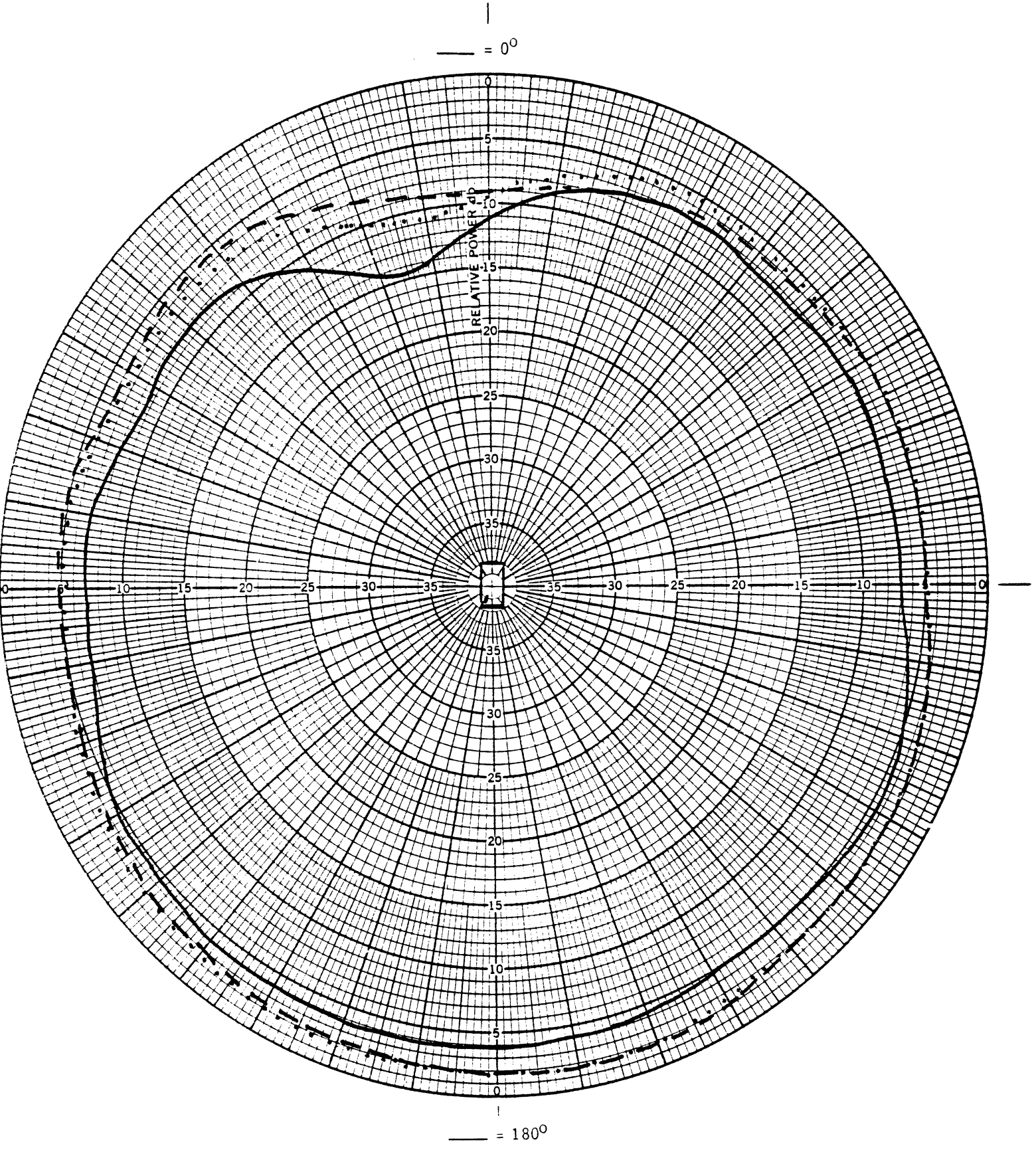
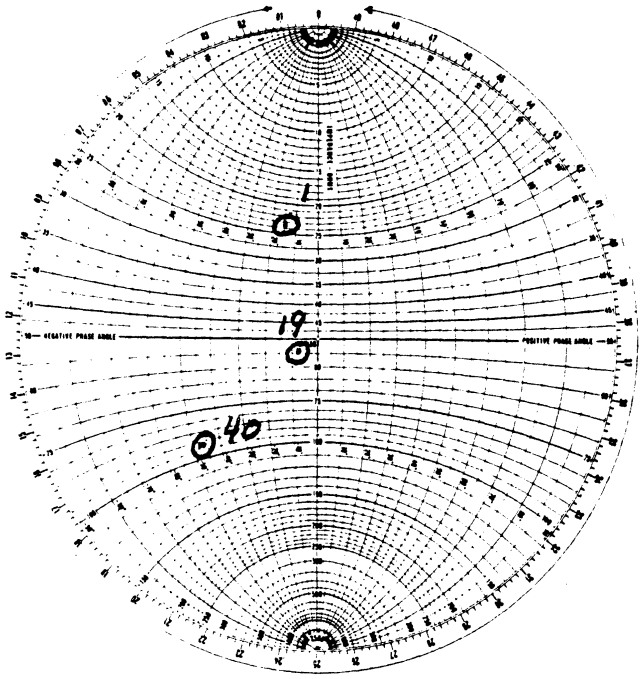
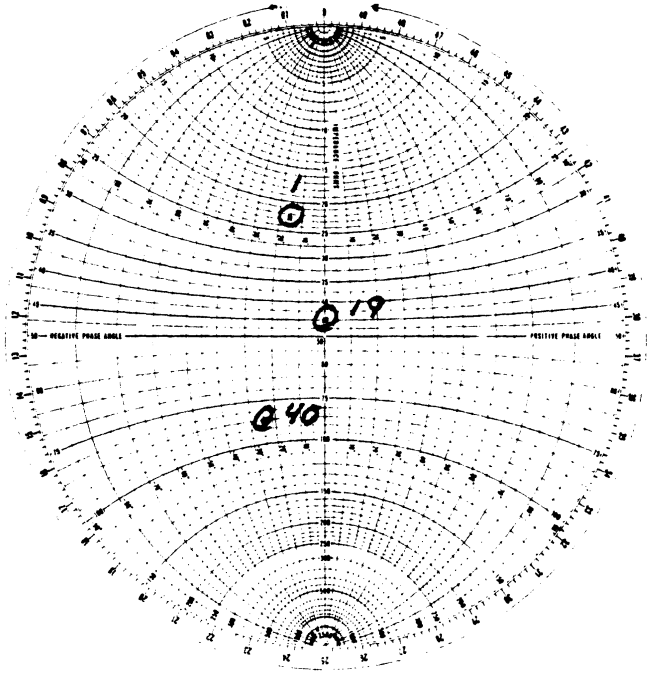


Figure 43(c). Radiation patterns at 108 MHz for test and FM reference antennas on 1978 Versailles.

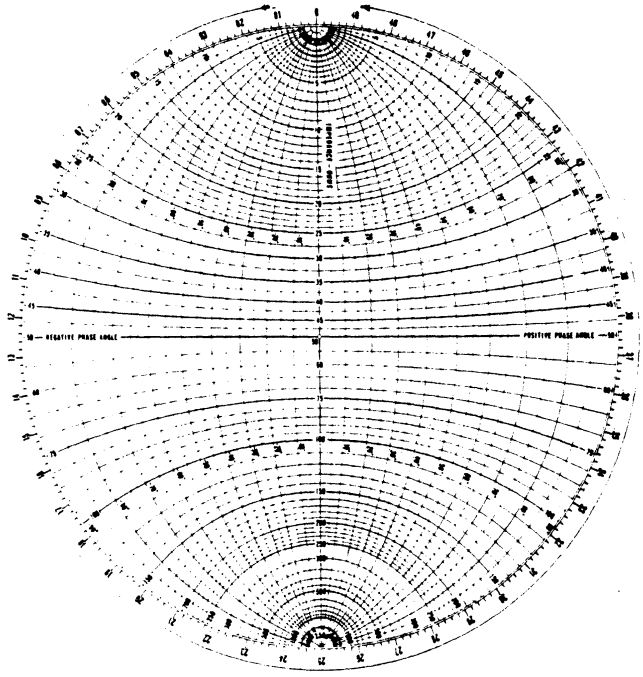
—— FM reference, ---- D84F-18B812-AC with padder capacitor, ····· D84F-18B812-AC without padder capacitor.



(a)



(b)



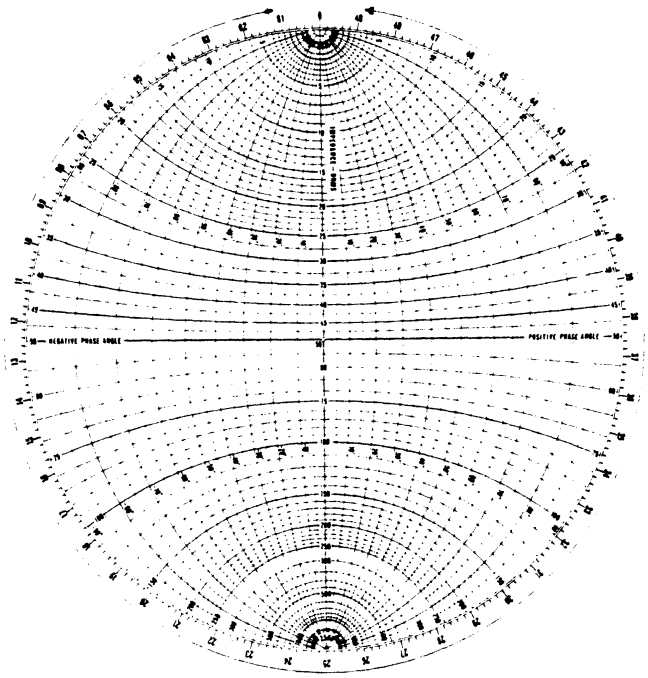
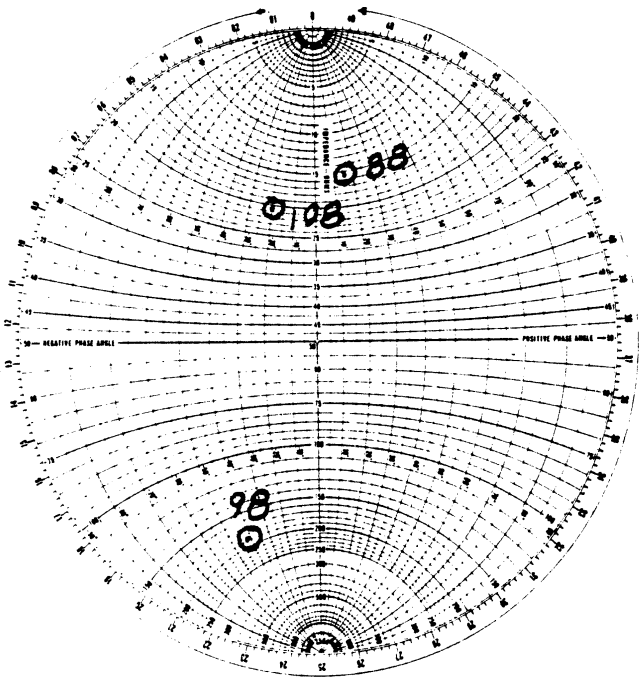
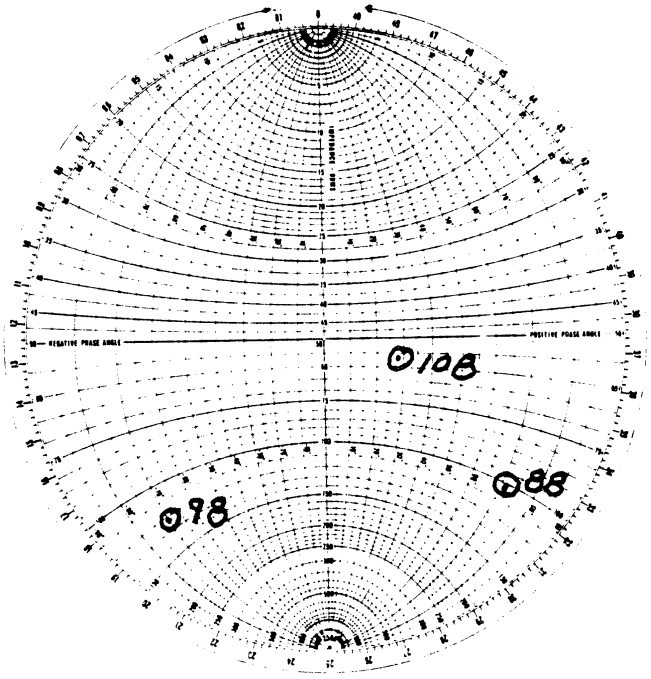


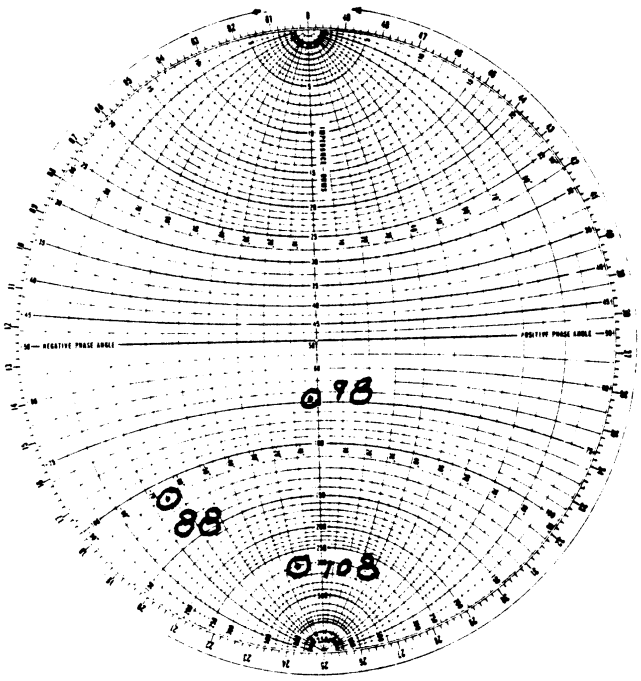
Figure 44. Impedance characteristics at CB channel 1, 19 and 40 frequencies for test antennas on 1978 Versailles. (a) D84F-18B812-AC with padder capacitor, (b) D84F-18B812-AC without padder capacitor.



(a)



(b)



(c)

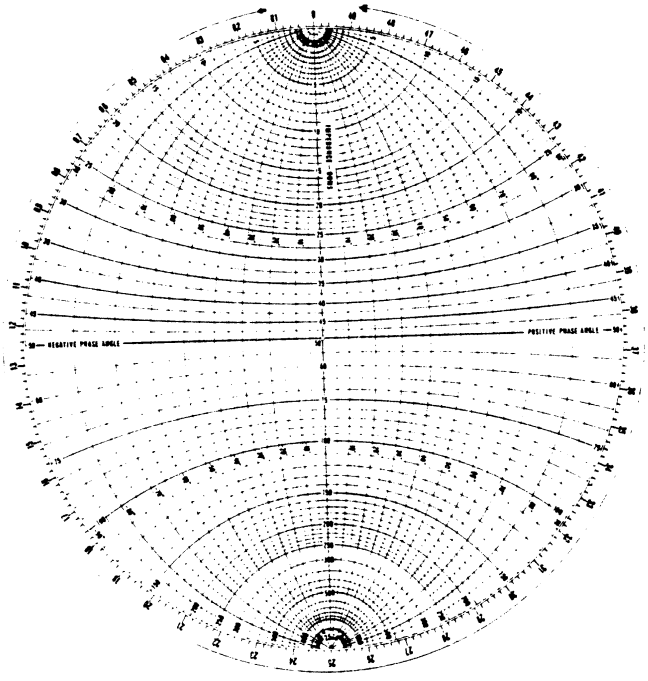


Figure 45. Impedance characteristics at 88, 98 and 108 MHz for test and reference antennas on 1978 Versailles. (a) D84F-18B812-AC with padder capacitor, (b) D84F-18B812-AC without padder capacitor, (c) FM reference.

the same performance, with a sensitivity larger than that of the standard antenna (Figure 43).

5.5 Performance Comparison

In addition to the above results, the AM band field strength, the isolation characteristics at CB frequencies and the system C and Q at AM frequencies were measured for each antenna mounted on the test cars. The results of these measurements, and also the average sensitivities and VSWRs derived from the data in scetions 5.1 - 5.4, are shown in Table 9, and these can be used to judge the comparative performance of the test antennas mounted on the test vehicles. Based on the results shown in Table 9, the following observations are made concerning the performance of the SLC and improved isolation production series antennas:

(i) Movement of the padder capacitor to the radio input increases the AM sensitivity of SLC antennas relative to the production antennas. The amount of increase depends on the test car. For example, the sensitivity of the SLC antenna relative to the production antenna is found to be 2 dB, 8 dB, 7 dB and 0 dB better, when mounted on Lincoln Mark V, Lincoln, Cougar and Versailles, respectively.

(ii) The FM sensitivities of SLC antennas are larger than those of the production antennas. The padder capacitor improves the VSWR of the SLC antennas at 88 and 98 MHz, but degrades it slightly at 108 MHz.

(iii) The CB sensitivities of the two test antennas mounted on Lincoln Mark V and Lincoln are almost identical. The SLC antenna on the Versailles has slightly better sensitivity, but the production antennas have more sensitivity (than the SLC) on the Cougar. The padder capacitor appears to reduce slightly the VSWR of antennas mounted on all test cars.

(iv) At CB channels 1 and 19, the improved isolation antennas generally provide more signal isolation than the SLC antennas for all test vehicles. At channel 40 no such trend is observed.

TABLE 9. PERFORMANCE DATA FOR TEST ANTENNAS ON 1978 LINCOLN MARK V AND LINCOLN.

PARAMETER	PERFORMANCE COMPARISON							
	Production (D-Series) Antennas				SLC Antennas			
	Mark V	Lincoln	Cougar	Versailles	Mark V	Lincoln	Cougar	Versailles
AM Sensitivity (dB/m)								
0.76 MHz	-66	-74	-73	-66	-63	-66	-66	-66
Relative FM Sensitivity (dB)								
88 MHz	-8.5	-6.5	-1.3	-5.3	-2.0	-1.0	-0.5	+1.0
98 MHz	-4.5	-5.0	-2.6	-6.1	-1.5	+0.5	-1.1	-2.1
108 MHz	-5.5	-2.5	-6.3	+2.0	-2.5	-2.5	-5.7	+2.0
Relative CB Sensitivity (dB)								
CH 1	-7.0	-6.0	-7.6	-7.0	-7.0	-6.0	-13.1	-6.0
CH 19	-5.5	-5.0	-8.1	-5.4	-5.5	-5.5	-10.1	-5.0
CH 40	-7.5	-6.5	-9.9	-5.6	-7.5	-6.0	-7.3	-5.2
FM VSWR								
88 MHz	6.57	16.00	4.27	7.80	3.19	5.55	3.43	3.45
98 MHz	5.00	6.64	3.54	8.58	2.75	4.26	2.51	5.32
108 MHz	2.03	1.59	9.70	1.71	3.73	2.60	9.53	2.68
CB VSWR								
CH 1	3.27	2.45	1.93	2.39	2.68	2.03	2.12	2.24
CH 19	1.46	1.13	1.07	1.14	1.08	1.13	1.03	1.19
CH 40	3.21	2.09	2.44	2.02	2.52	2.50	2.12	3.00
Signal Isolation (mv)								
CH 1	175	172	350	160	226	260	370	204
CH 19	140	128	165	141	125	180	165	138
CH 40	150	285	320	185	180	225	210	241
AM Capacitance (pF)								
0.5	80	206		206	111	156		210
1.0	85	217		218	118	165		222
1.5	78	205		205	109	155		209
AM Q								
0.5	871	997		597	65,175	92		1,108
1.0	613	599		335	446	72		612
1.5	404	383		213	341	55		371

VI. PANTHER PROGRAM

The primary purpose of the Panther Program was to evaluate the performance of different antenna systems having variable input capacitances when mounted on a 1979 Ford LTD. For completeness some limited measurements were also carried out with a 1978 Lincoln Mark V. Both manual and power operated dual-band entertainment (ME and PE, respectively) and tri-band (MT and PT, respectively) antennas were tested, and the antennas and cars used are as listed in Table 1(c). Note that the three capacitance values (95, 123 and 202 pF) shown in Table 1(c) under each test antenna are the nominal values of the input capacitances of the antenna obtained by chosing the proper cable length, or by adding extra in-line capacitance or by a combination of both. All the test antennas in this program were front mounted, in which case a 123 pF capacitance is normally used (202 pF when the same antenna is rear mounted). Generally, the test antennas were of the same nominal length. In the following sections each antenna will be represented by a symbol indentifying its type and input capacitance. For example, ME 123 denotes a manual entertainment antenna having 123 pF input capacitance.

6.1. Manual Entertainment (ME) Antennas on LTD

The FM band horizontal plane radiation patterns of ME antennas with different input capacitances are shown in Figures 46(a)-(e). Observe that the ME 95 and ME 202 antennas have slightly less sensitivity than the ME 123 antenna at all of the test frequencies except 103 MHz where they have slightly more sensitivity. The shapes of the patterns are independent of the input capacitances. Results for the impedances of the three antennas are shown in Figures 47(a)-(c).

6.2. Power Entertainment (PE) Antennas on LTD

Horizontal plane radiation patterns of the PE antennas at three selected frequencies in the FM band are shown in Figures 48(a)-(c). The results indicate that the PE 95 antenna has slightly more, and the PE 202 slightly

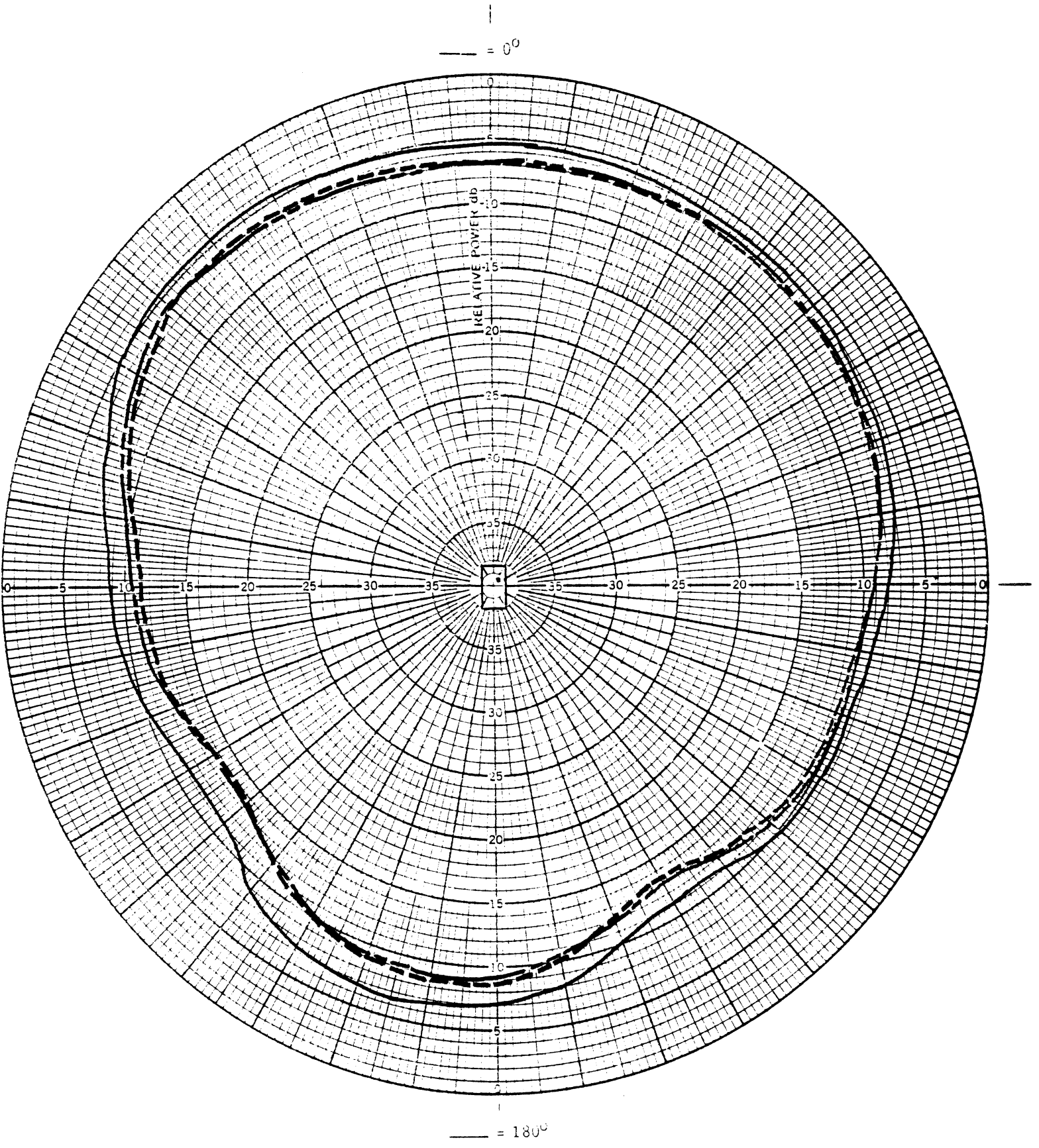


Figure 46(a) Radiation patterns at 88 MHz for manual Entertainment (ME) antennas on 1979 LTD.

—— -- —— ME95, ——— ME 123, ----- ME 202.

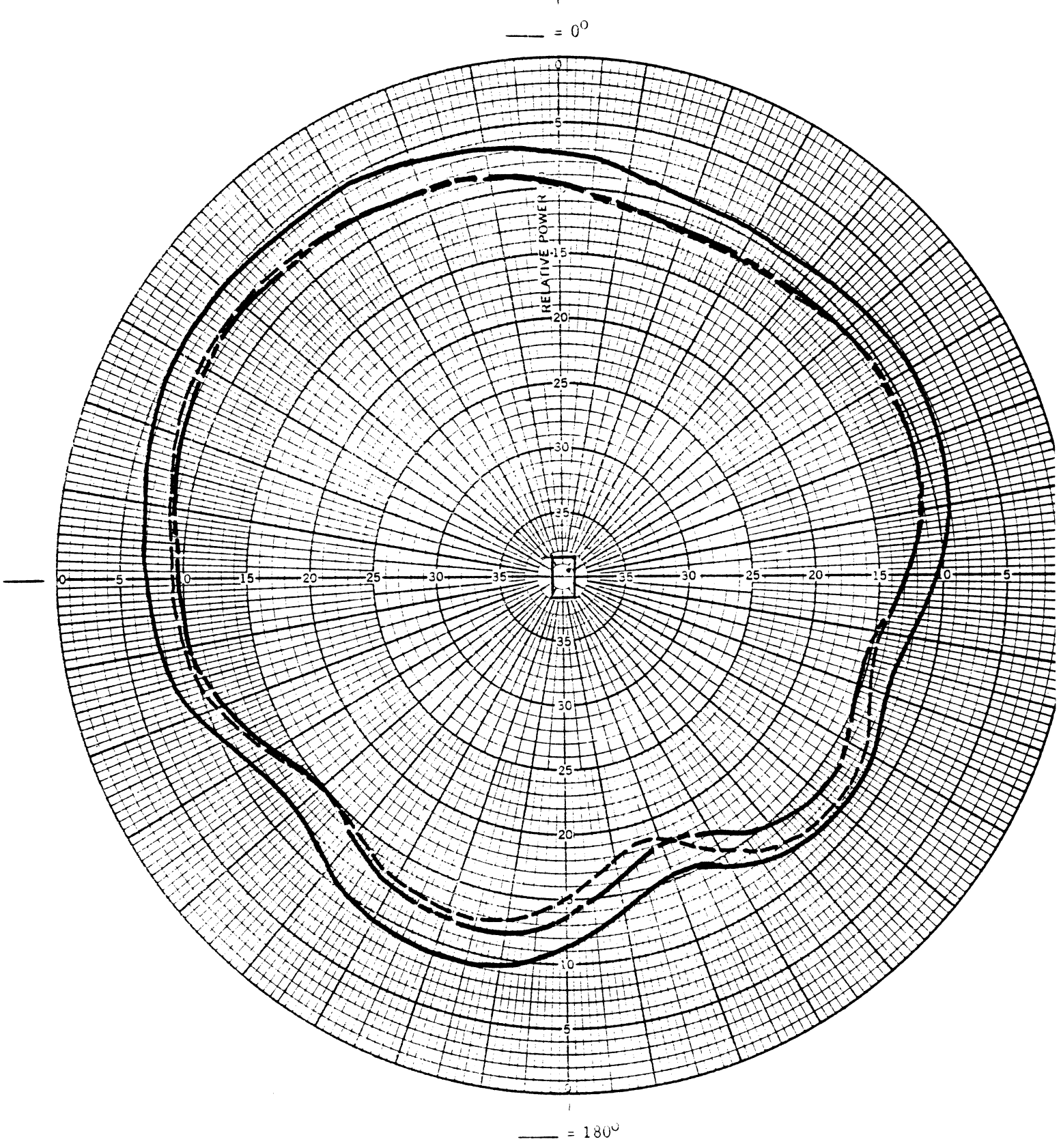


Figure 46(b). Radiation patterns at 93 MHz for Manual Entertainment (ME) antennas on 1979 LTD.

—— -- —— ME95, ——— ME 123, ---- ME 202.

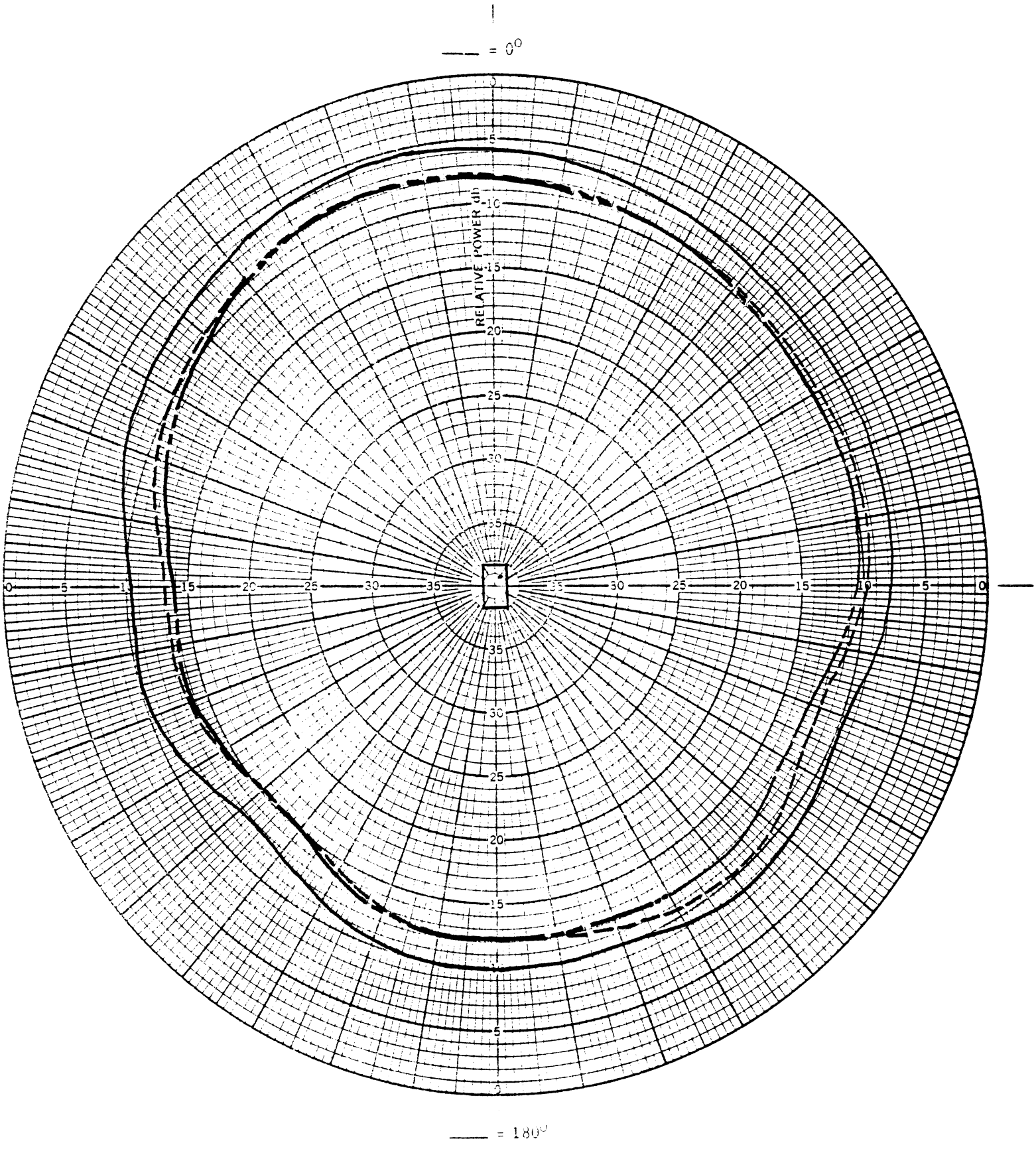


Figure 46(c). Radiation patterns at 98 MHz for Manual Entertainment (ME) antennas on 1979 LTD.

—— -- —— ME 95, ——— ME 123, ----- ME 202.

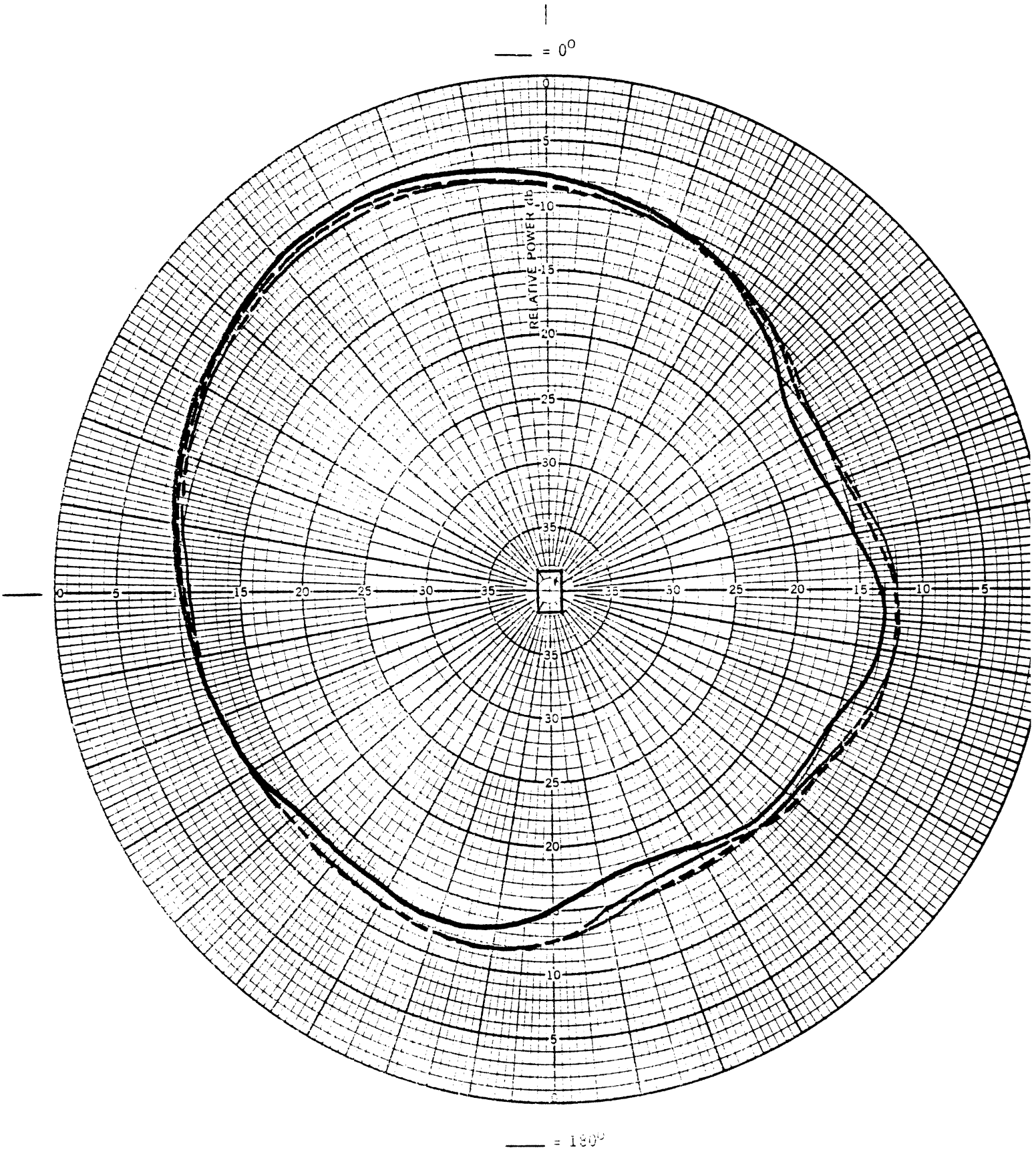


Figure 46(d). Radiation patterns at 103 MHz for Manual Entertainment (ME) antennas on 1979 LTD.

—— -- —— ME 95, ——— ME 123, ----- ME 202.

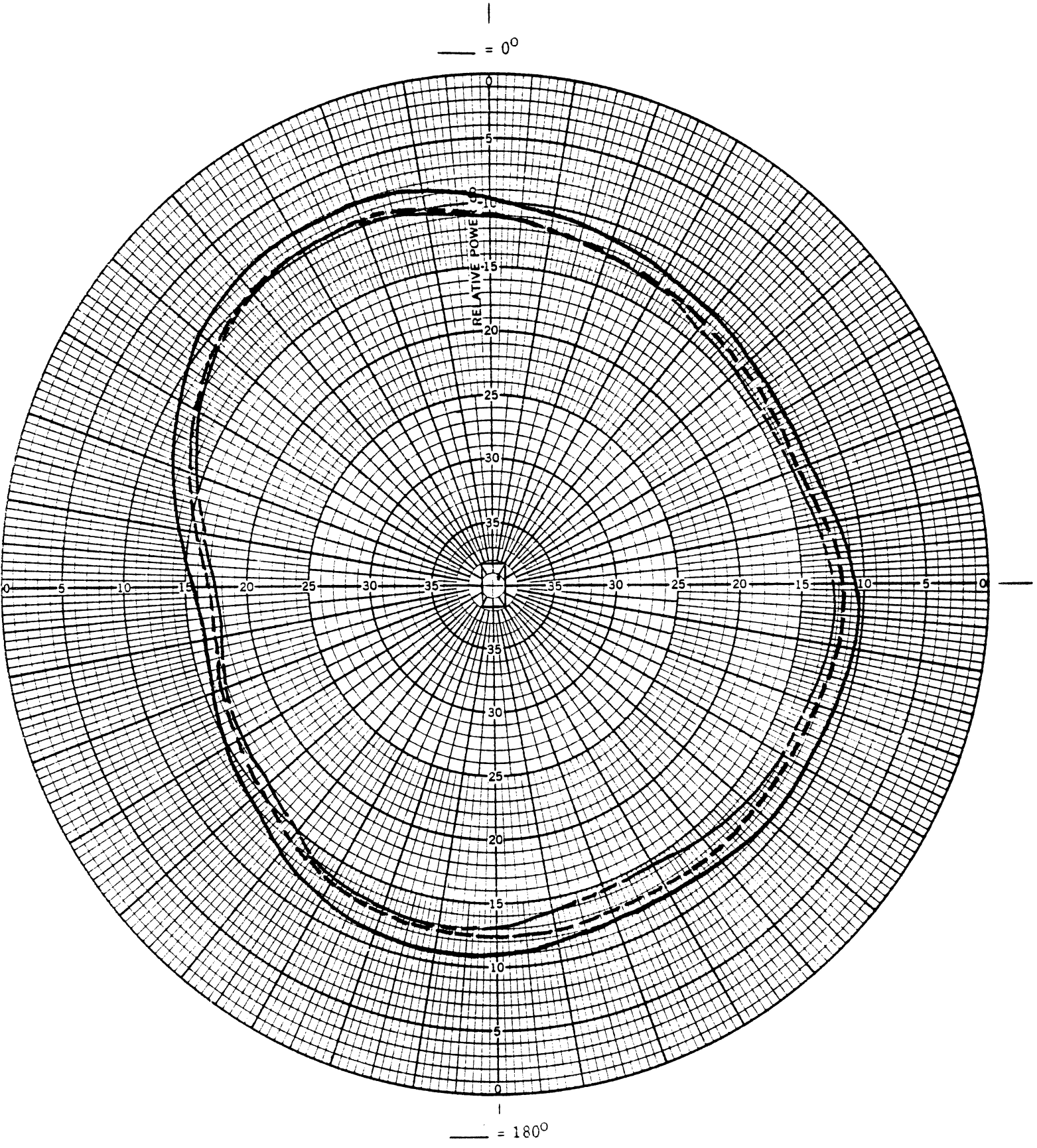
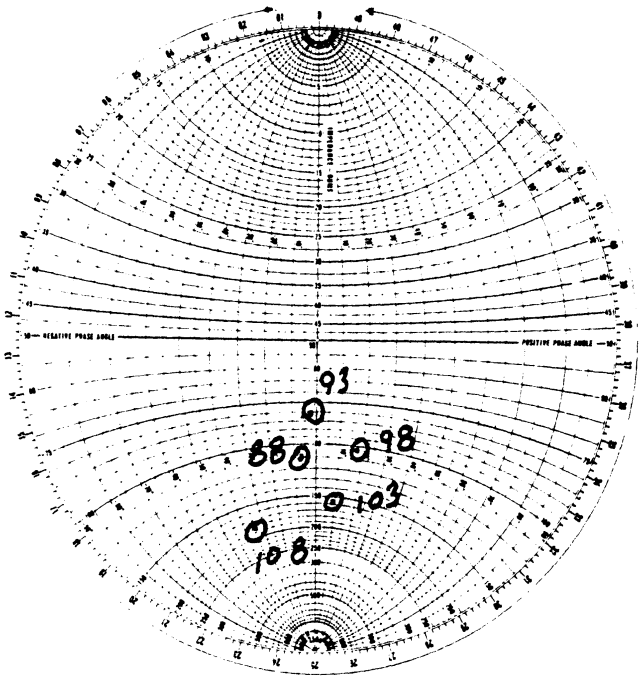
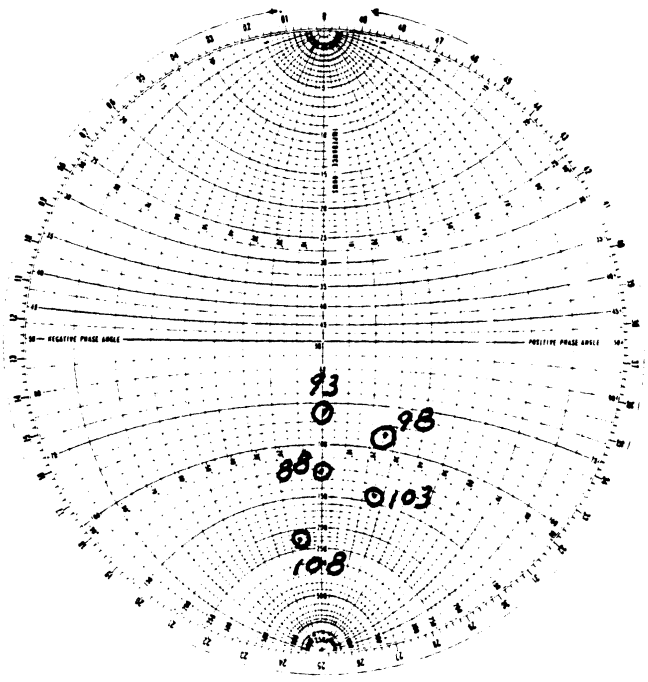


Figure 46(e). Radiation pattern at 108 MHz for Manual Entertainment (ME) antennas on 1979 LTD.

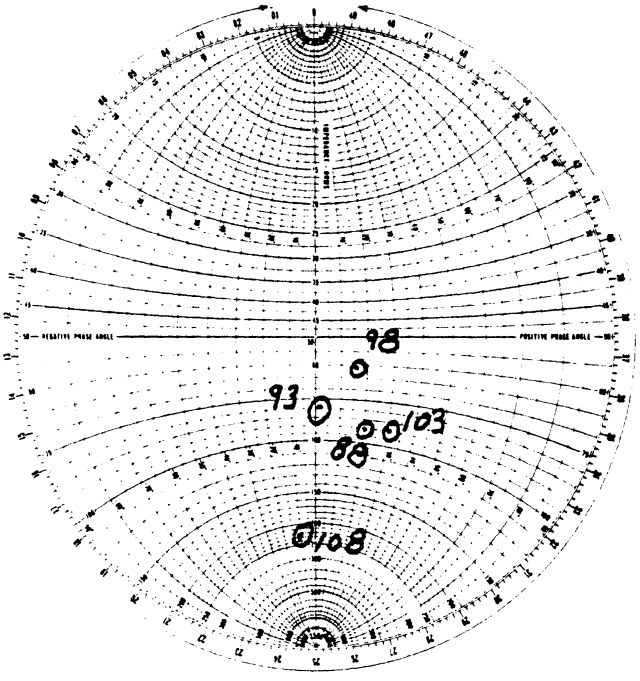
—— -- —— ME 95, ——— ME 123, ----- ME 202.



(a)



(b)



(c)

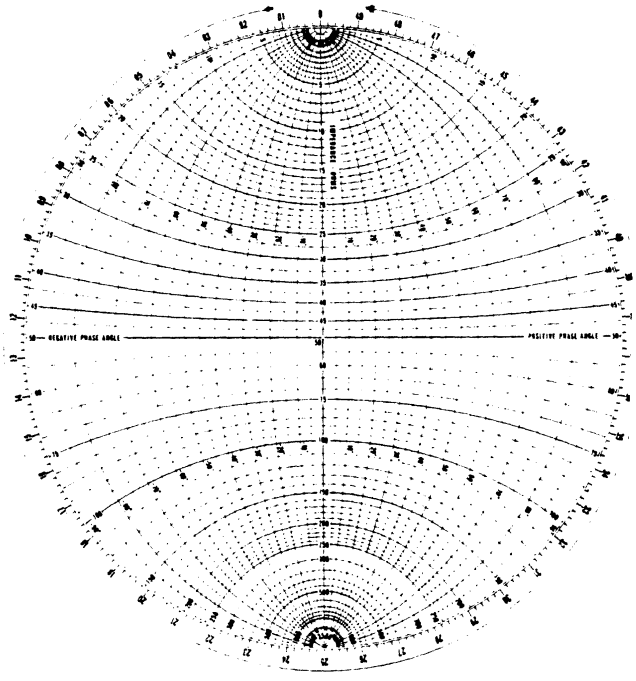


Figure 47. Impedance characteristics in the FM band for Manual Entertainment (ME) antennas on 1979 LTD. (a) ME 95 (b) ME 123 (c) ME 202

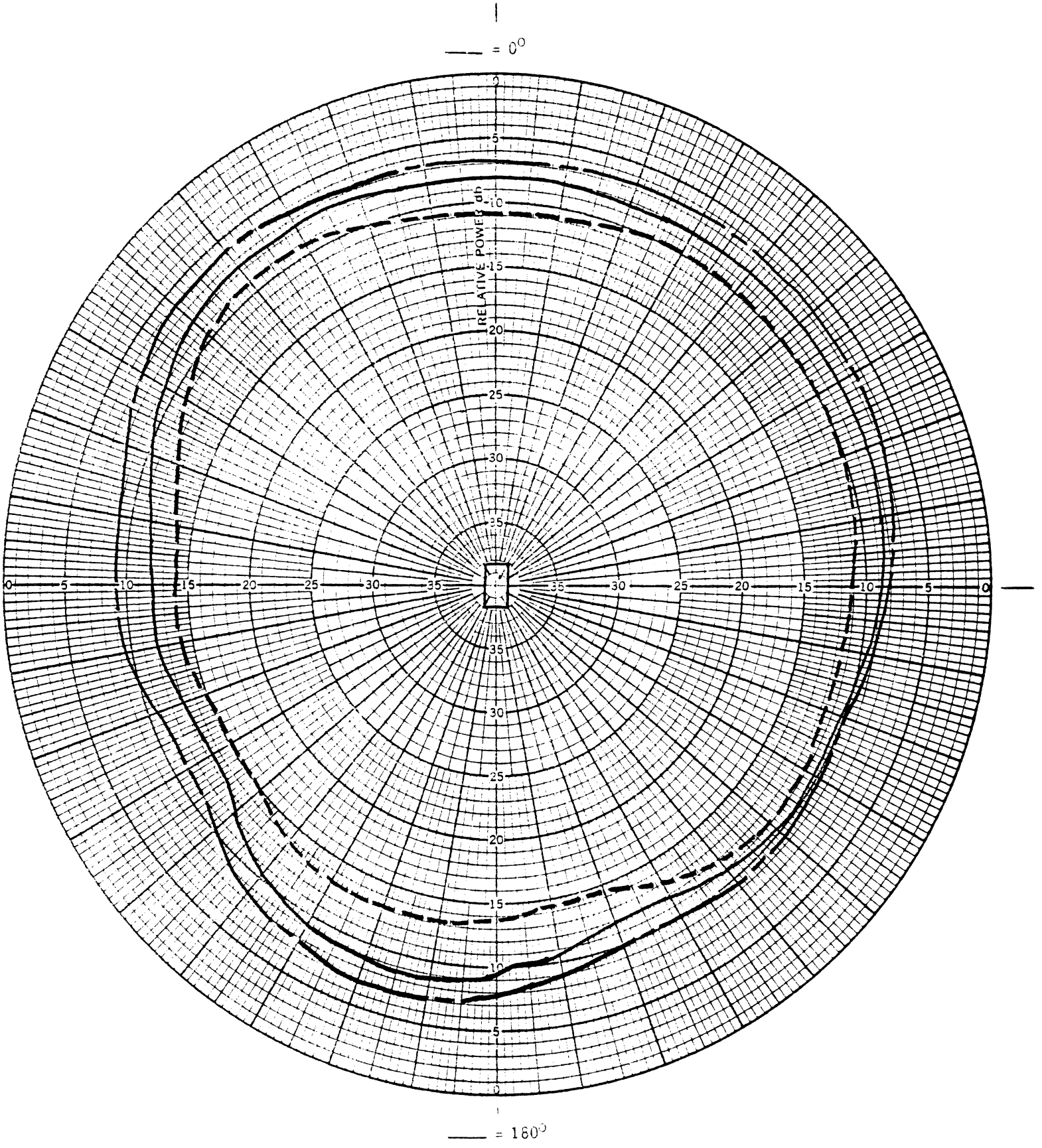


Figure 48(a). Radiation patterns at 88 MHz for Power Entertainment (PE) antennas on 1979 LTD.

— --- — PE 95, ——— PE 123, ----- PE 202.

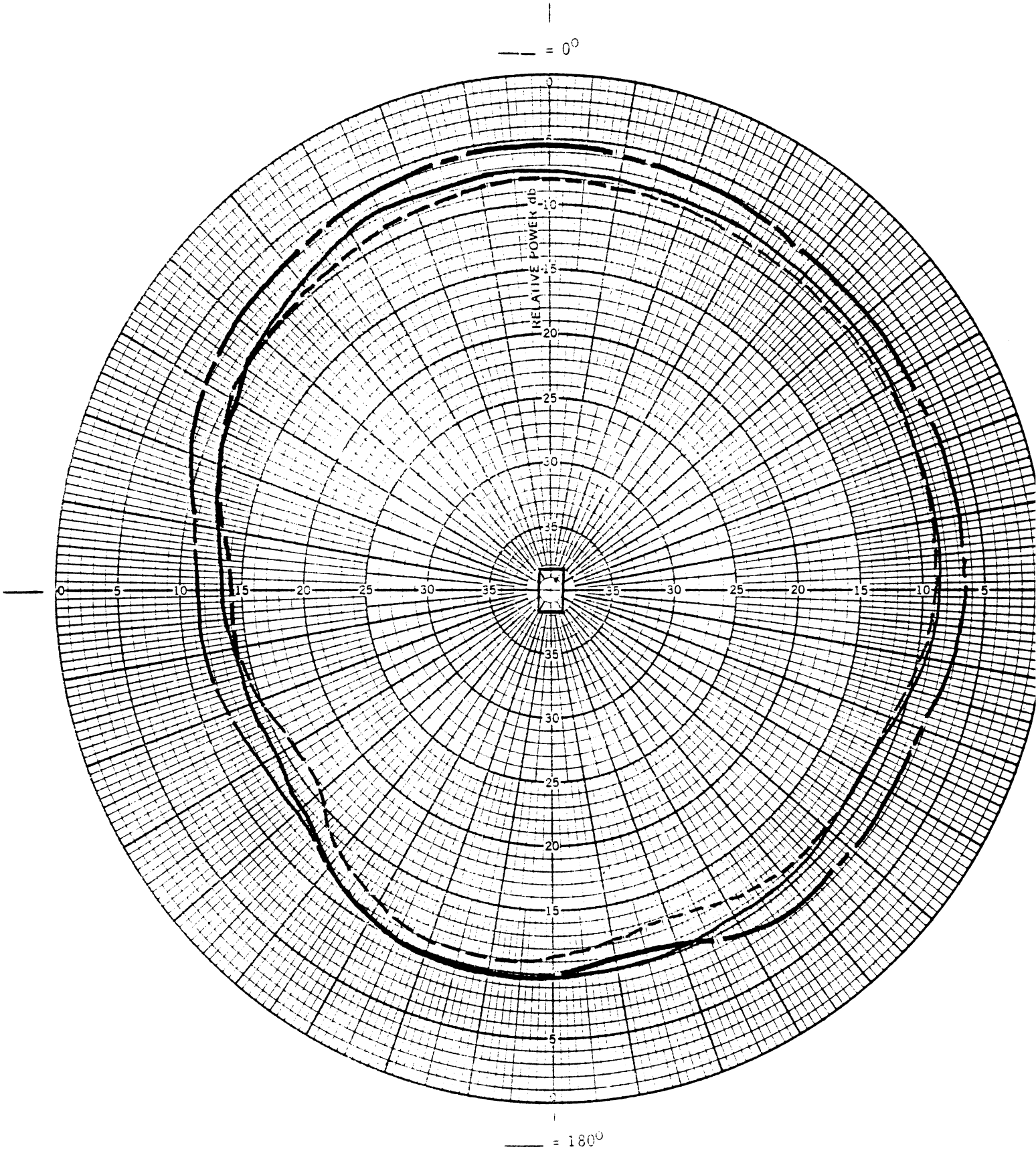


Figure 48(b). Radiation patterns at 98 MHz for Power Entertainment (PE) antennas on 1979 LTD.

— --- — PE 95, ——— PE 123, ----- PE 202.

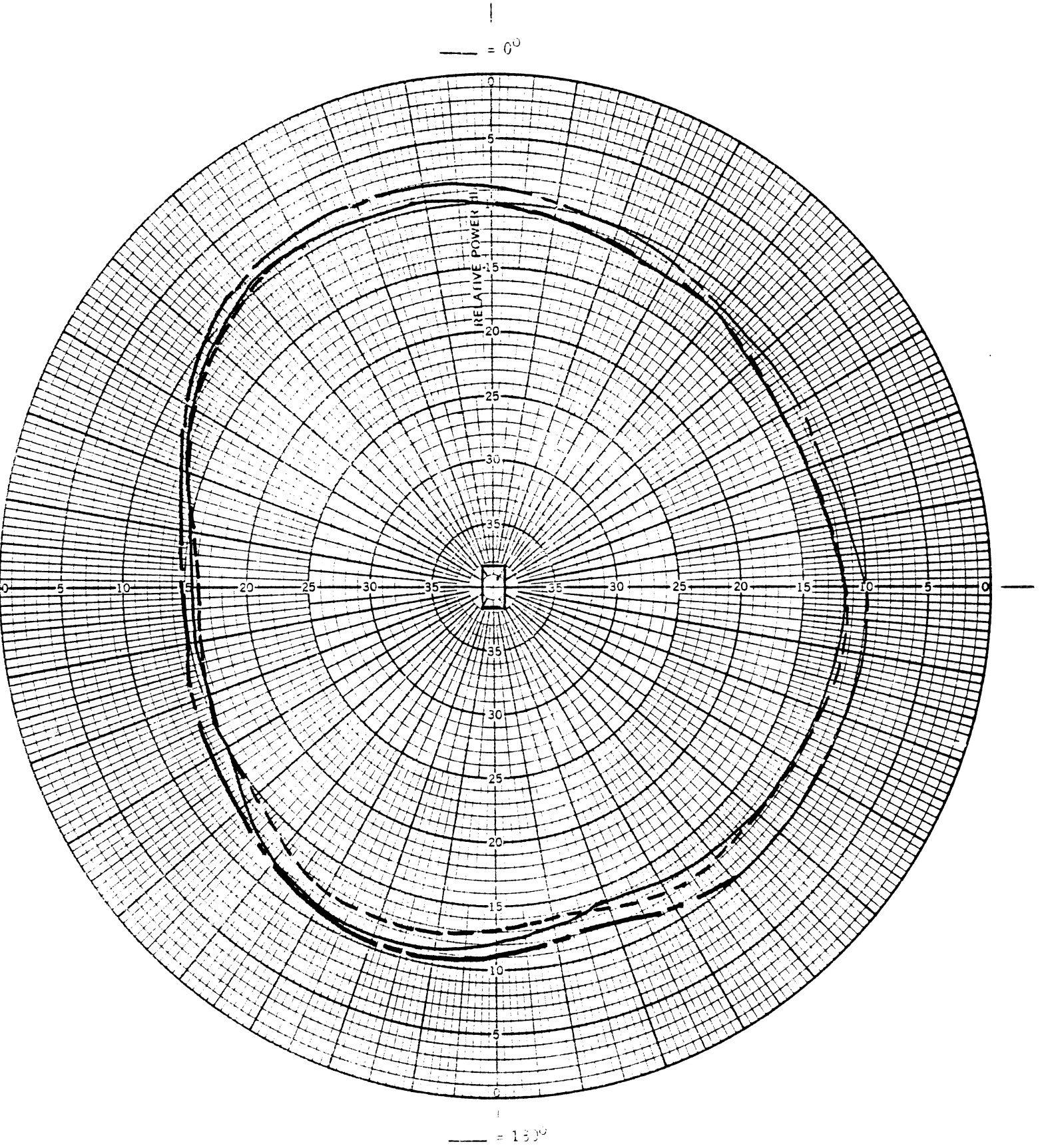


Figure 48(c). Radiation patterns at 108 MHz for Power Entertainment antennas on 1979 LTD.

—— --- —— PE 95, ——— PE 123, ----- PE 202.

less, sensitivity than the PE 123 antenna at the three test frequencies. Again, the shapes of the patterns are found to be fairly independent of the input capacitance. Figures 49(a)-(c) show the corresponding impedance results.

6.3. Manual Tri-band (MT) Antennas on LTD

Horizontal plane radiation patterns of the MT antennas at three selected frequencies in the FM band are shown in Figures 50(a)-(c). At all three frequencies the MT 202 antenna is considerably less sensitive than the MT 123 antenna, and the PT 95 antenna about 1 dB less sensitive than the MT 123. The corresponding patterns for the three antennas at the CB frequencies are shown in Figures 51(a)-(c) The patterns and sensitivities are almost identical at all frequencies with the exception of the MT 202 antenna which has slightly less sensitivity at the lowest CB channel frequency.

The impedance results at FM and CB frequencies for the MT antennas are shown in Figures 52(a)-(c) and 53(a)-(c), respectively.

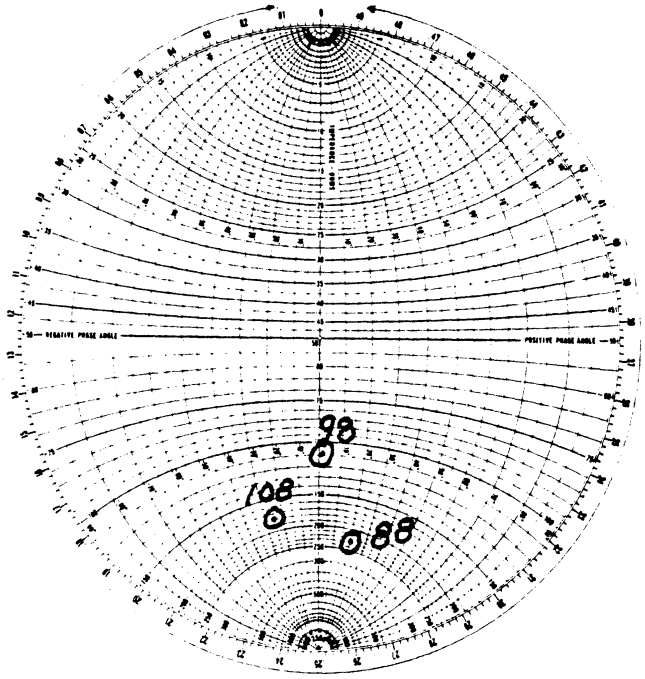
6.4. Power Tri-band (PT) Antennas on LTD

The radiation patterns of PT antennas measured at FM and CB frequencies are shown in Figures 54(a)-(c) and 55(a)-(c), respectively. Figures 54(a) and (b) indicate that at 88 and 98 MHz, the PT 123 antenna has significantly less sensitivity than the PT 95 and PT 202 antennas. Of the three antennas, the PT 95 has the largest sensitivity at the three test frequencies in the FM band. As can be seen from Figure 55, there is very little difference between the patterns of the three antennas at CB frequencies.

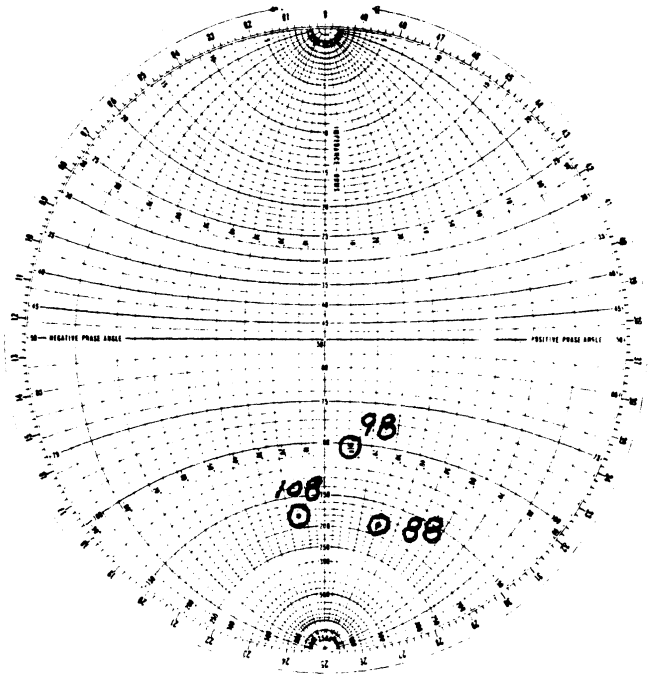
Figures 56(a)-(c) and 57(a)-(c) show the impedances of the three antennas at FM and CB frequencies, respectively.

6.5. Performance Comparison for Antennas on LTD

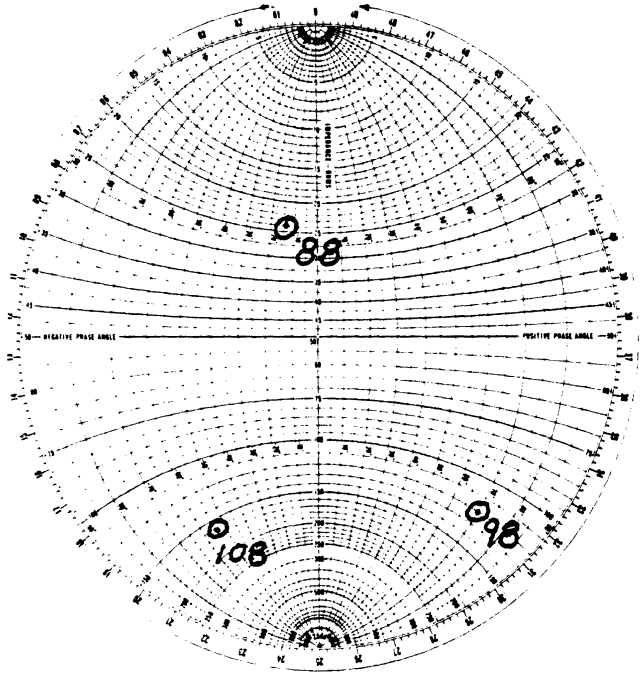
In addition to the above results, the AM band field strengths, the isolation charactercitics of CB frequencies, and the system C and Q at



(a)



(b)



(c)

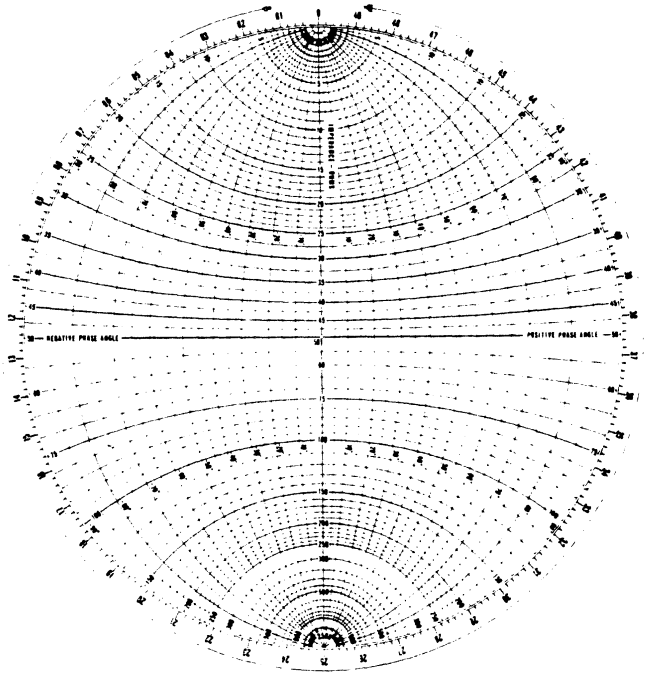


Figure 49. Impedance characteristics in the FM band for Power Entertainment antennas on 1979 LTD.
(a) PE 95, (b) PE 123, (c) PE 202.

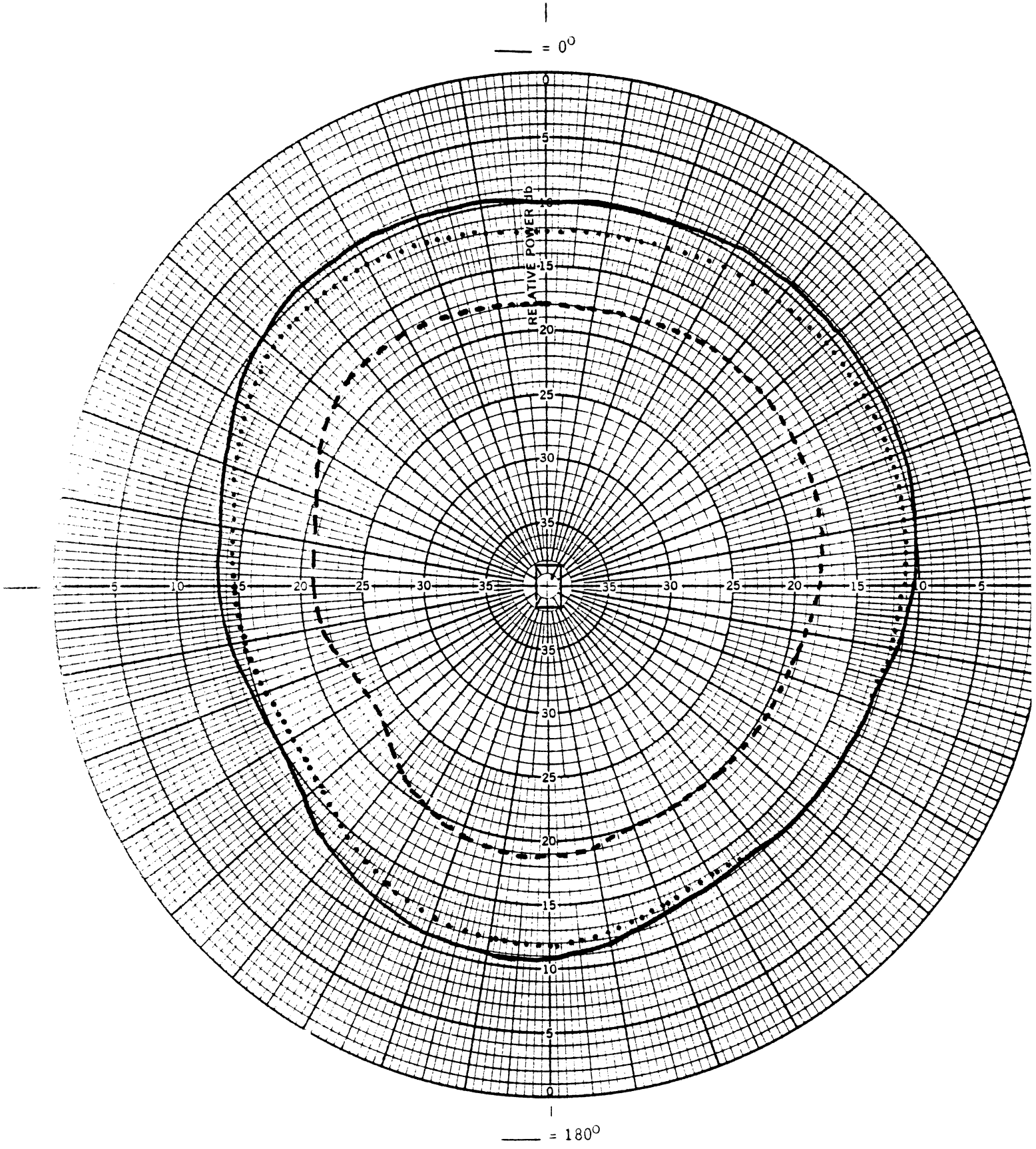


Figure 50(a). Radiation patterns at 88 MHz for Manual Tri-band (MT) antennas on 1979 LTD.

····· MT 95, ——— MT 123, ----- MT 202.

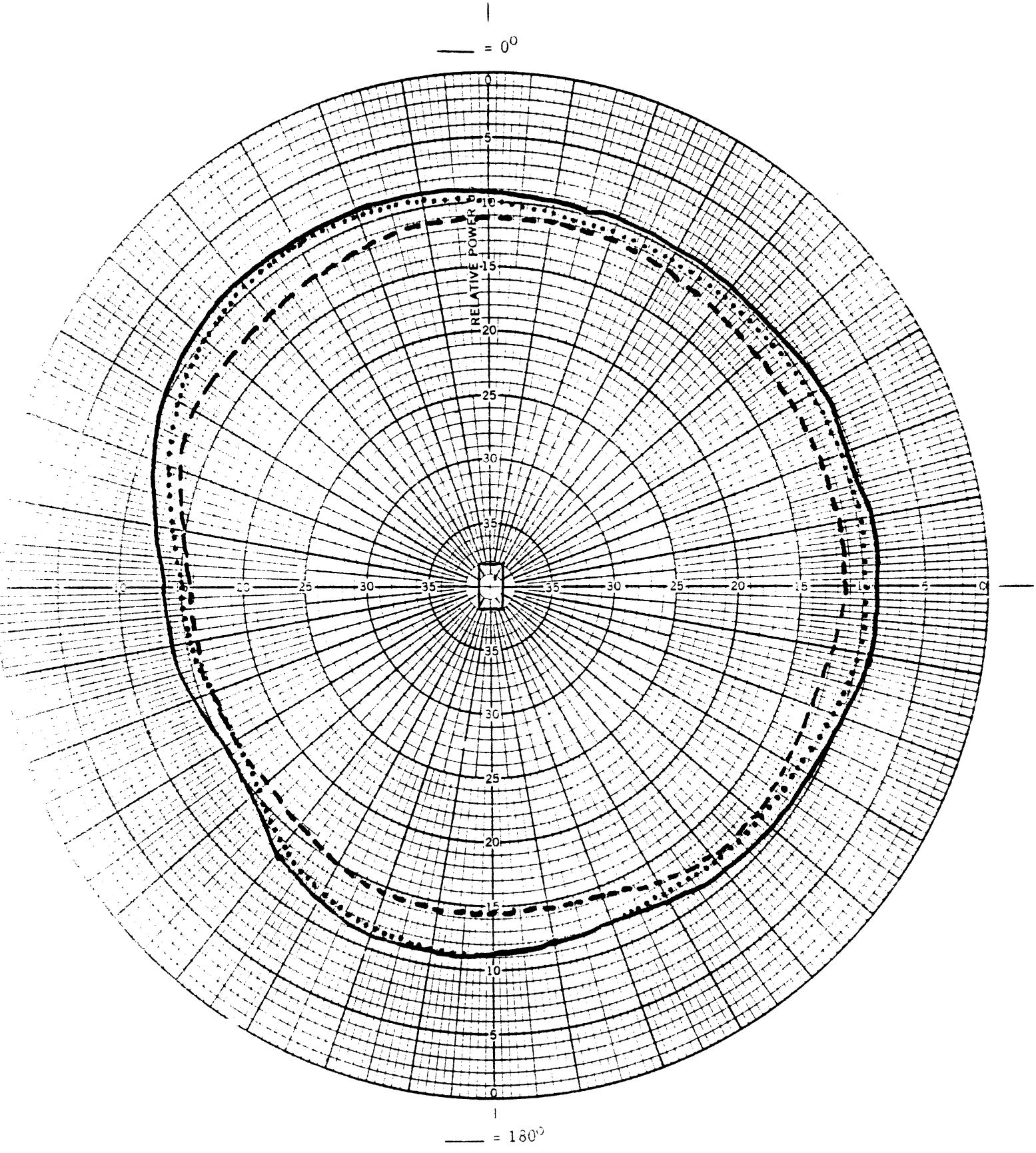


Figure 50(b). Radiation patterns at 98 MHz for Manual Tri-band (MT) antennas on 1979 LTD.

····· MT 95, ——— MT 123, ----- MT 202.

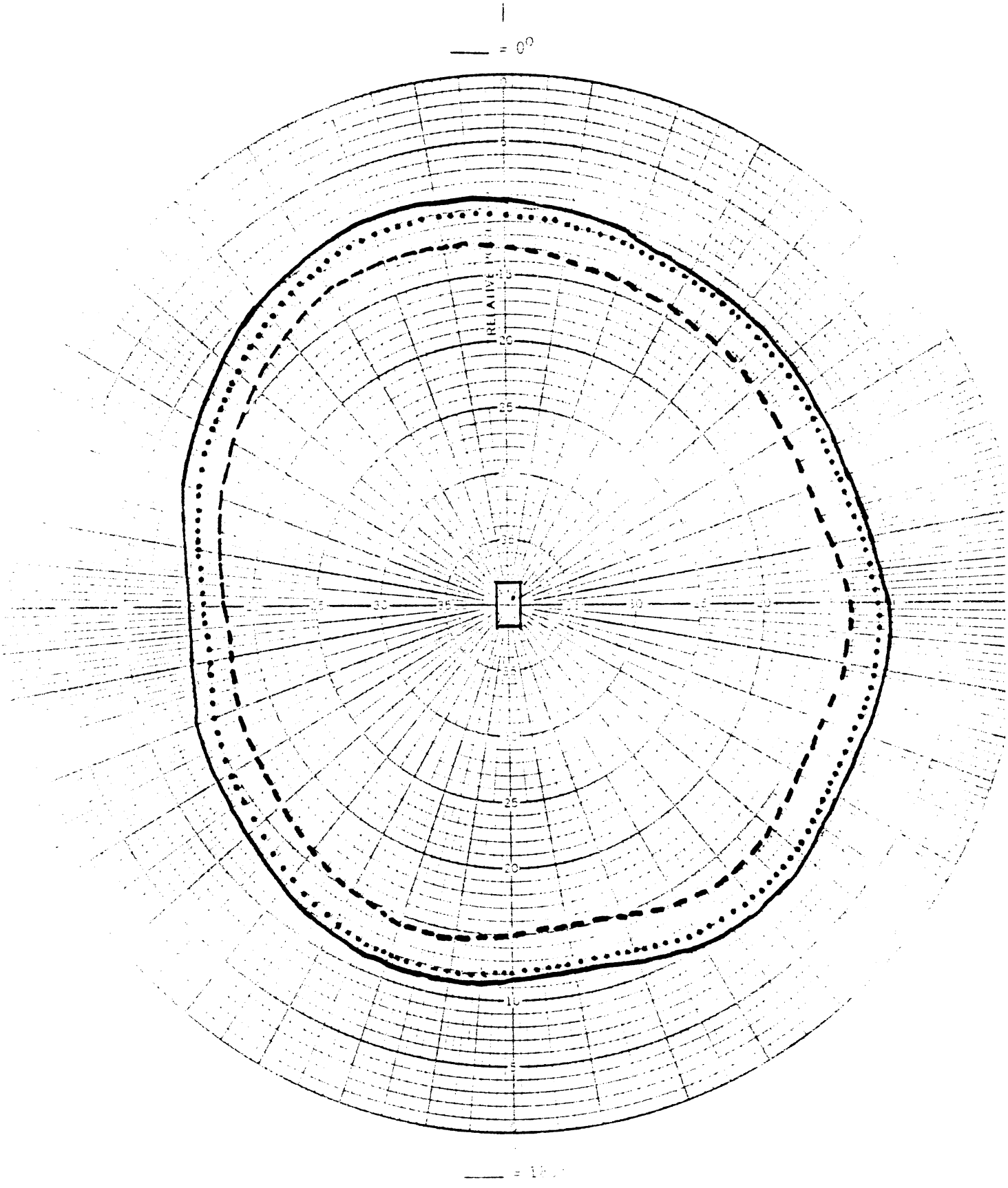


Figure 50(c). Radiation patterns at 108 MHZ for Manual Tri-band (MT) antennas on 1979 LTD.

····· MT 95, ——— MT 123, ----- MT 202.

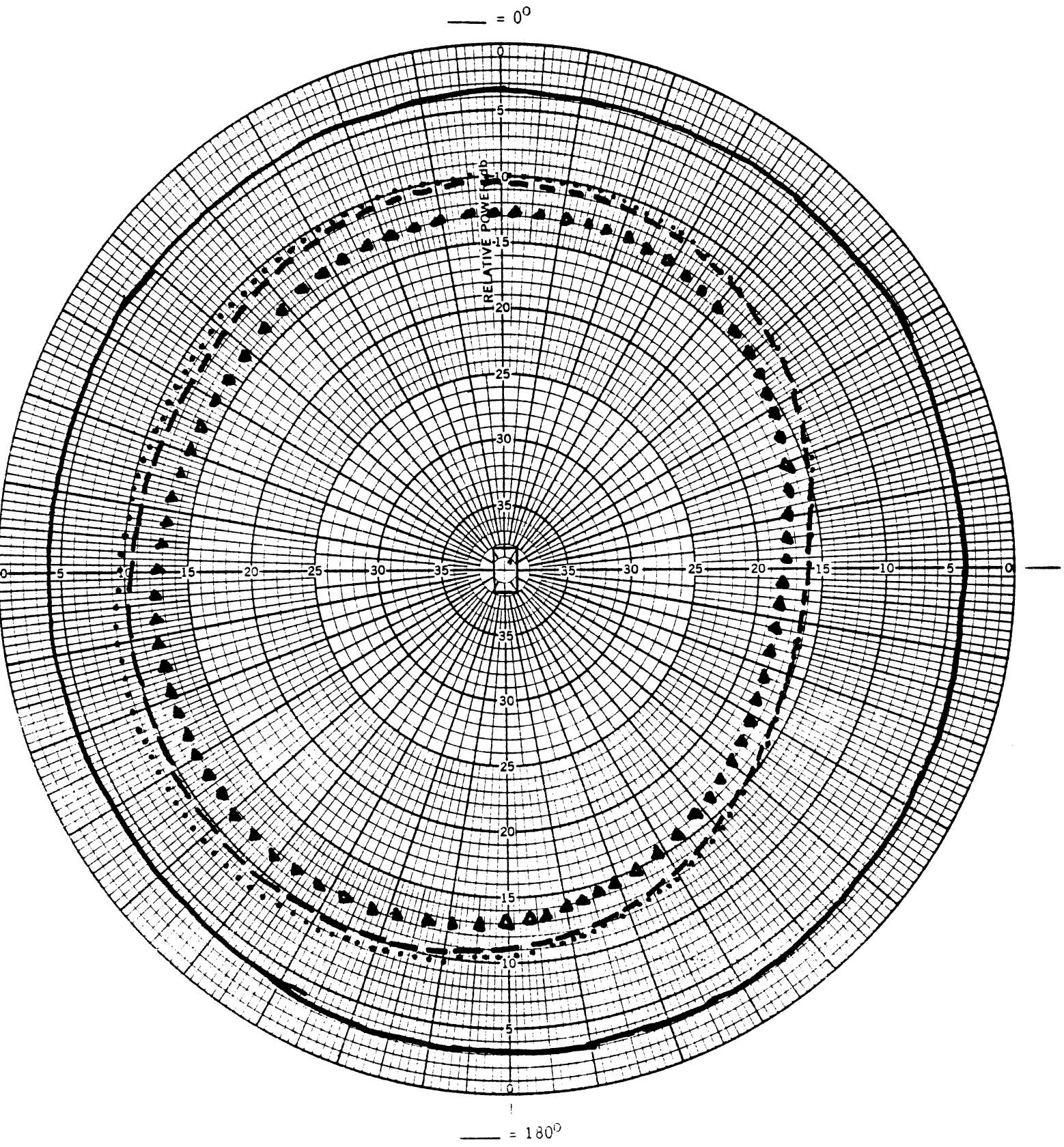


Figure 51(a). Radiation patterns at CB Channel 1 for Manual Tri-band (MT) and reference antennas on 1979 LTD.

—— CB Reference, ····· MT 95, ----- MT 123, ΔΔΔΔΔ MT 202.

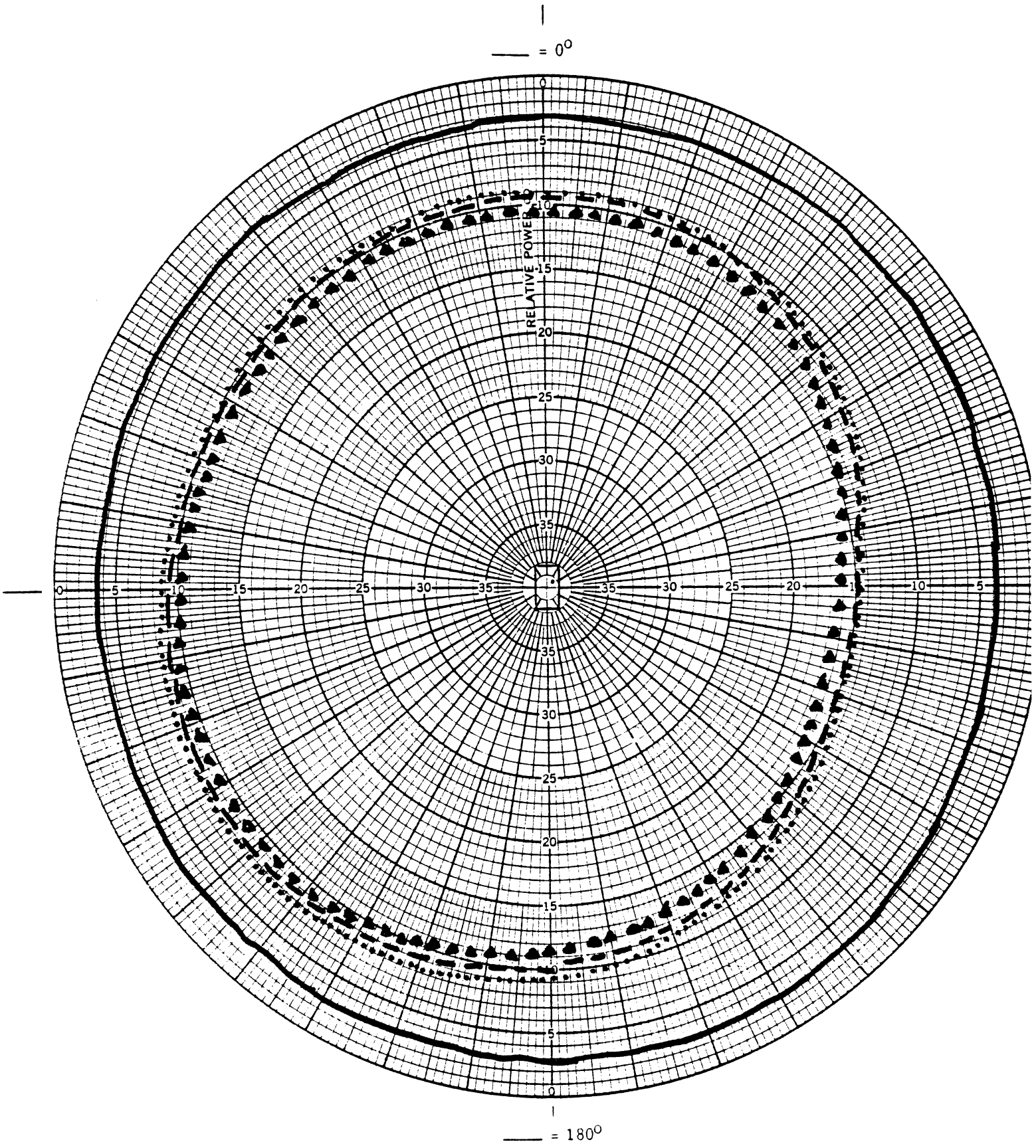


Figure 51(b). Radiation patterns at CB Channel 19 for Manual Tri-band (MT) and reference antennas on 1979 LTD.

——— CB Reference, ····· MT 95, ----- MT 123, ΔΔΔΔΔ MT 202.

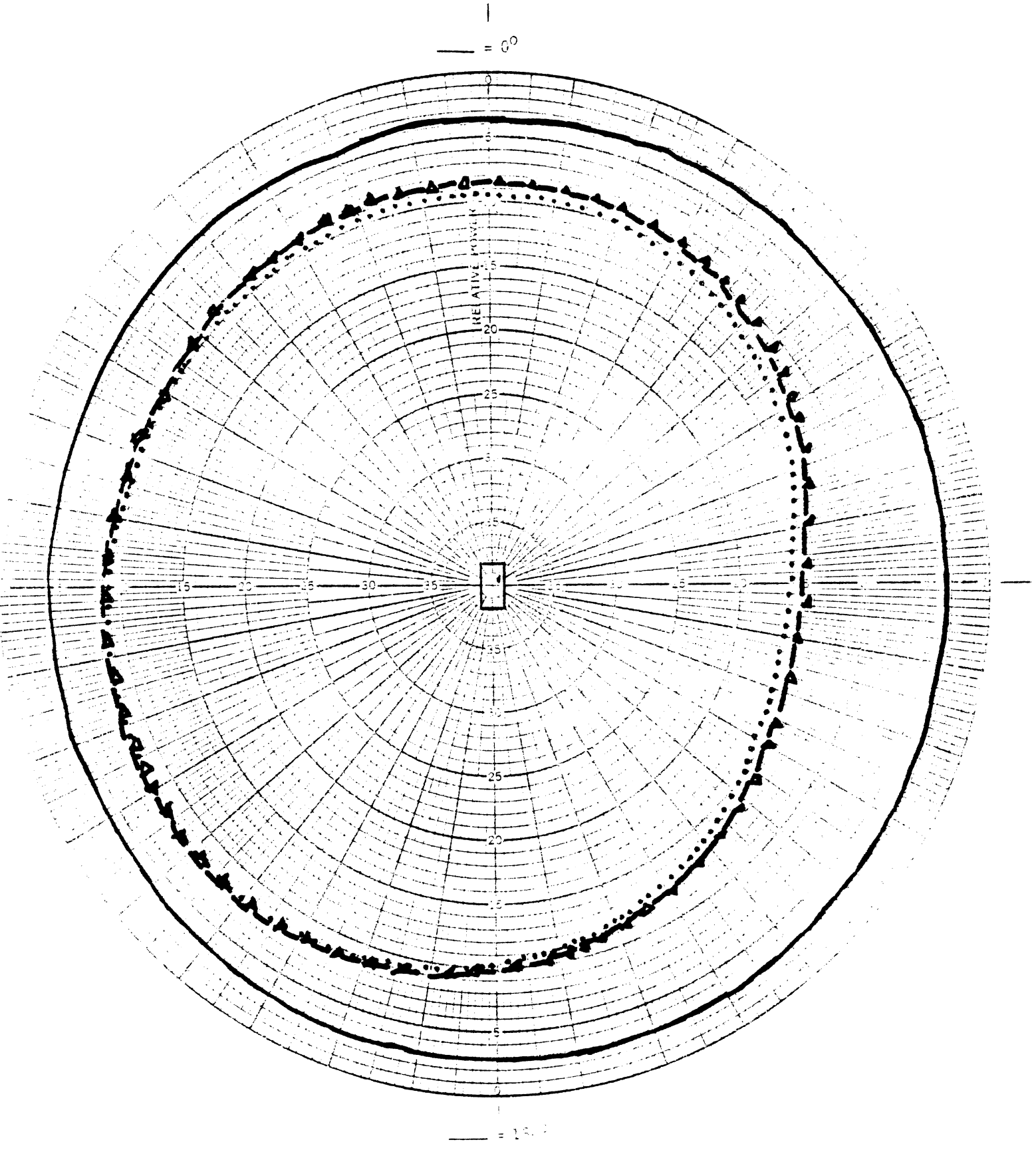
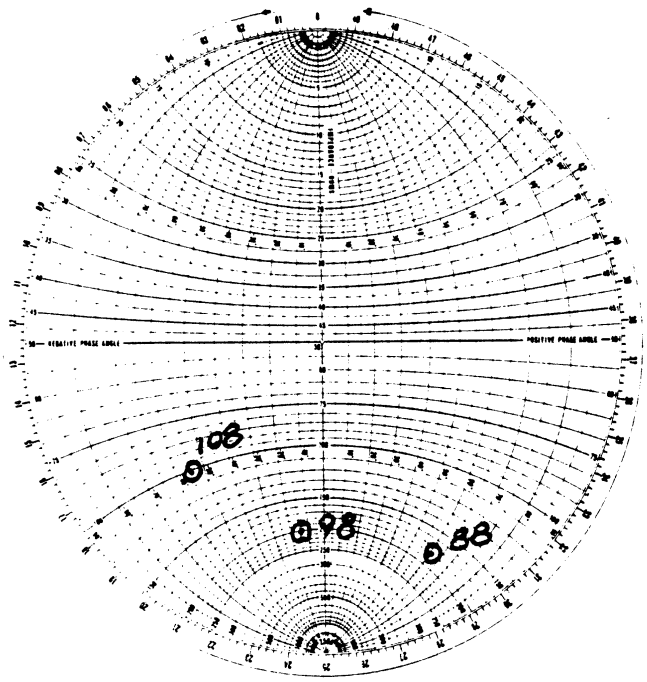
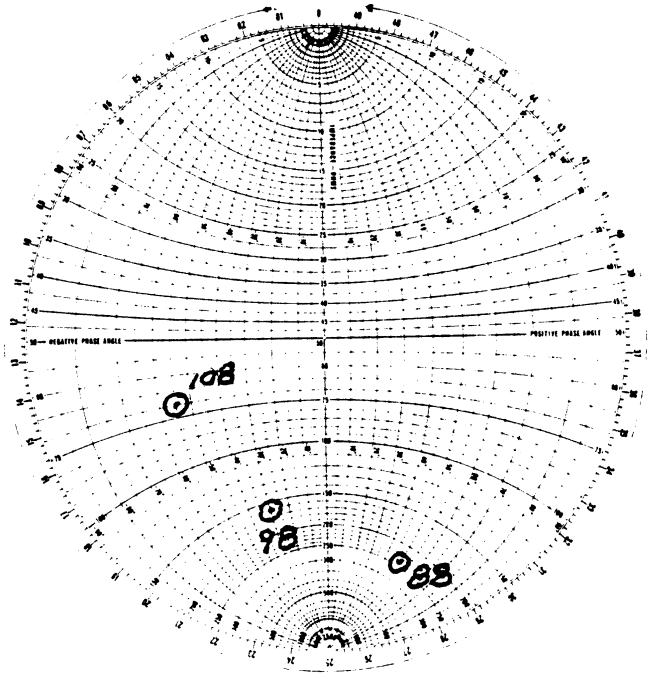


Figure 51(c). Radiation patterns at CB Channel 40 for Manual Tri-band (MT) and reference antennas on 1979 LTD.

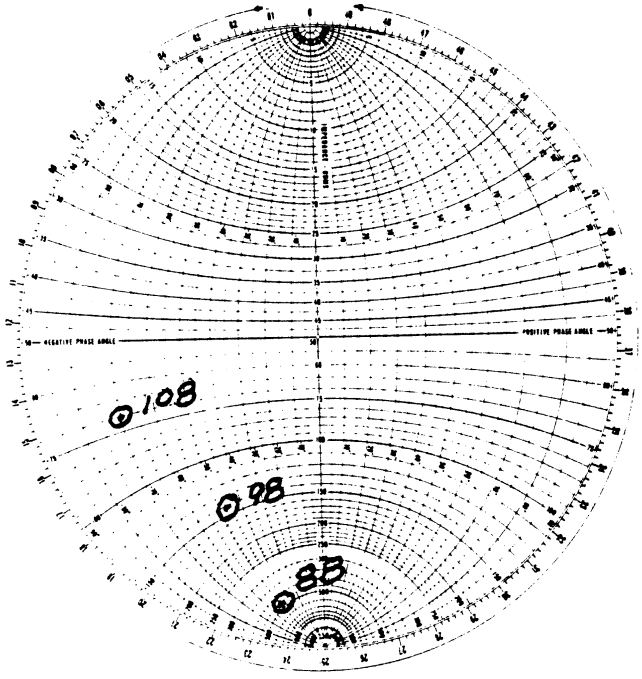
——— CB Reference, ····· MT 95, ----- MT 123, ΔΔΔΔΔ MT 202.



(a)



(b)



(c)

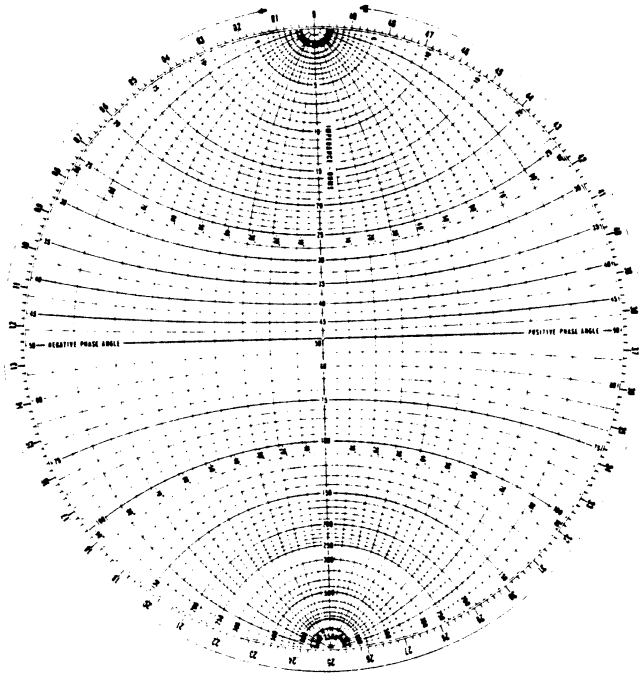
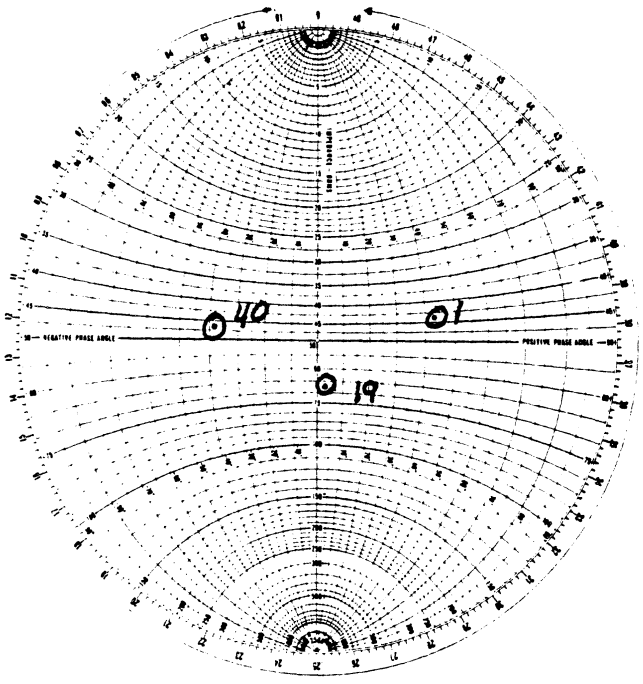
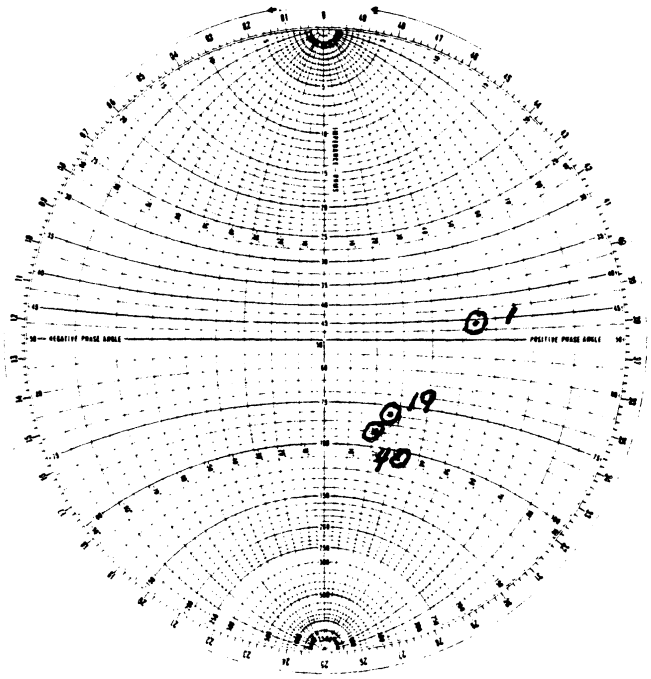


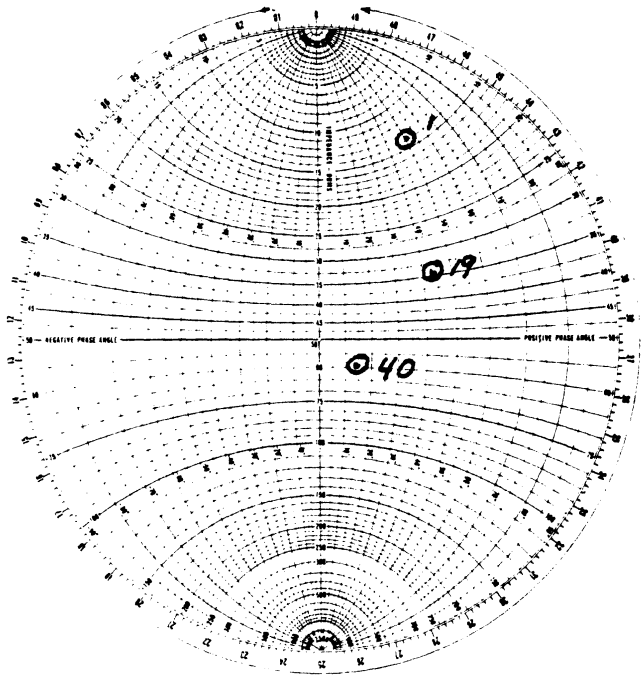
Figure 52. Impedance characteristics in the FM band for Manual Tri-band (MT) antennas on 1979 LTD.
(a) MT 95, (b) MT 123, (c) MT 202.



(a)



(b)



(c)

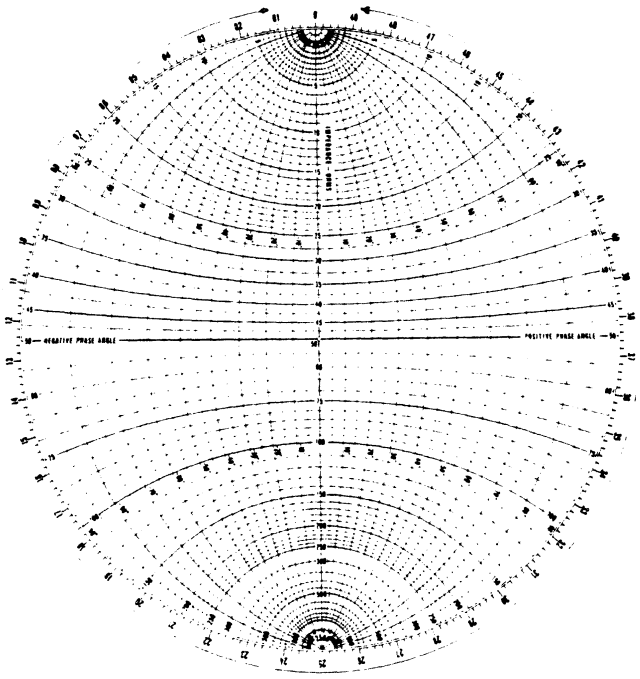


Figure 53. Impedance characteristics at CB frequencies for Manual Tri-band (MT) antennas on 1979 LTD.
(a) MT 95, (b) MT 123, (c) MT 202.

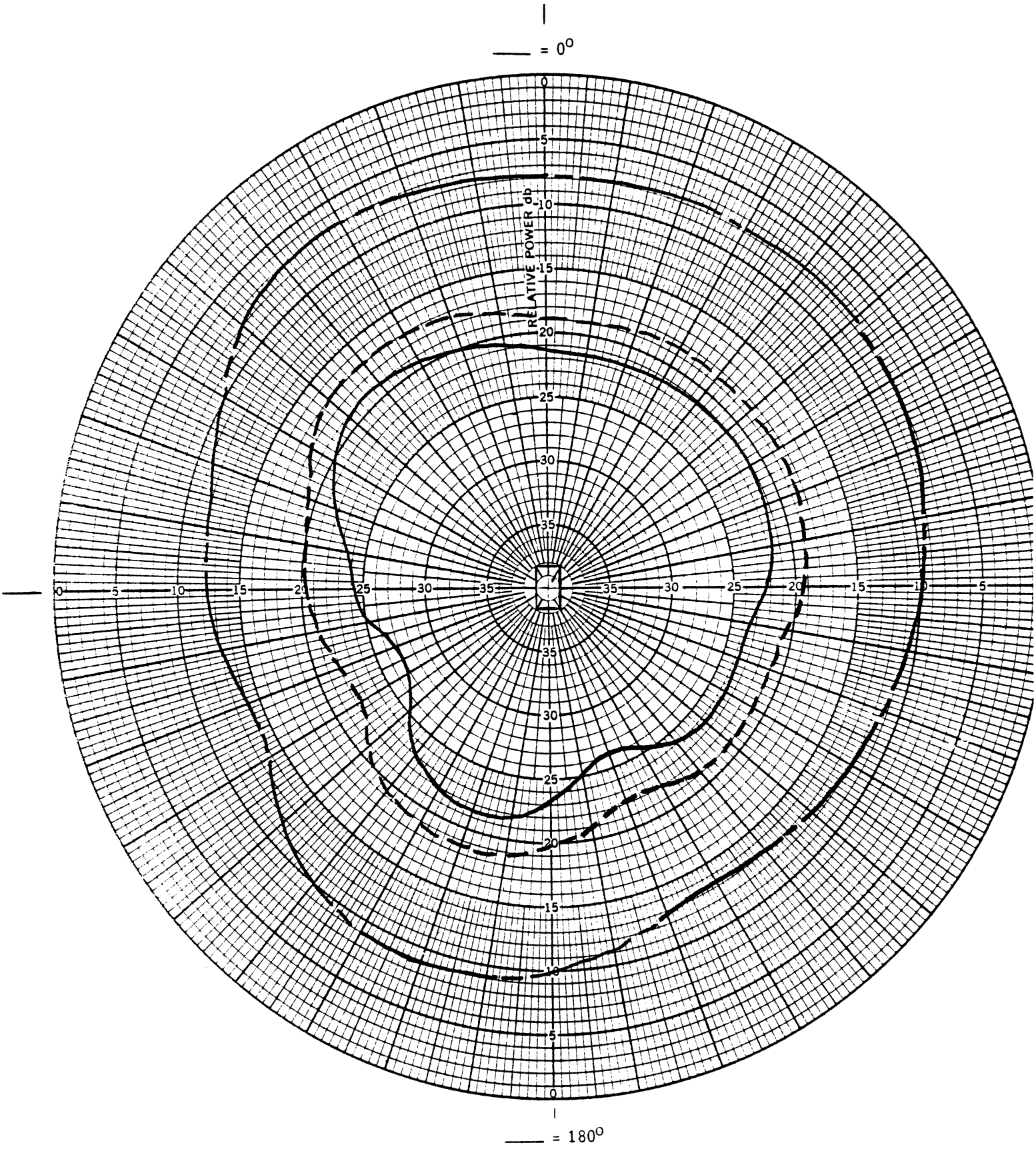


Figure 54(a). Radiation patterns at 88 MHz for Power Tri-band (PT) antennas on 1979 LTD.

— - — PT 95, ——— PT 123, ----- PT 202.

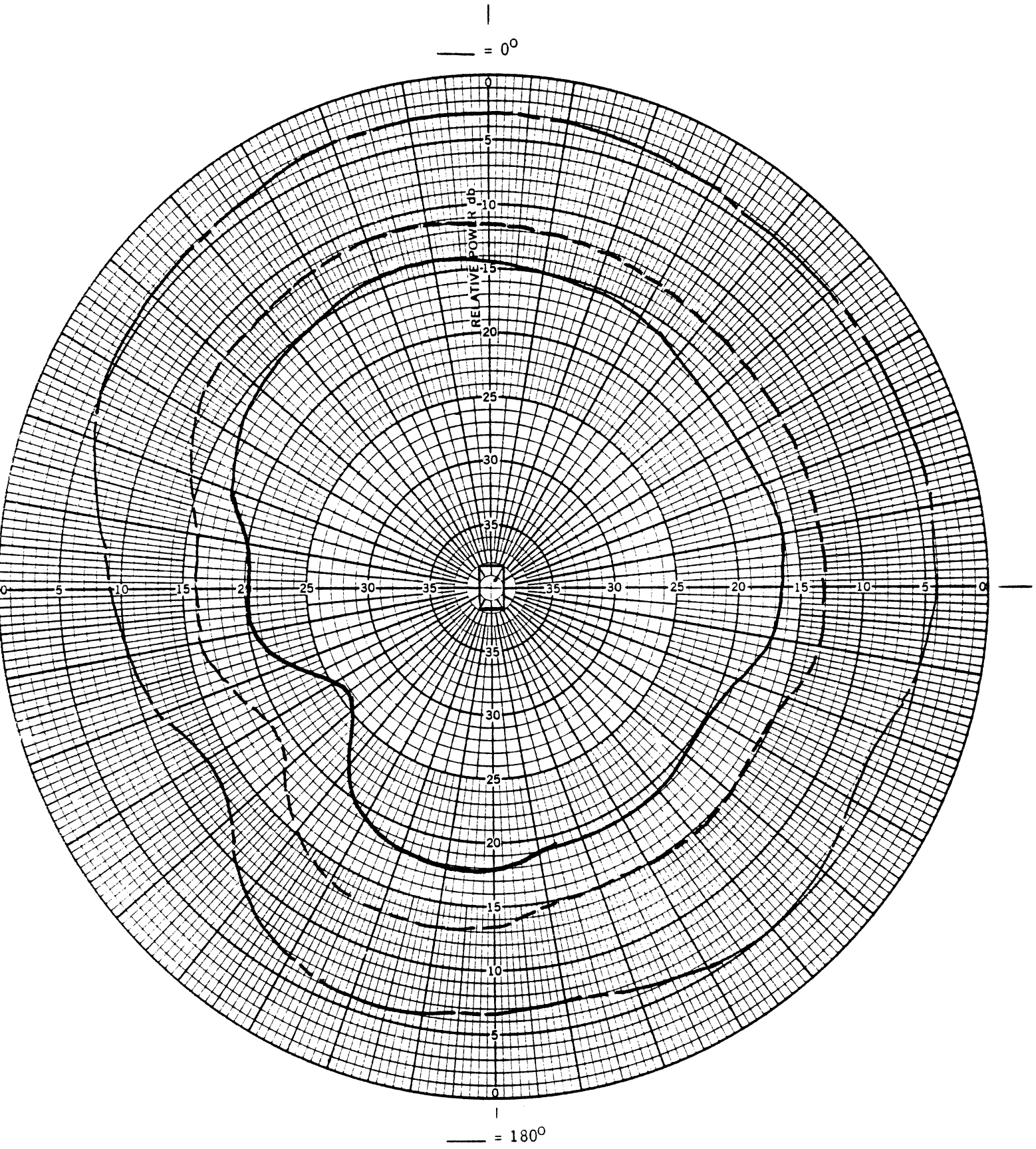


Figure 54(b). Radiation patterns at 98 MHz for Power Tri-band (PT) antennas on 1979 LTD.

— - — PT 95, ——— PT 123, ----- PT 202.

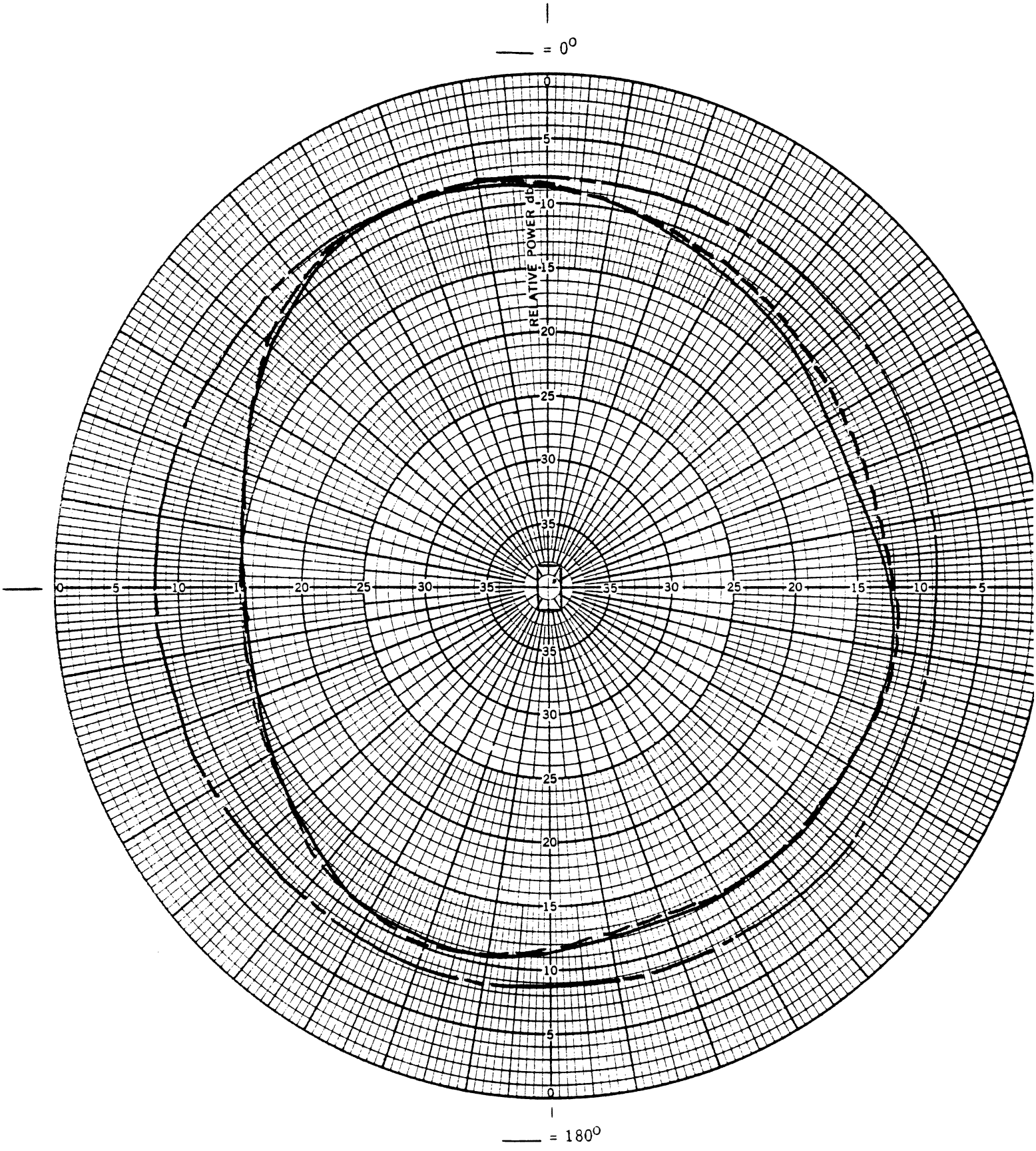


Figure 54(c). Radiation patterns at 108 MHz for Power Tri-band (PT) antennas on 1979 LTD.

— - — PT 95, ——— PT 123, ----- PT 202.

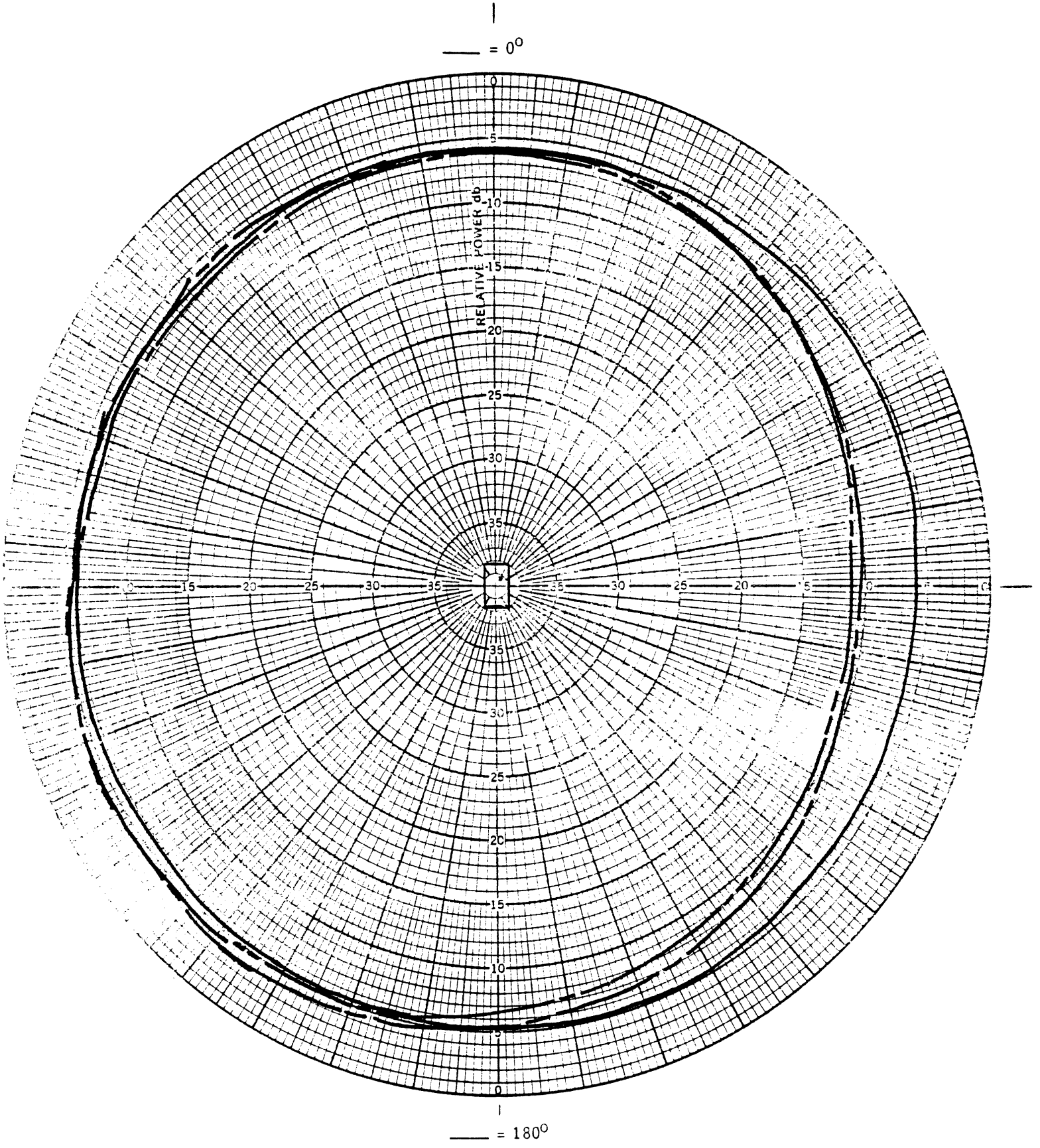


Figure 55(a). Radiation patterns at CB Channel 1 for Power Tri-band (PT) and reference antennas on 1979 LTD.

——— CB Reference, — - — PT 95, — - - — PT 123, — - - - — PT 202.

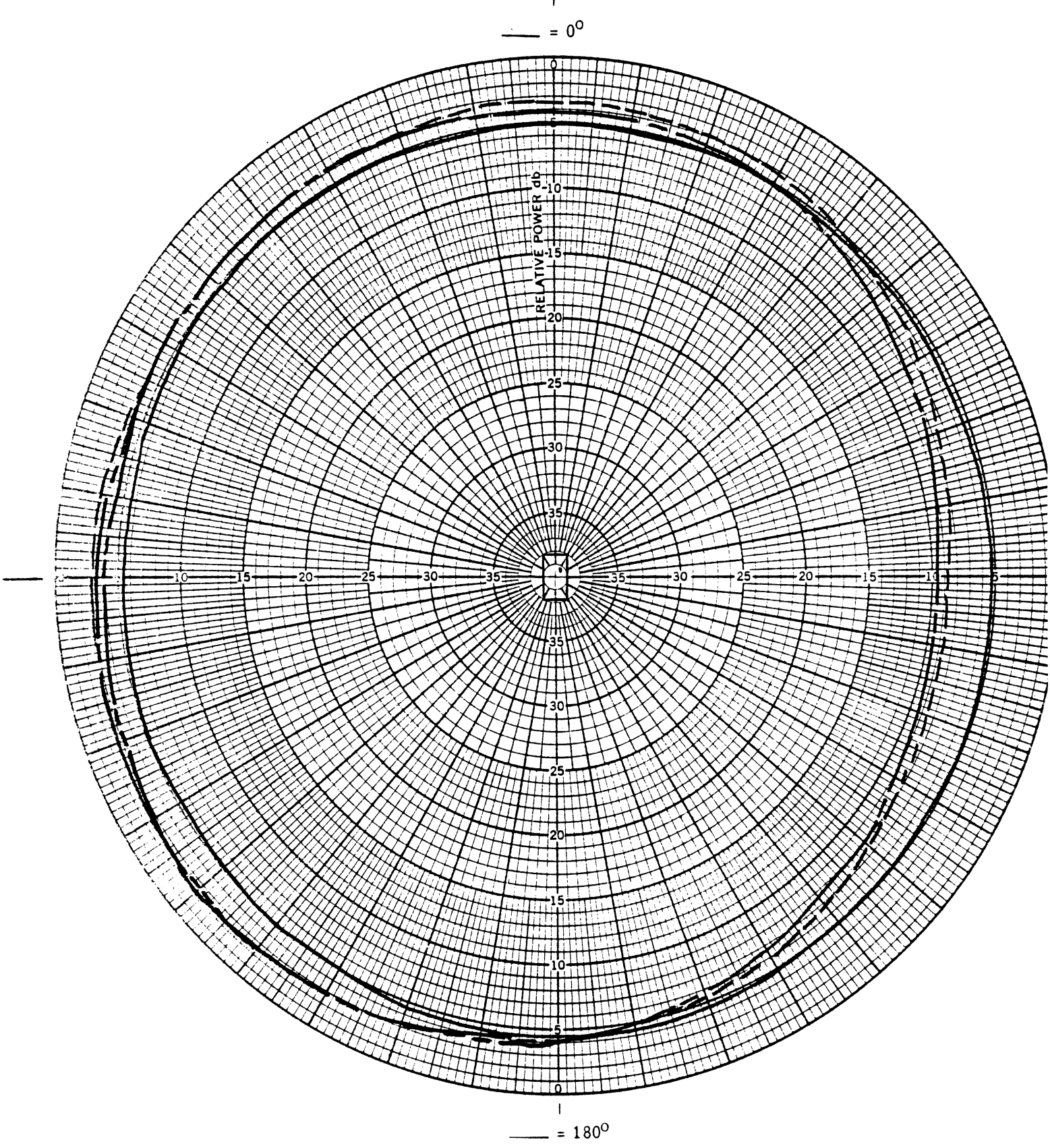


Figure 55(b). Radiation patterns at CB Channel 19 for Power Tri-band (PT) and reference antennas on 1979 LTD.

——— CB Reference, — - — PT 95, — - - — PT 123, — - - - — PT 202.

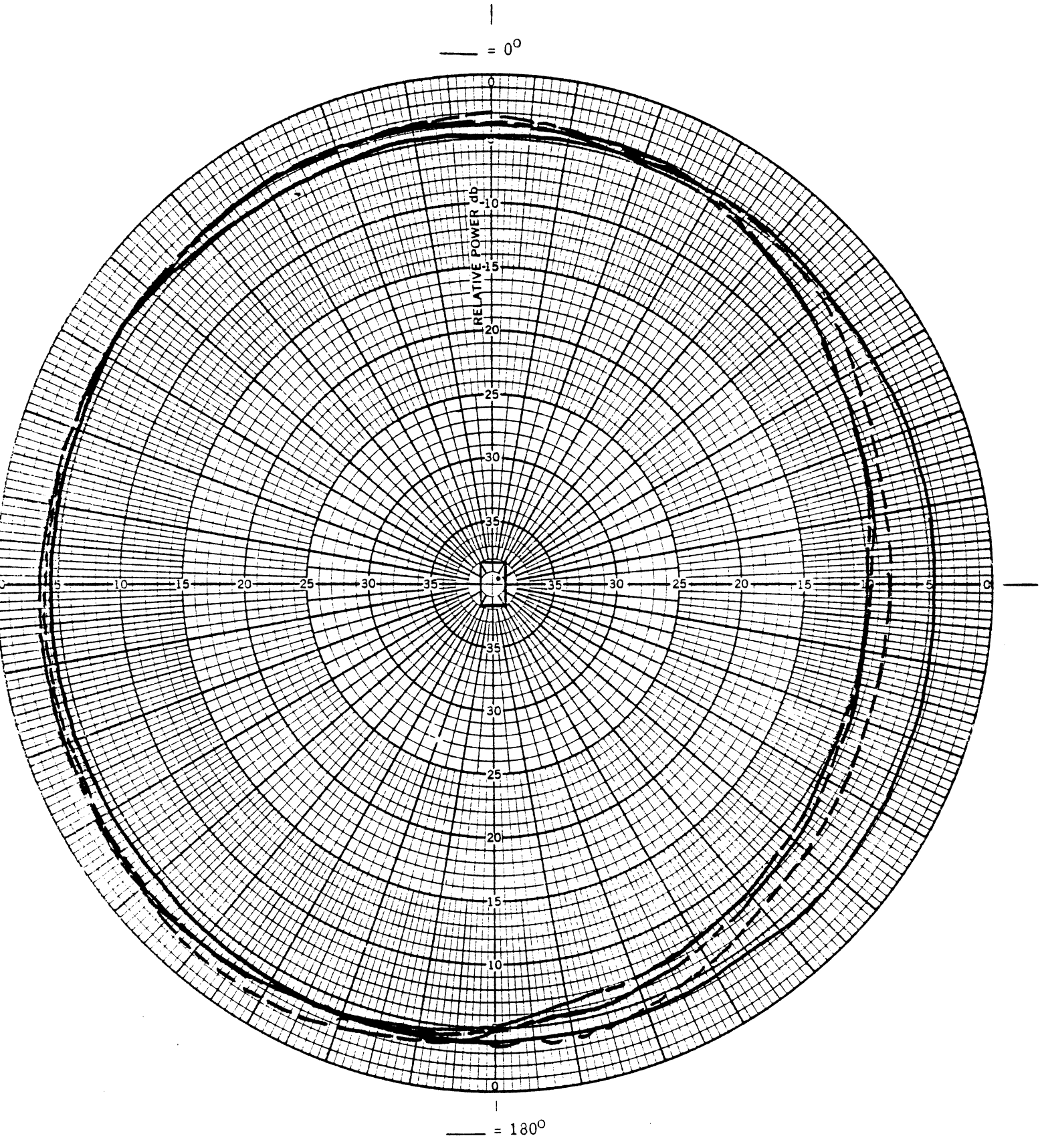
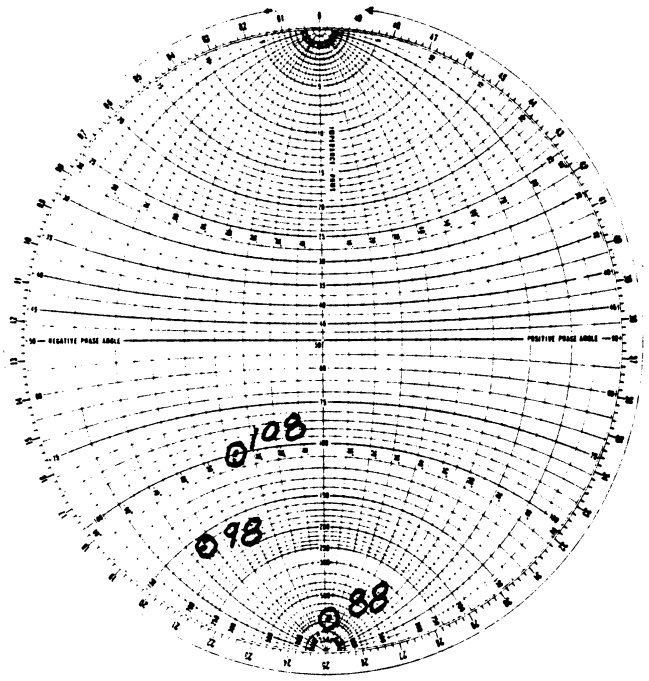
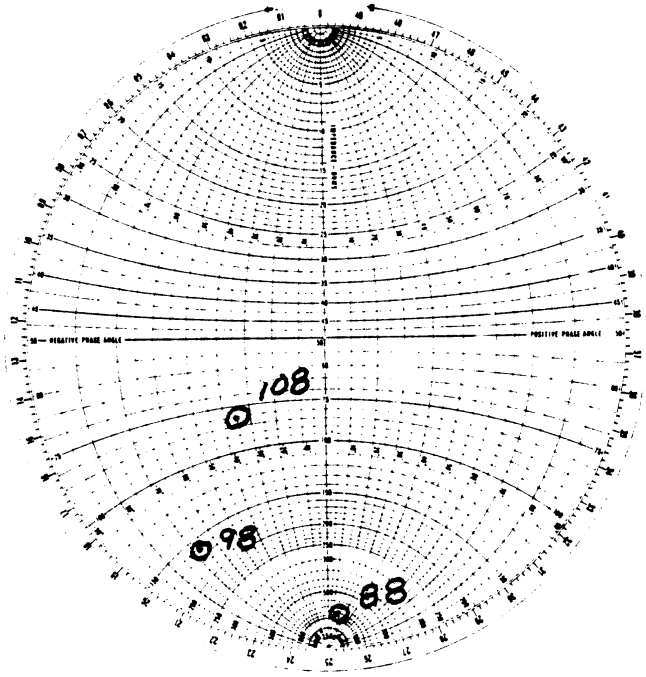


Figure 55(c). Radiation patterns at CB Channel 40 for Power Tri-band (PT) and reference antennas on 1979 LTD.

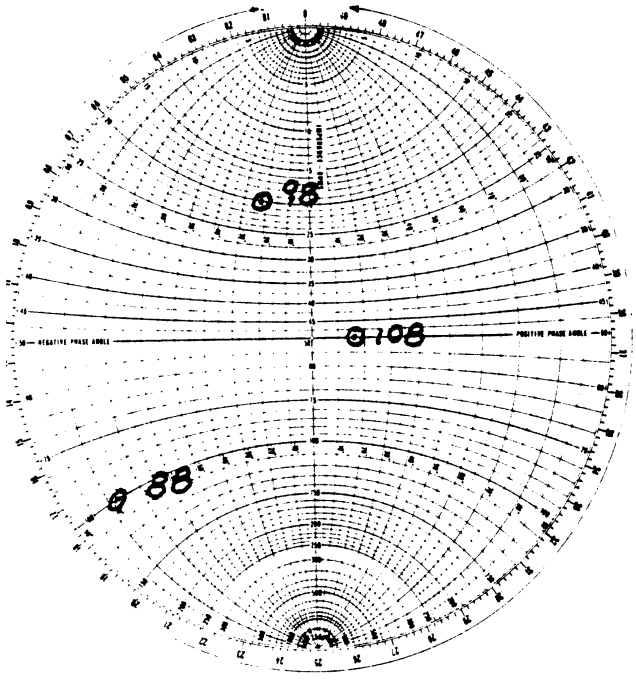
——— CB Reference, — - — PT 95, — - - — PT 123, — - - - — PT 202.



(a)



(b)



(c)

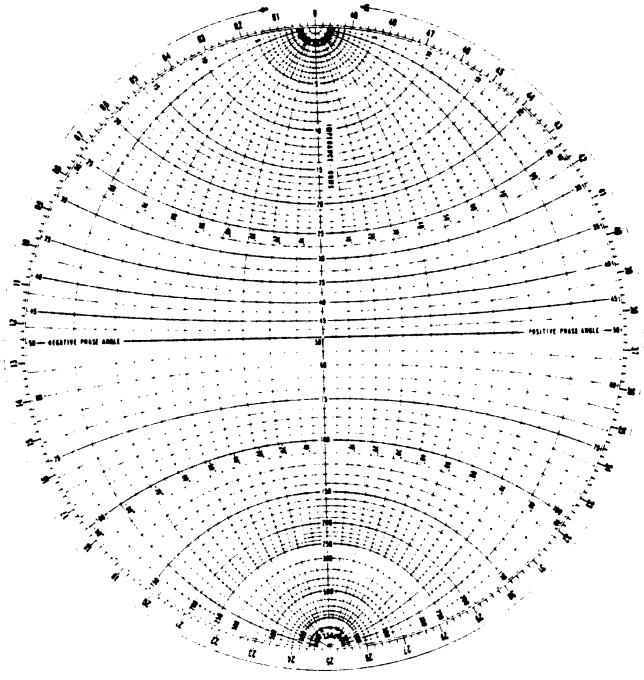
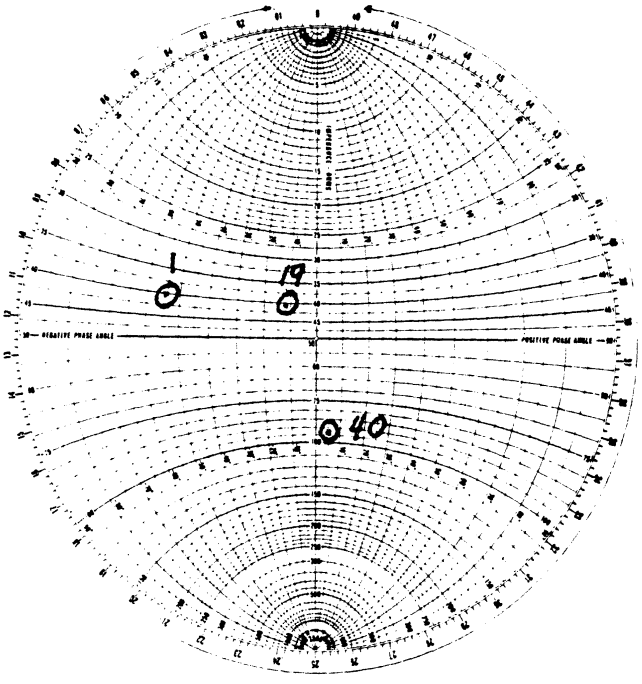
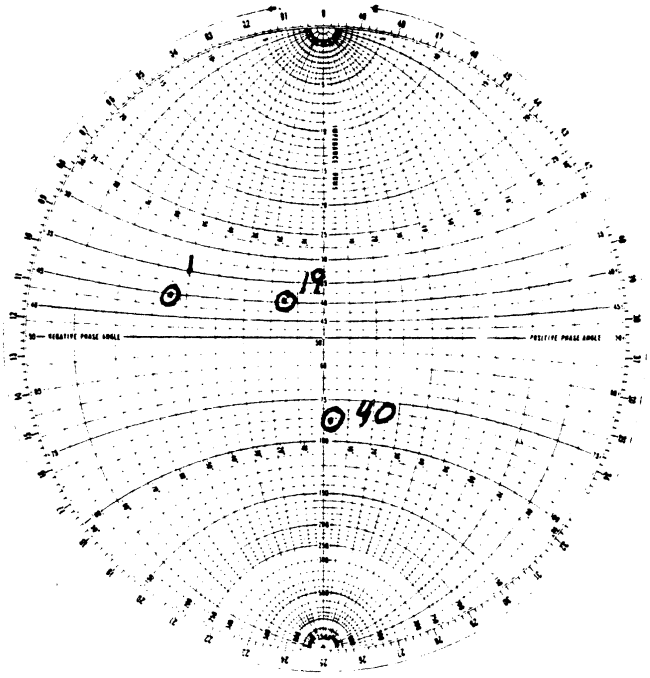


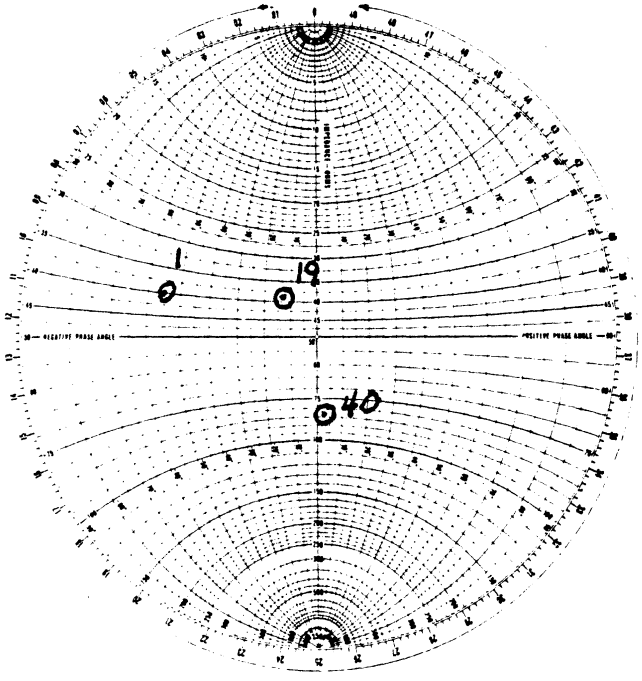
Figure 56. Impedance characteristics in the FM band for Power Tri-band (PT) antennas on 1979 LTD.
(a) PT 95, (b) PT 123, (c) PT 202.



(a)



(b)



(c)

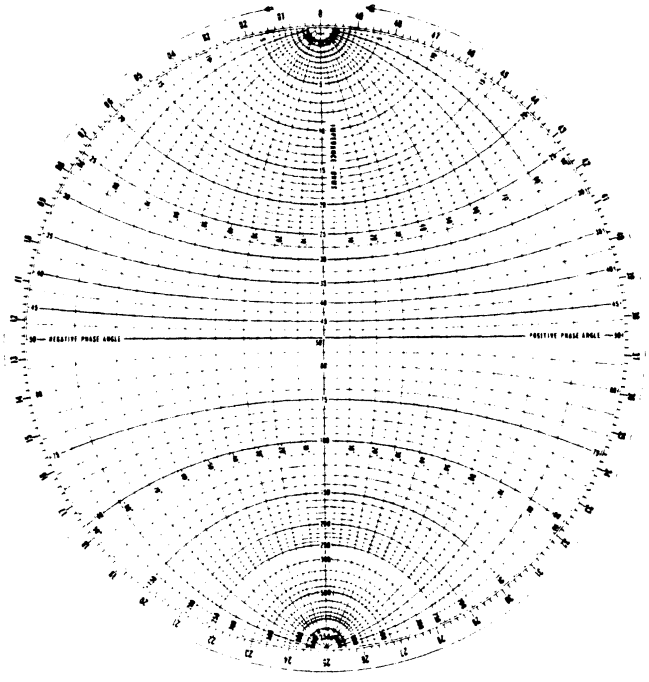


Figure 57. Impedance characteristics at CB frequencies for Power Tri-band (PT) antennas on 1979 LTD.
(a) PT 95, (b) PT 123, (c) 202.

AM frequencies were measured for each antenna mounted on a 1979 Ford LTD. The results of these measurements, and also the average sensitivities and VSWR's derived from the data in sections 5.1 - 5.4, are shown in Table 9, and these can be used to estimate the effects of the input capacitance on the performance of a test antenna mounted on the LTD. Based on the results shown in Table 10, the following observations are made concerning the effects of the antenna input capacitance:

(i) The AM sensitivity of ME and PE antennas is substantially independent of the antenna input capacitance. The MT 202 antenna has appreciably more, and the MT 95 less, sensitivity than the MT 123 antenna. The behavior of the PT antennas is similar.

(ii) The shapes of the FM band patterns are independent of the antenna input capacitance. The average sensitivity of ME 95 and ME 202 antennas is generally less than that of the ME 123, the maximum reduction of sensitivity being about 2 dB. Over the FM band, the PE 95 antenna can have about 1.5 dB and the PE 202 about 2 dB sensitivity relative to the PE 123 antenna.

The MT 95 has about 1 dB less sensitivity, and the MT 202 antenna is as much as 8 dB less sensitive than the MT 123.

Both the PT 95 and the PT 202 antennas have substantially larger sensitivities than the PT 123 antenna.

(iii) There is no general trend in the behavior of the VSWR at the FM band frequencies as the input capacitance is varied.

(iv) The CB sensitivities of all the antennas are generally within 1 dB of each other. The input capacitance seems to have some effect on the VSWR at CB frequencies but no general trend can be cited.

(v) The PT 202 antenna has the poorest CB isolation characteristics, to the extent that these may not be acceptable. With the other antennas, the input capacitance seems to have some effect on the isolation characteristics which otherwise stay within acceptable limits.

6.6 Results for Antennas on 1978 Mark V

Due to unavailability of a 1979 Ford, results were collected with a 1978 model car. This section describes the results obtained with manual an tri-band antennas (MT and PT, respectively) front mounted on a 1978 model Mark V.

TABLE 10. PERFORMANCE DATA FOR TEST ANTENNAS ON 1979 LTD.

PARAMETER	ANTENNA TYPE											
	ME			PE			MT			PT		
	95	123	202	95	123	202	95	123	202	95	123	202
AM Sensitivity (dB/m)												
0.76 MHz	-68	-68	-68	-68	-67	-68	-70	-70	-69	-66	-67	-61
1.10 MHz	-76	-76	-76	-78	-78	-77	-80	-75	-77	-75	-76	-77
1.60 MHz	-84	-84	-84	-84	-84	-84	-92	-90	-85	-82	-82	-80
Relative FM Sensitivity (dB)												
88 MHz	-1.51	0	-1.51	1.51	0	-2.18	-1.13	0	-7.72	12.61	0	3.12
98 MHz	-2.18	0	-2.18	1.62	0	- .73	- .81	0	-2.36	12.11	0	4.27
108 MHz	-1.40	0	-1.40	1.23	0	- .16	- .97	0	-3.30	4.04	0	.29
Relative CB Sensitivity (dB)												
CH 1							-7.03	-7.78	-9.85	- .62	- .76	- .76
CH 19							-6.62	-7.17	-8.20	.44	.30	.62
CH 40							-6.61	-6.24	-6.24	-6.24	- .75	- .10
FM VSWR												
88 MHz	2.45	2.54	2.20	4.53	4.20	2.17	8.33	7.89	15.00	20.00	17.50	13.00
98 MHz	2.13	2.22	1.37	2.09	2.06	8.09	4.11	3.78	4.50	9.22	9.00	2.83
108 MHz	4.48	4.53	6.11	3.95	3.88	5.00	4.16	3.48	6.08	2.70	2.30	1.33
CB VSWR												
CH 1							2.33	3.00	4.71	3.10	3.32	3.32
CH 19							1.35	1.96	2.64	1.41	1.48	1.56
CH 40							2.08	1.93	1.29	1.86	1.73	1.65
Isolation (mv)												
CH 1							200	125	165	218	300	850
CH 19							125	180	122	120	170	775
CH 40							140	360	200	143	170	520
AM Capacitance (pF)												
0.6 MHz	95.5	123.89	202.0	98.0	128.0	200.0	99.0	125.0	210.0	97.0	125.0	202.0
1.0 MHz	96.25	124.95	202.0	98.0	129.0	202.0	99.0	127.0	212.0	102.0	127.0	203.0
1.5 MHz	98.3	125.0	201.0	101.0	332.0	203.0	112.0	130.0	215.0	100.0	130.0	202.0
AM Q												
0.5 MHz	1776	3382	2357	1873	3917	1422	1334	741	511	1138	1032	1403
1.0 MHz	1648	2543	3113	1550	3138	1074	1814	1082	404	923	676	1010
1.5 MHz	1163	1917	893	1338	2544	822	2251	1141	243	576	487	651

The horizontal plane patterns at FM and CB frequencies obtained with various MT antennas are shown in Figures 58(a)-(c) and 59(a)-(c), respectively. Note that all the test antennas have similar patterns, and the impedances are shown in Figures 60 and 61.

The corresponding results for the three power tri-band (PT) antennas are shown in Figures 62-65.

In addition to the above, the AM band field strengths, the isolation characteristics at CB frequencies, and the system C and Q at the AM frequencies, were also measured for each antenna. The results of these measurements, and also the average sensitivities and VSWR's derived from the data in Figures 58-65, are shown in Table 11. The general behavior of the MT and PT antennas on the Lincoln Mark V is similar to that found for the corresponding antennas mounted on the 1979 Ford LTD (see section 5.5), and hence is not discussed further.

6.7. Discussion

There is no unique input capacitance value for the manual and tri-band antennas which would provide better performance according to all the performance criteria. Although the 202 pF capacitance system seems to provide a better AM sensitivity, the PT 202 antenna has the worst isolation characteristics, and on the average, a 123 pF input capacitance would provide the best overall performance.

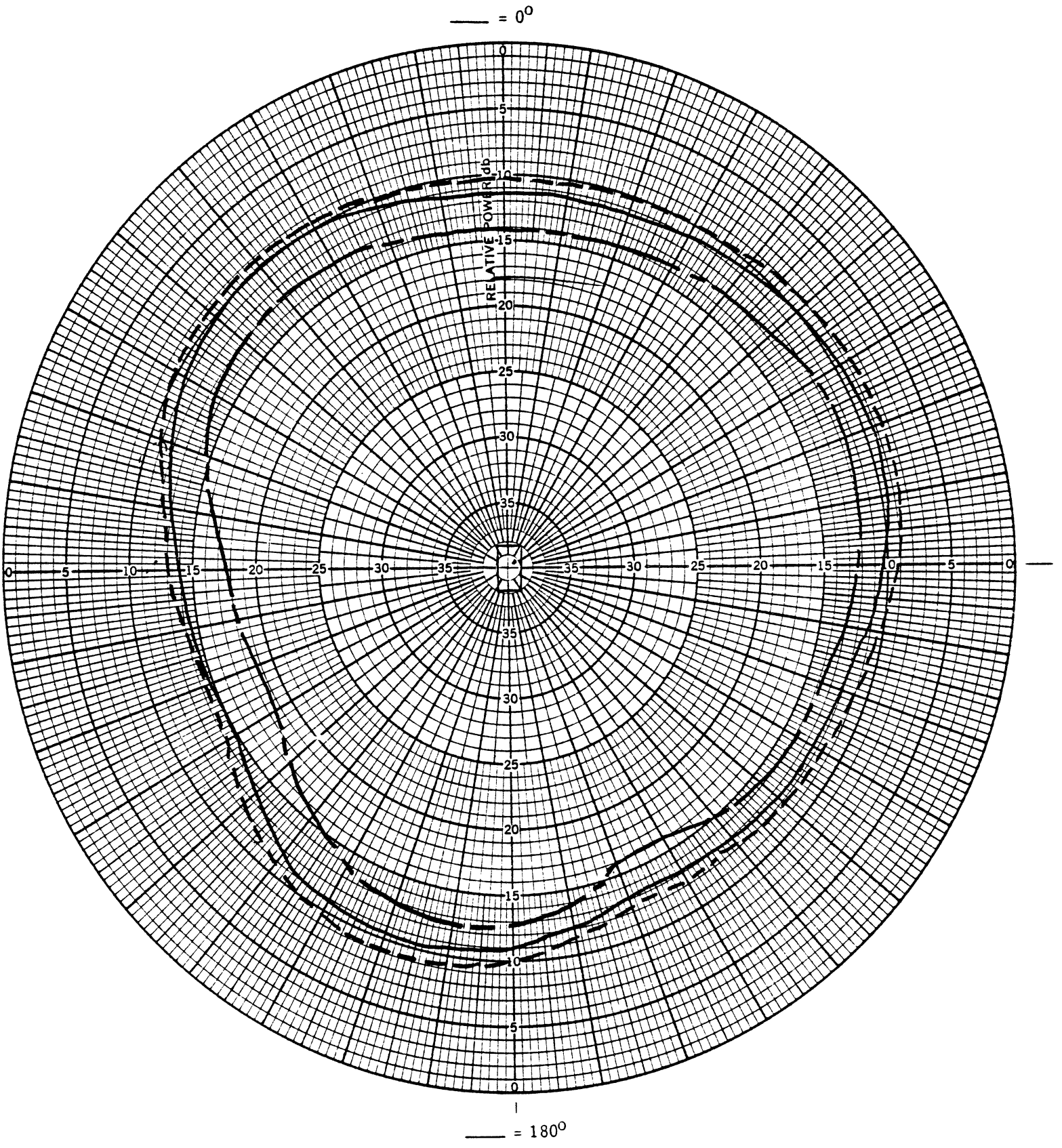


Figure 58(a). Radiation patterns at 88 MHz for Manual Tri-band (MT) antennas on 1978 Mark V.

—— MT 95, — - - — MT 123, — - — MT 202.

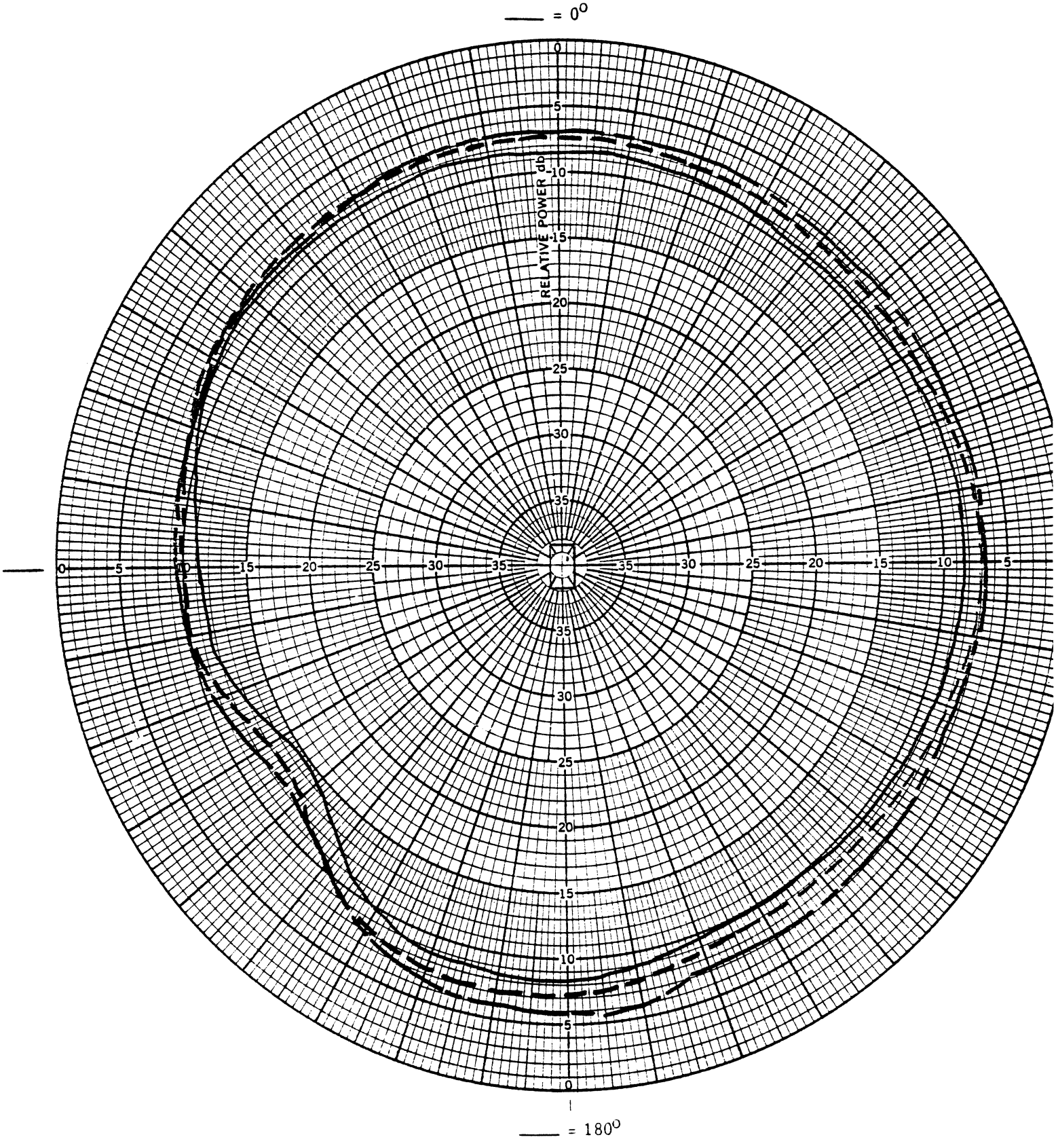


Figure 58(b). Radiation patterns at 98 MHz for Manual Tri-band (MT) antennas on 1978 Mark V.

—— MT 95, — - - — MT 123, — - — MT 202.

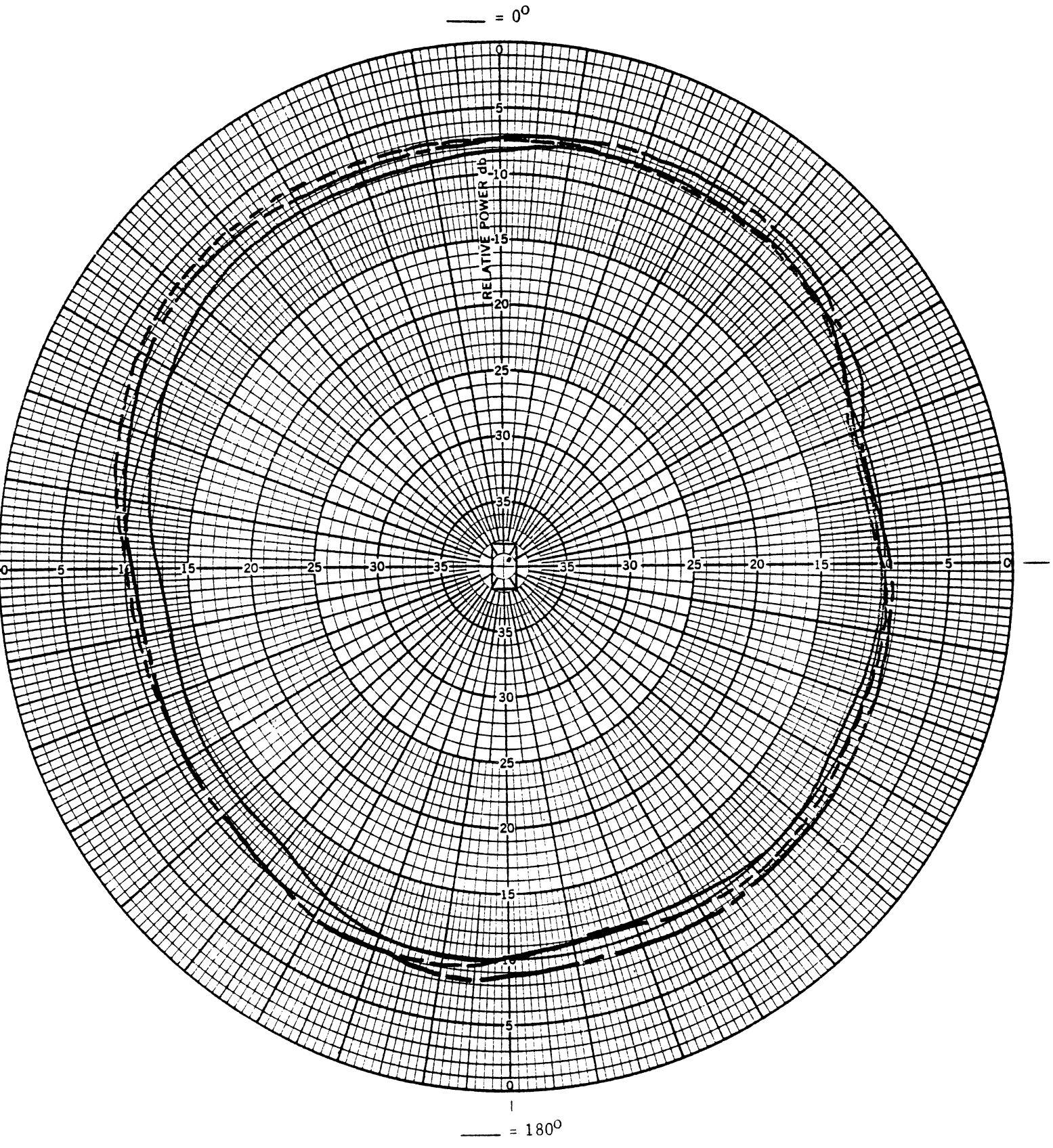


Figure 58(c). Radiation patterns at 108 MHz for Manual Tri-band (MT) antennas on 1978 Mark V.

——— MT 95, ----- MT 123, — - — MT 202.

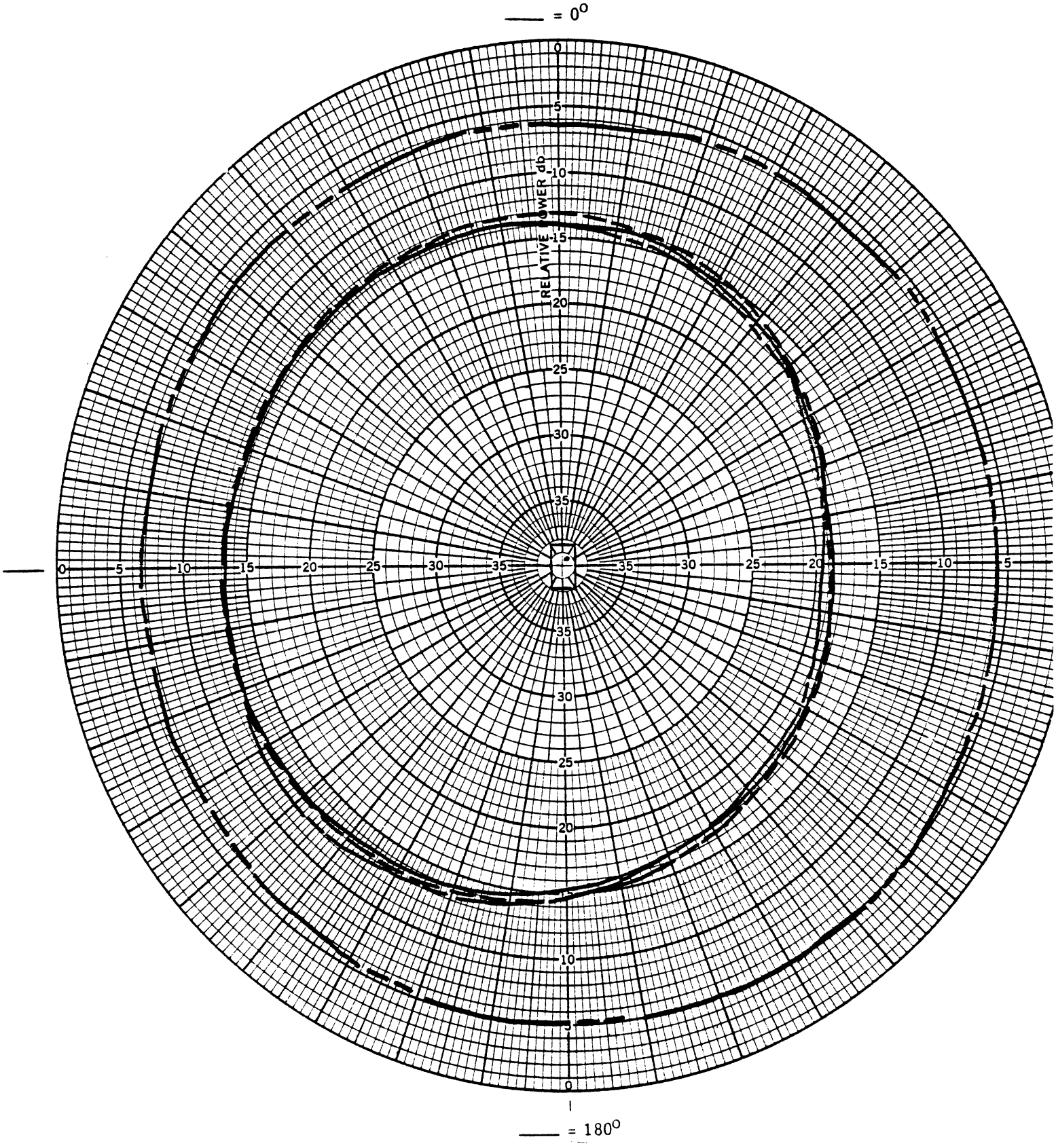


Figure 59(a). Radiation patterns at CB Channel 1 for Manual Tri-band (MT) and reference antennas on 1978 Mark V.

— - - — CB Reference, ——— MT 95, ----- MT 123, — - — MT 202.

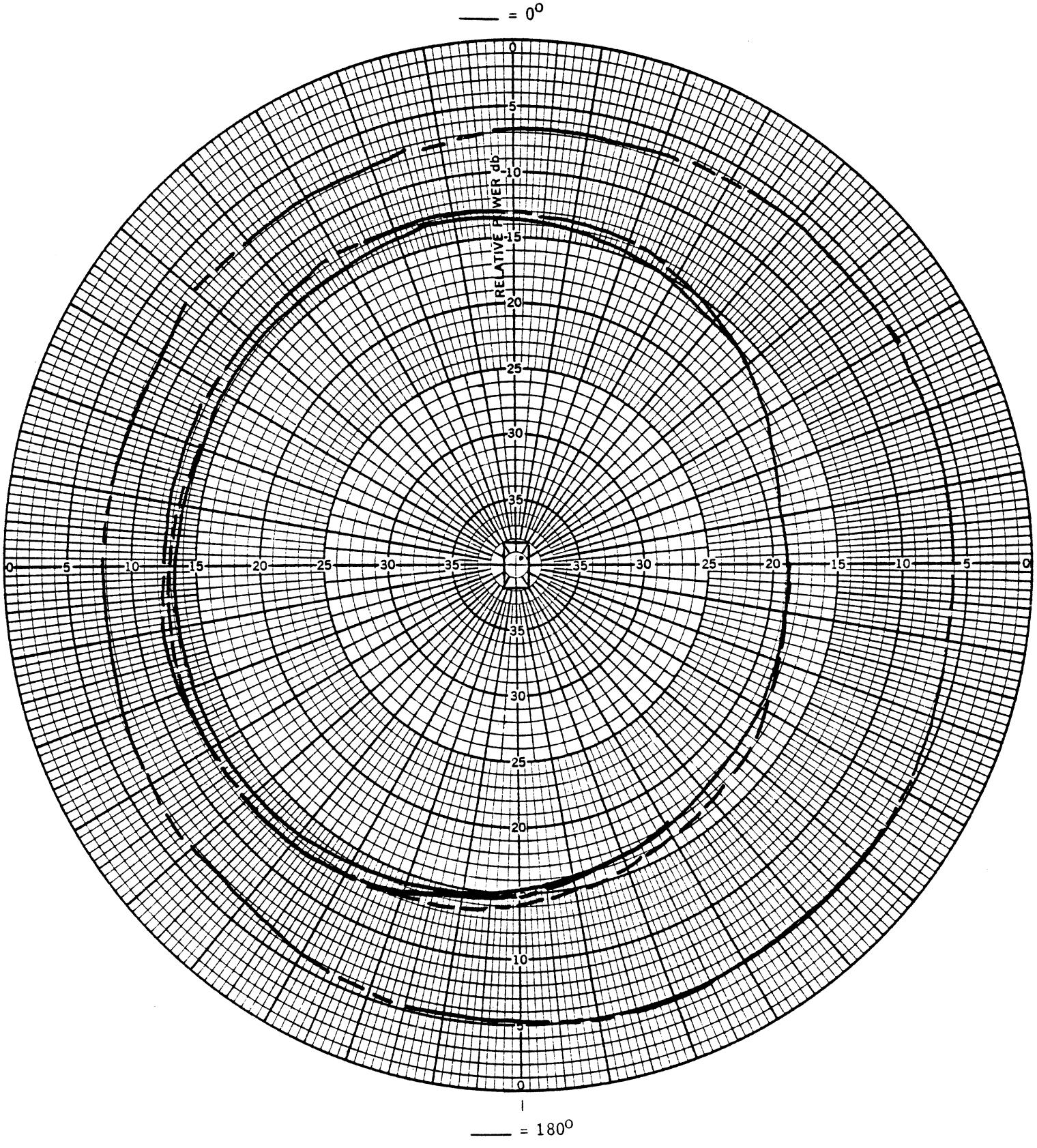


Figure 59(b). Radiation patterns at CB Channel 19 for Manual Tri-band (MT) and reference antennas on 1978 Mark V.

— - - — CB Reference, ——— MT 95, ----- MT 123, — - — MT 202.

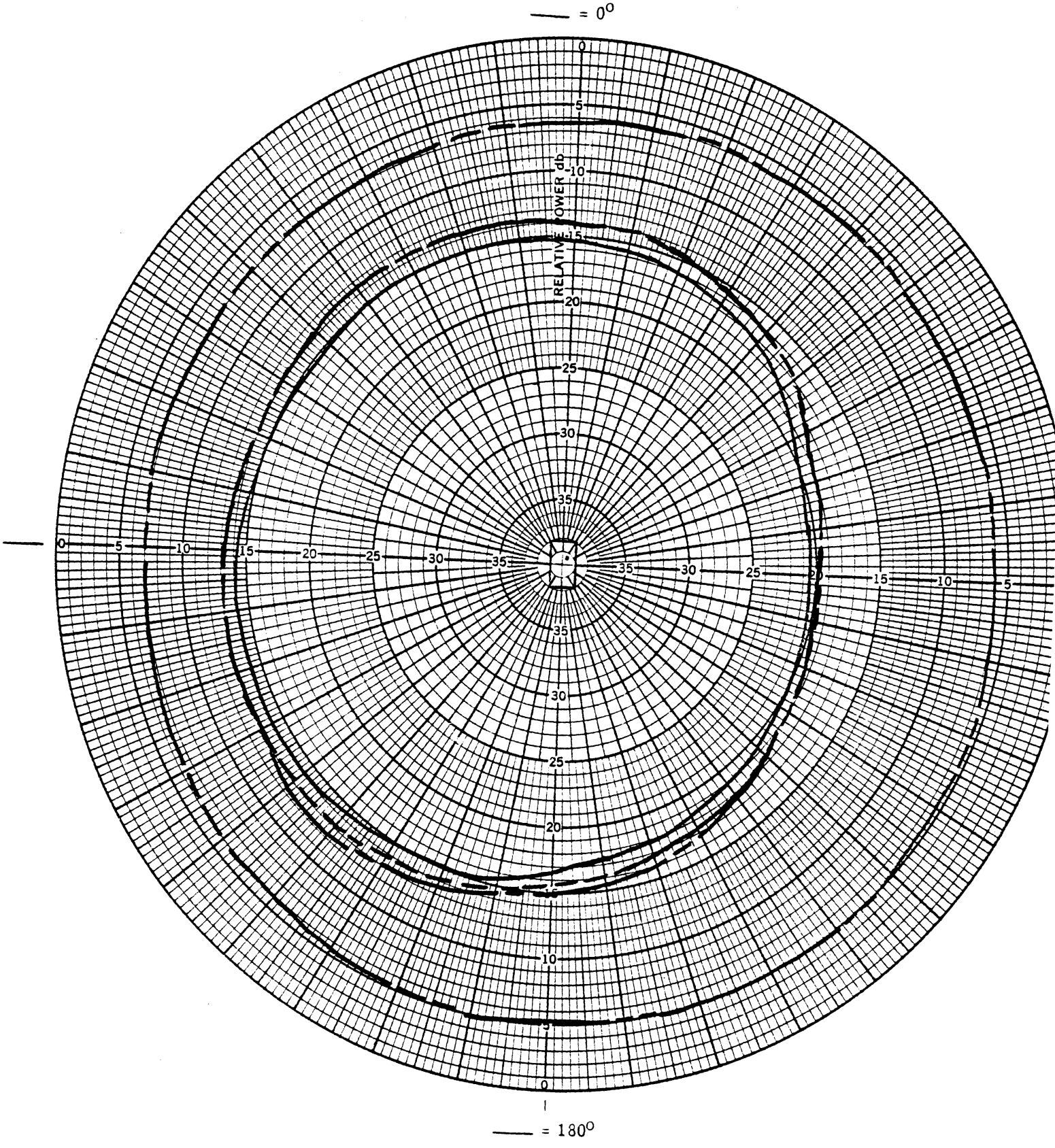
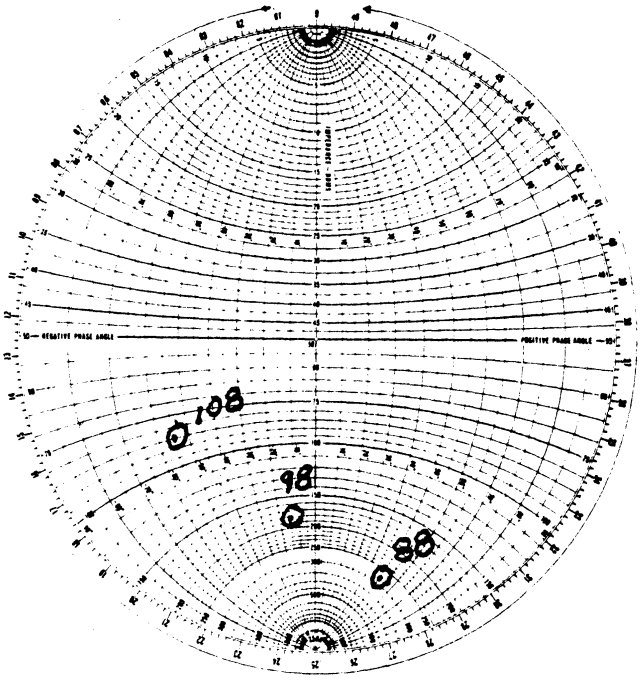
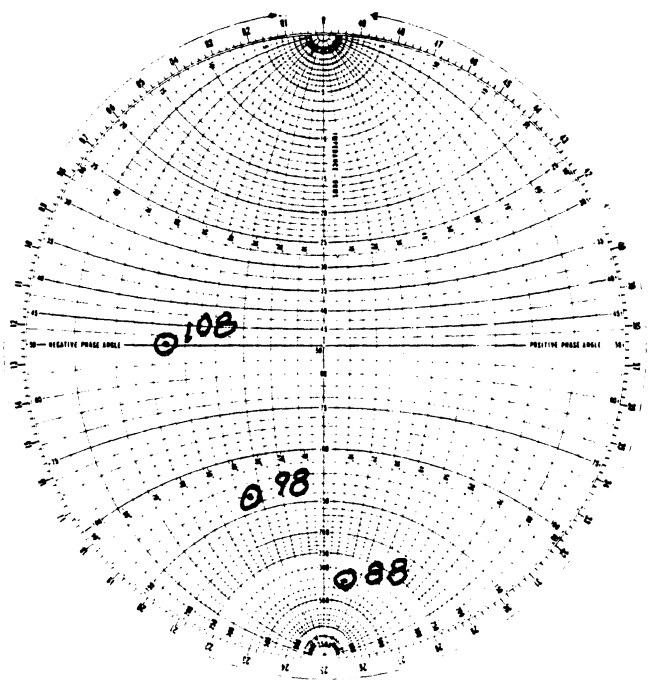


Figure 59(c). Radiation patterns at CB Channel 40 for Manual Tri-band (MT) and reference antennas on 1978 Mark V.

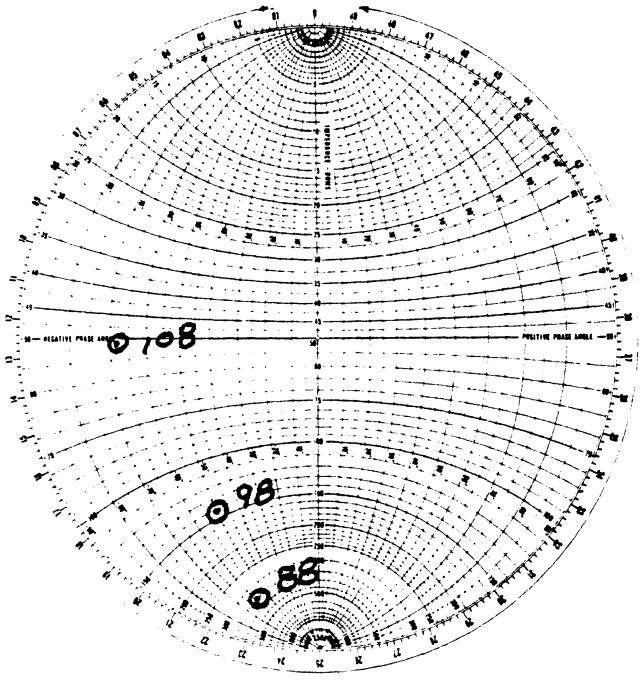
— - - — CB Reference, —— MT 95, ----- MT 123, — - — MT 202.



(a)



(b)



(c)

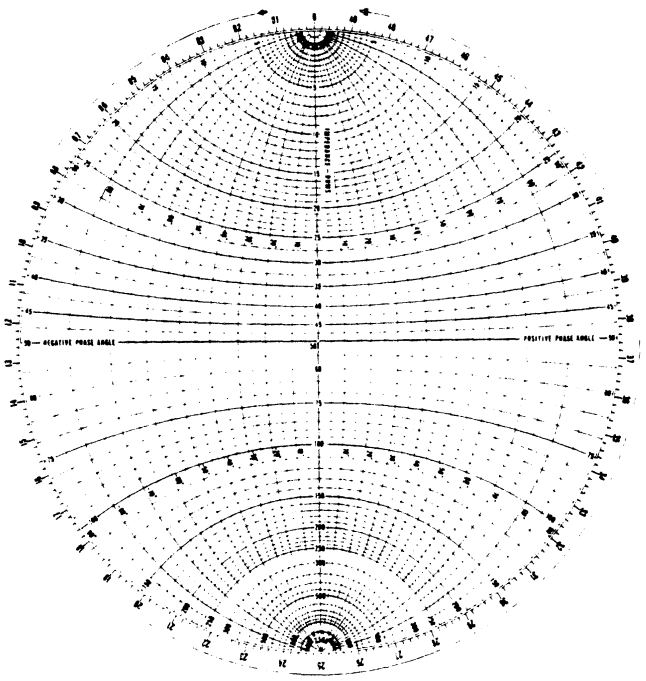
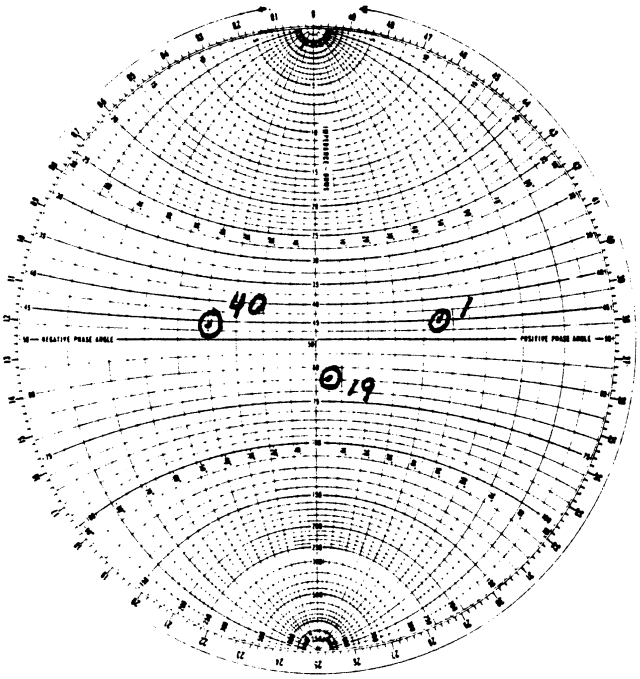
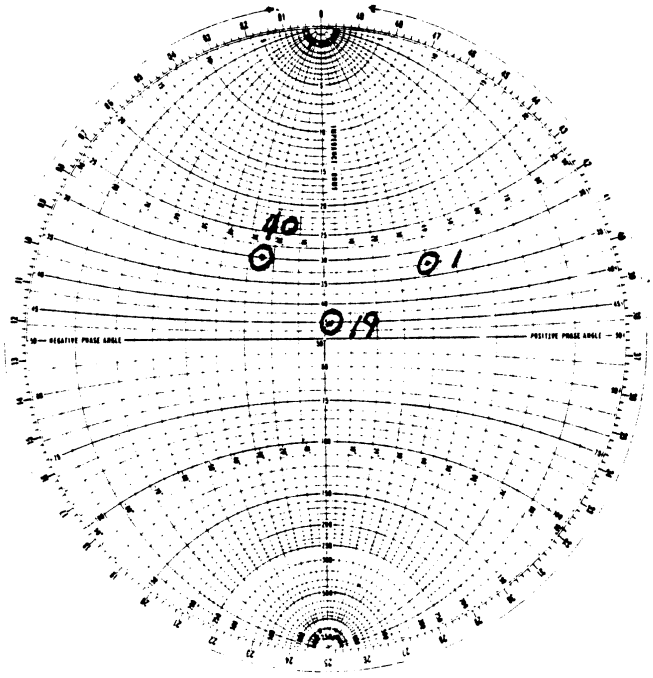


Figure 60. Impedance characteristics in the FM band for Manual Tri-band (MT) antennas on 1978 Mark V.
(a) MT 95, (b) MT 123, (c) MT 202.



(a)



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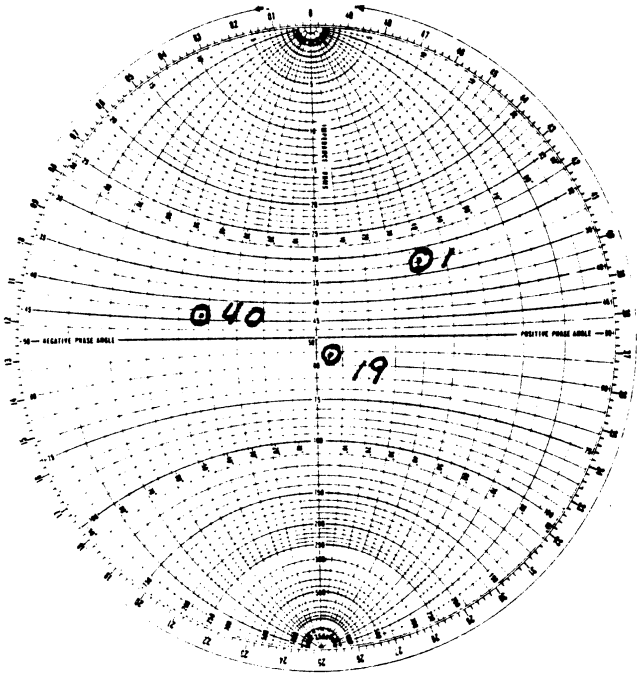


(c)

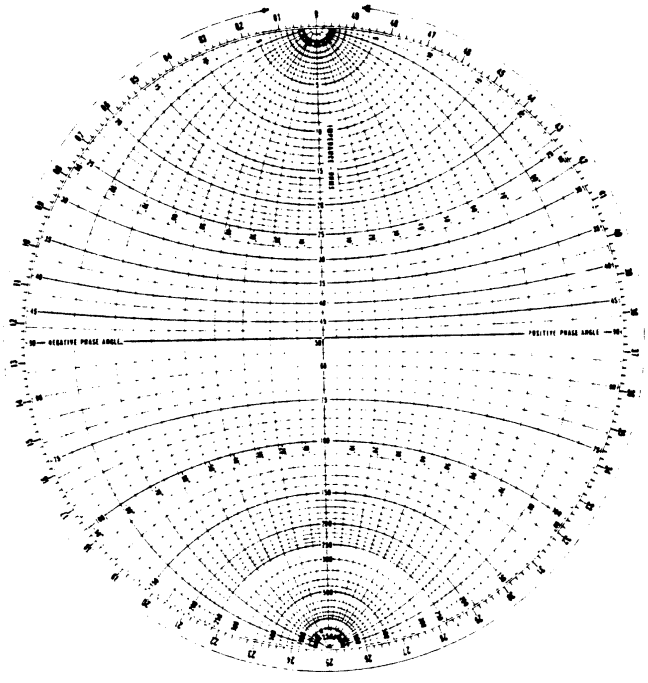


Figure 61. Impedance characteristics at CB frequencies for Manual Tri-band (MT) antennas on 1978 Mark V.
(a) MT 95, (b) MT 123, (c) MT 202.

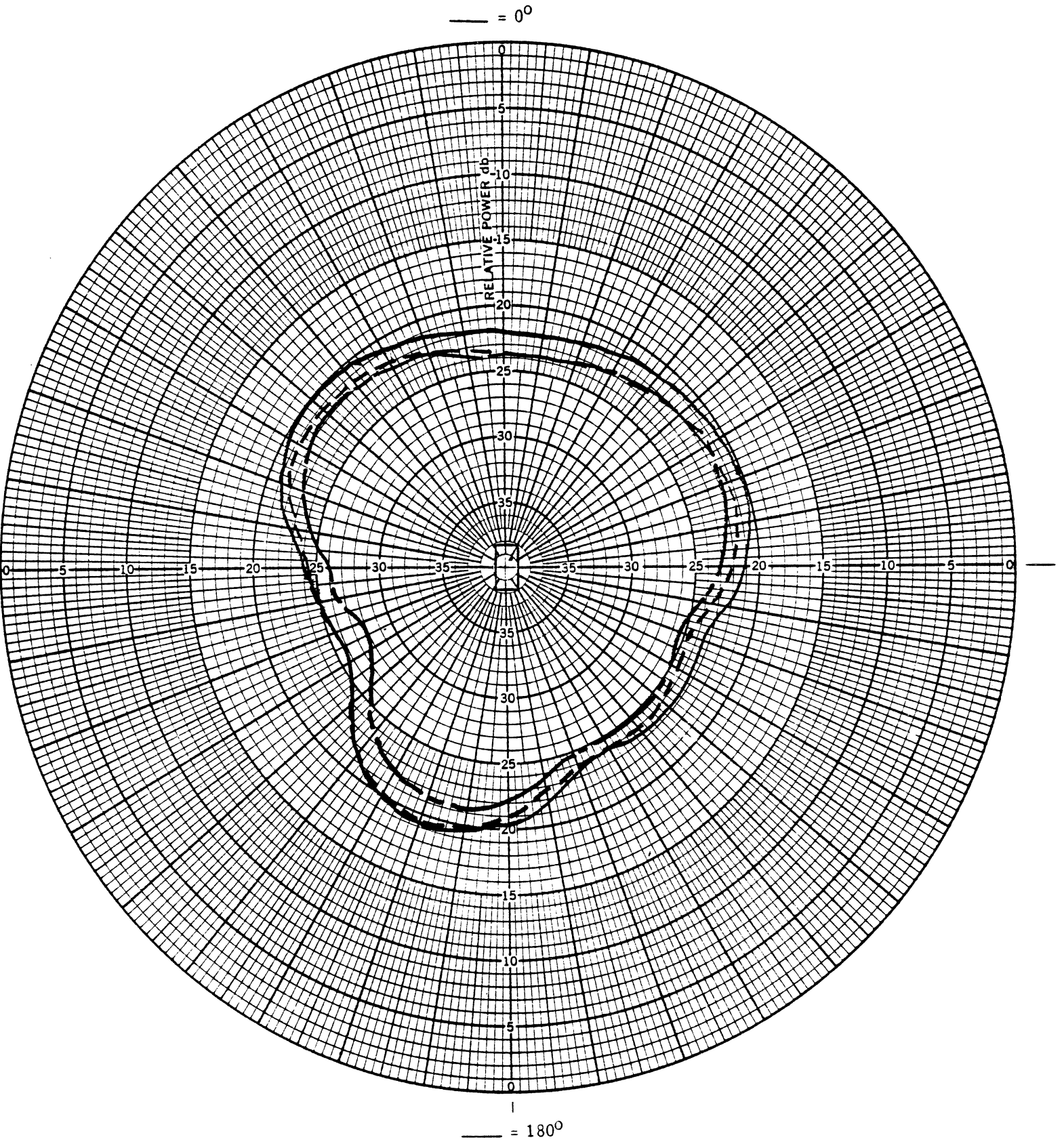


Figure 62(a). Radiation patterns at 88 MHz for Power Tri-band (PT) antennas on 1978 Mark V.

——— PT 95, ----- PT 123, — - — PT 202.

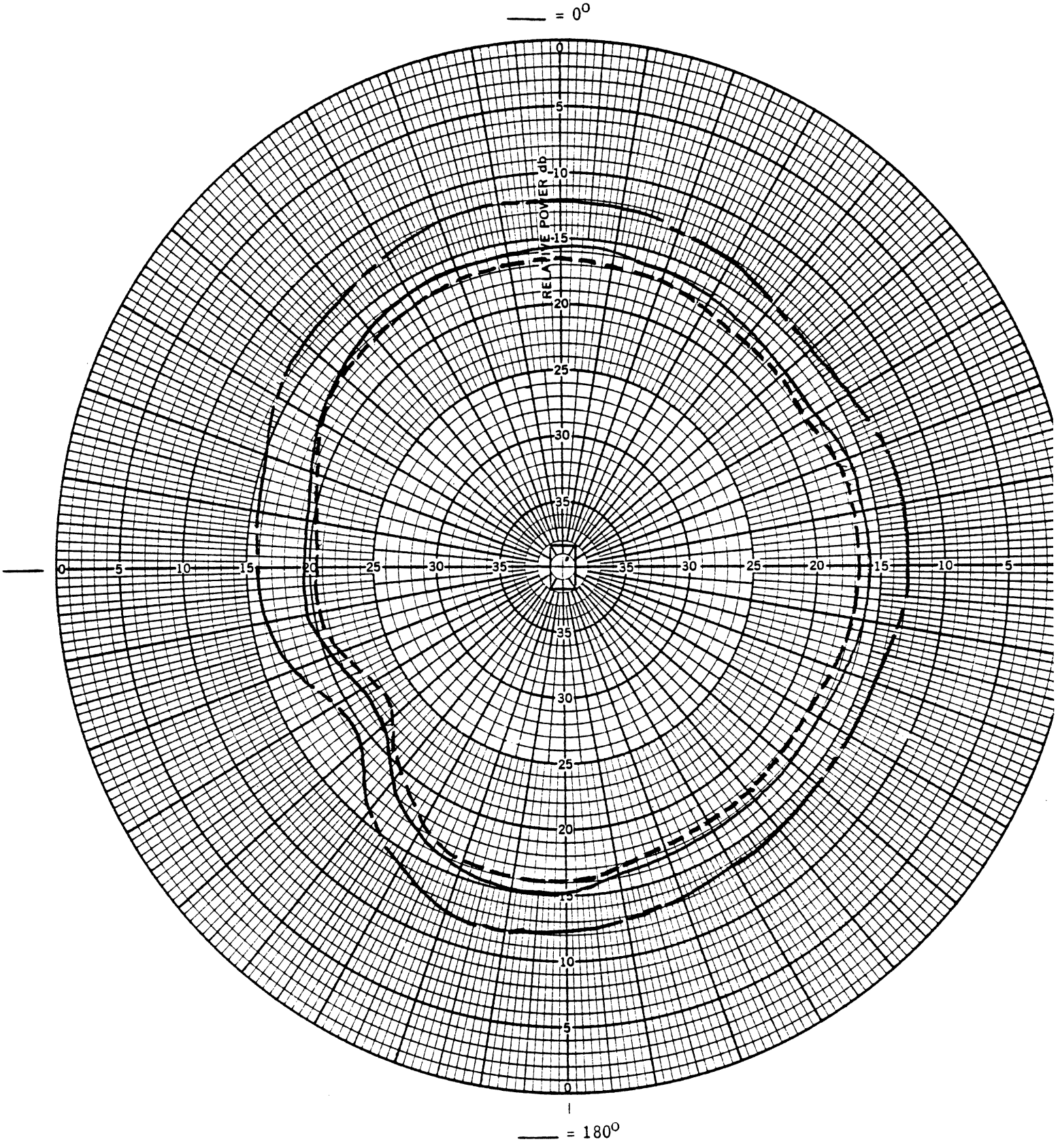


Figure 62(b). Radiation patterns at 98 MHz for Power Tri-band (PT) antennas on 1978 Mark V.

——— PT 95, ----- PT 123, — - — PT 202.

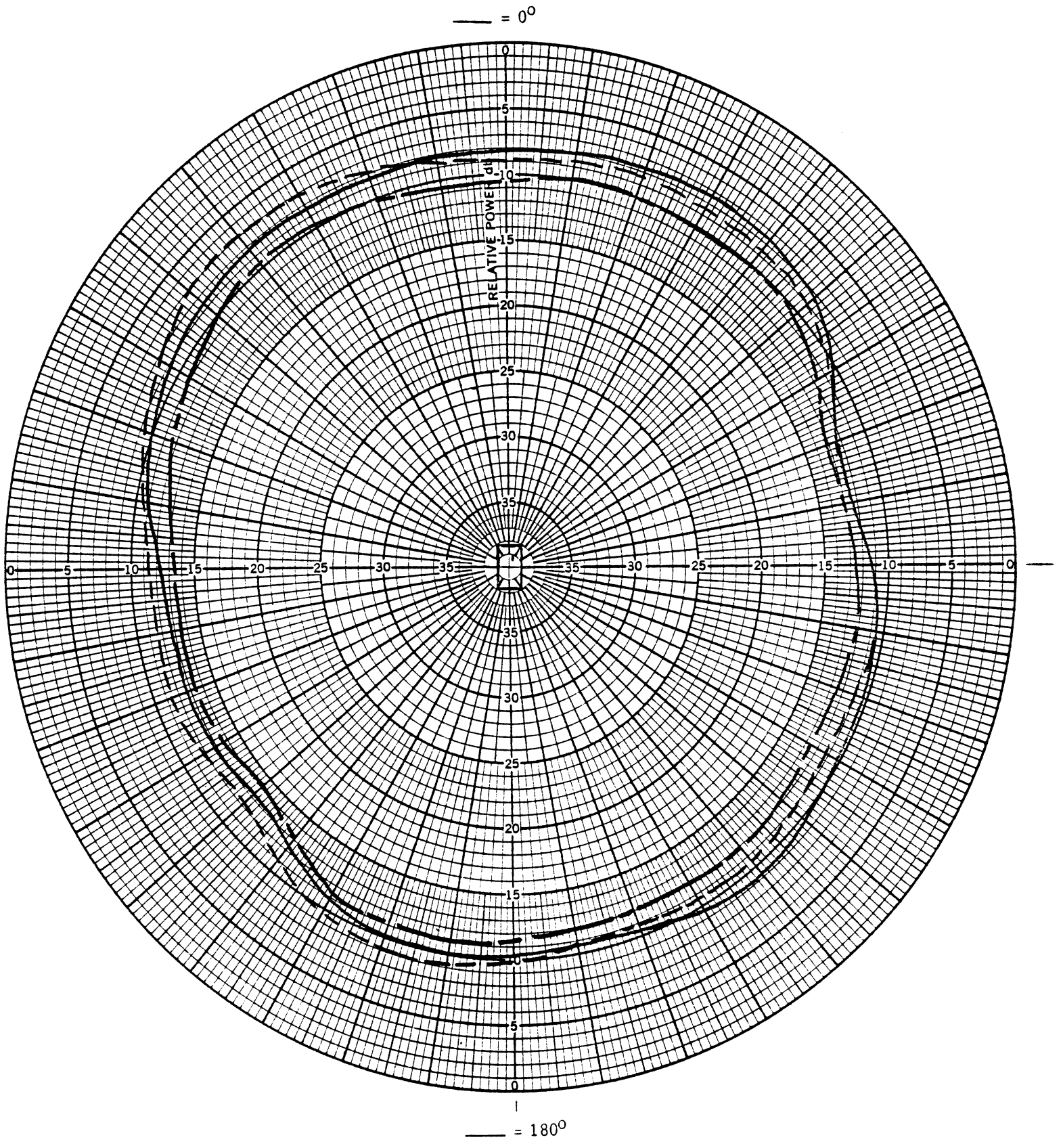


Figure 62(c). Radiation patterns at 108 MHz for Power Tri-band (PT) antennas on 1978 Mark V.

——— PT 95, ----- PT 123, — - — PT 202.

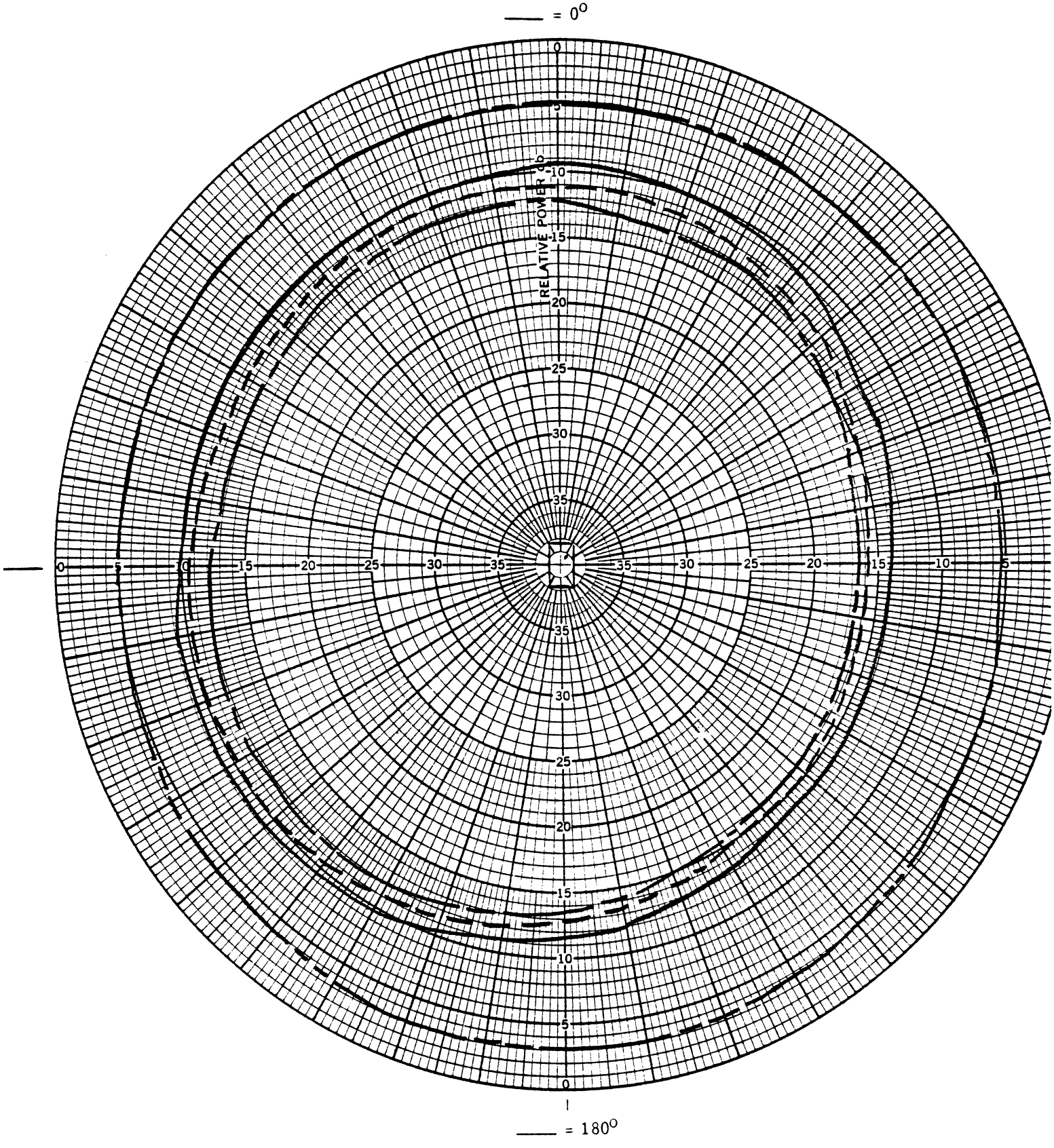


Figure 63(a). Radiation patterns at CB Channel 1 for Power Tri-band (PT) and reference antennas on 1978 Mark V.

— - - — CB Reference, ——— PT 95, ----- PT 123, — - — PT 202.

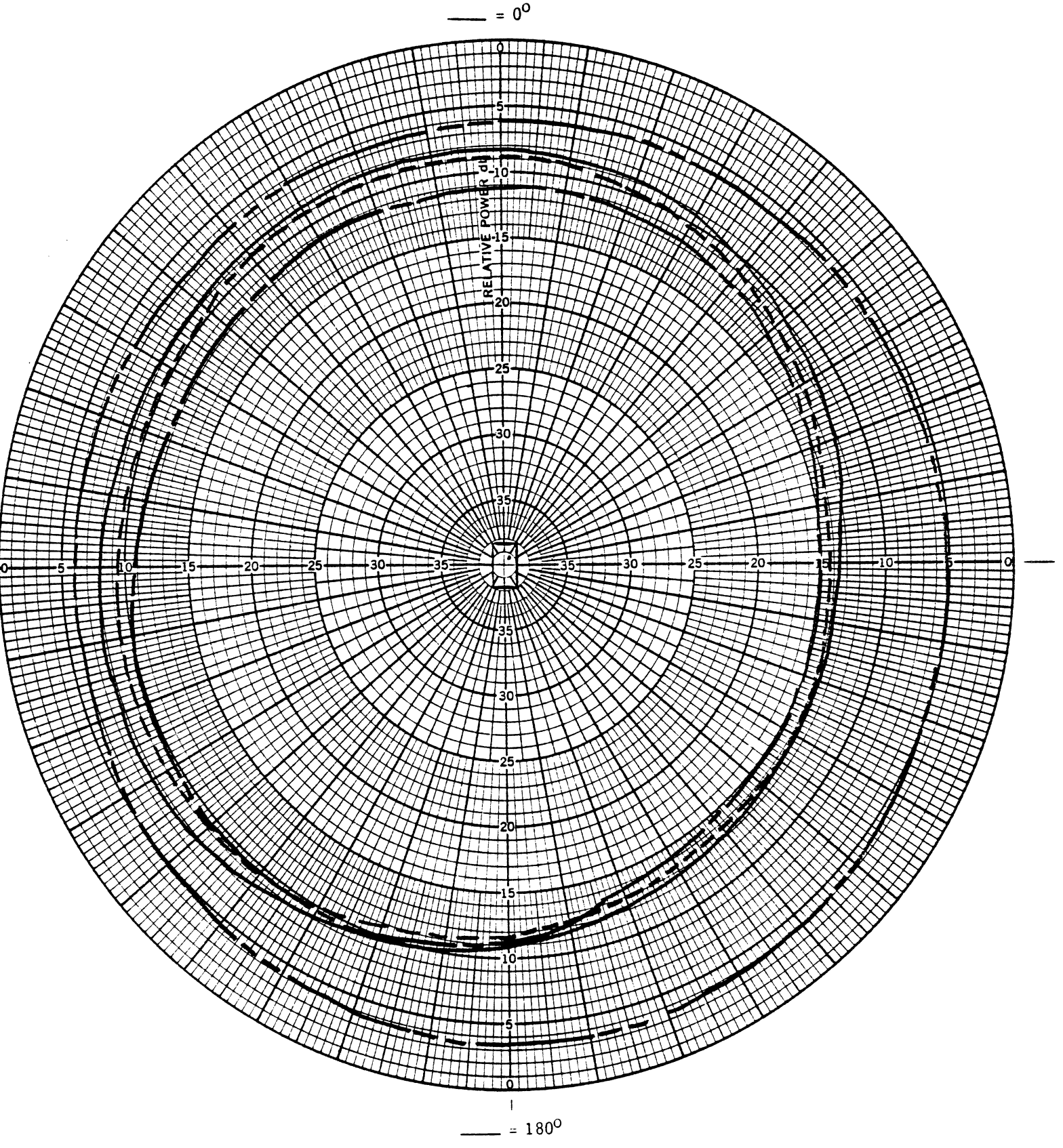


Figure 63(b). Radiation patterns at CB Channel 19 for Power Tri-band (PT) and reference antennas on 1978 Mark V.

— - - — CB Reference, ——— PT 95, ----- PT 123, — - — PT 202.

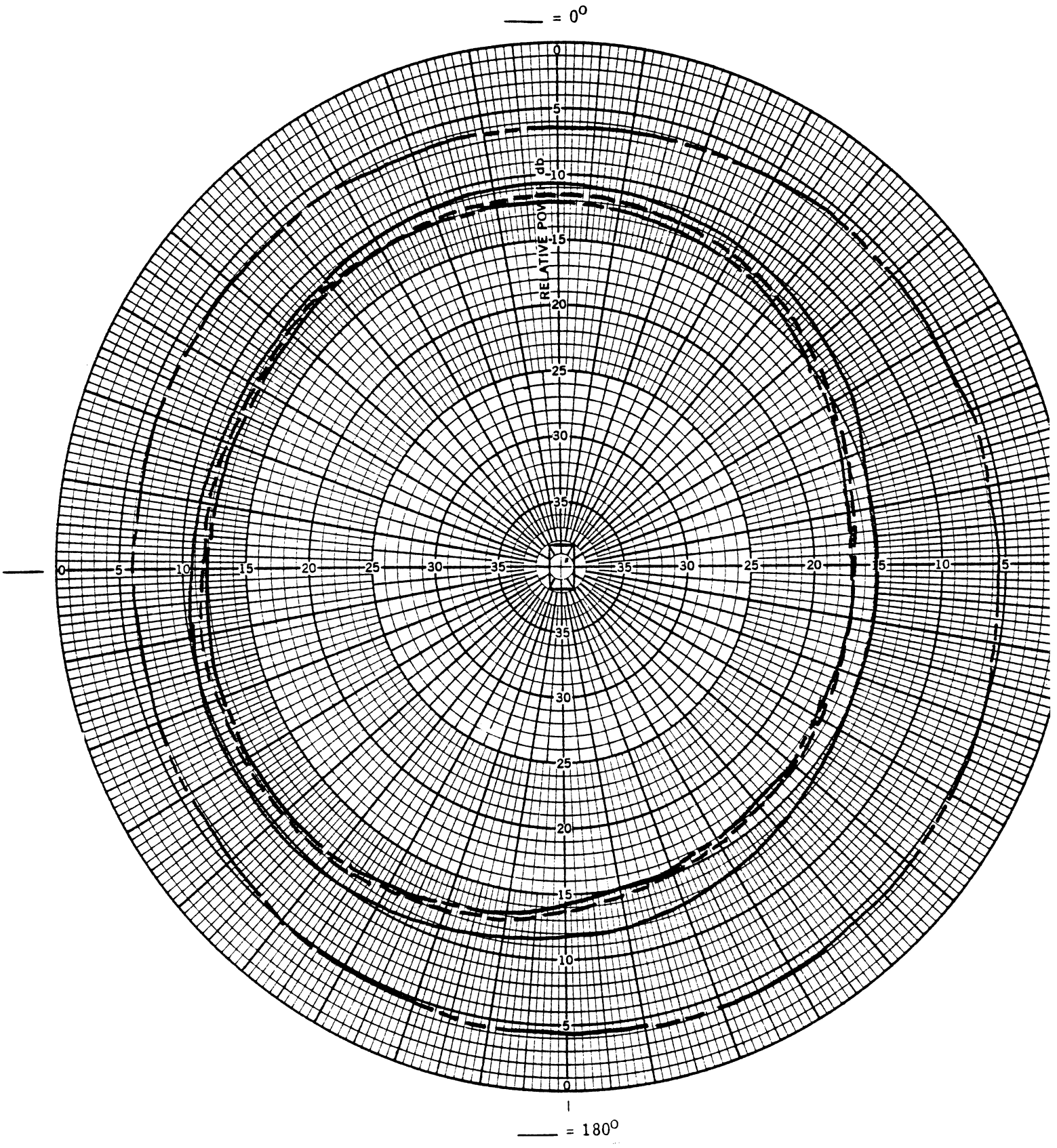
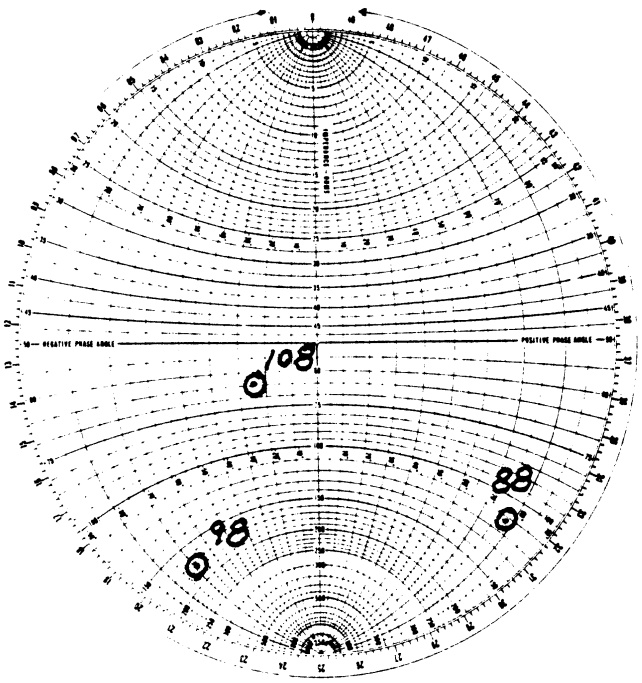
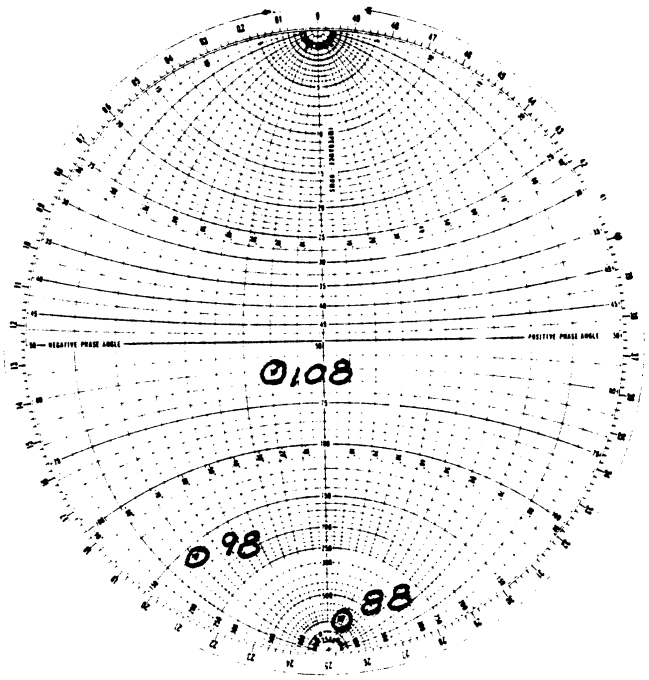


Figure 63(c). Radiation patterns at CB Channel 40 for Power Tri-band (PT) and reference antennas on 1978 Mark V.

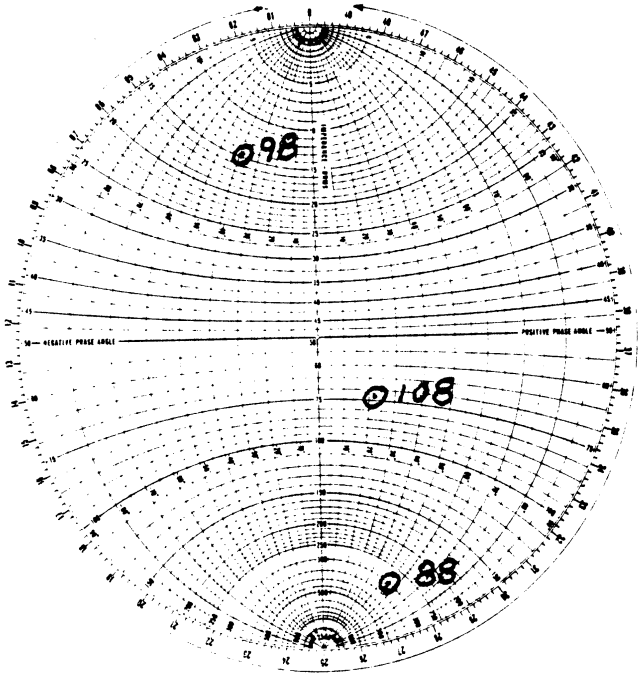
— - - — CB Reference, ——— PT 95, ----- PT 123, — - — PT 202.



(a)



(b)



(c)

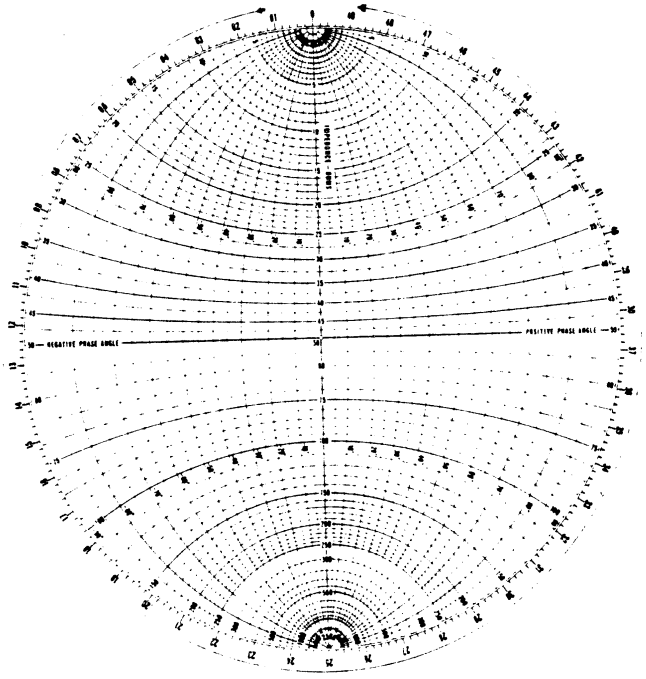
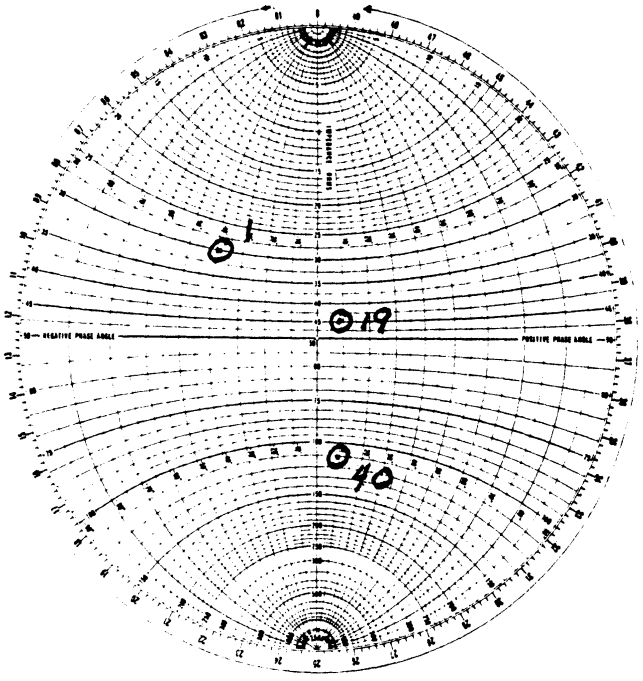
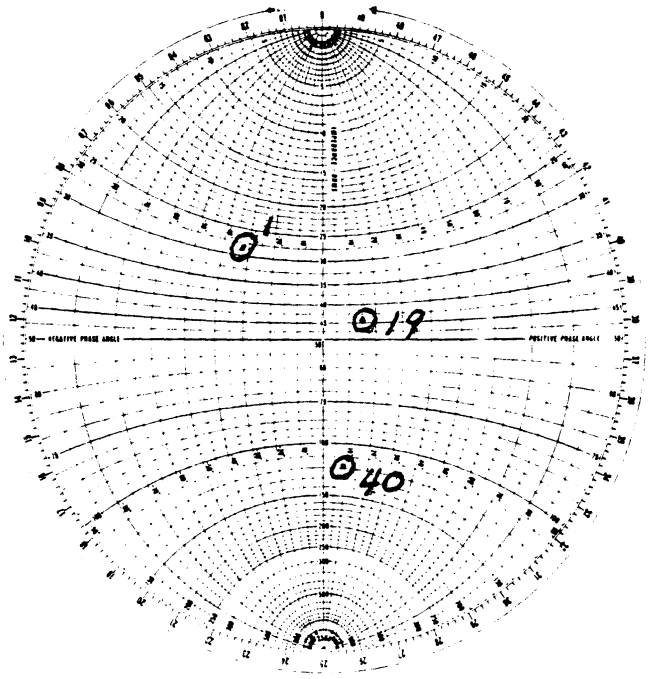


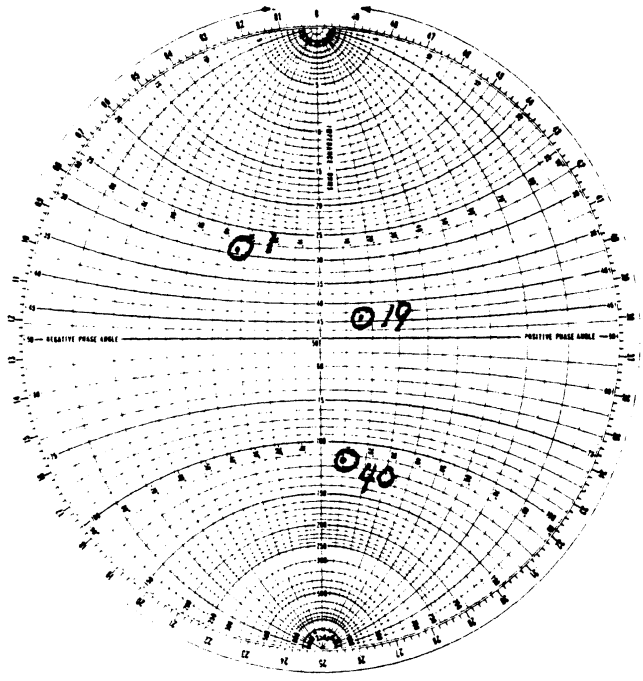
Figure 64. Impedance characteristics in the FM band for Power Tri-band (PT) antennas on 1978 Mark V.
(a) PT 95, (b) PT 123, (c) PT 202.



(a)



(b)



(c)

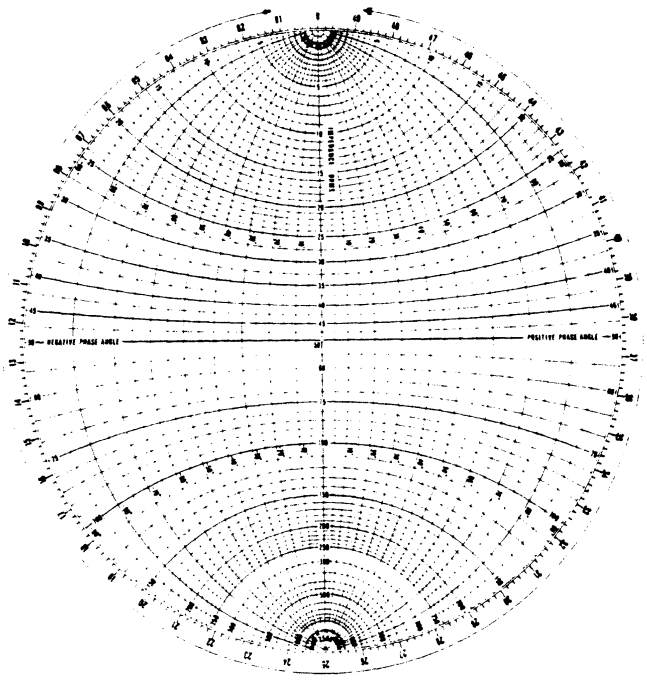


Figure 65. Impedance characteristics at CB frequencies for Power Tri-band (PT) antennas on 1978 Mark V.
(a) PT 95, (b) PT 123, (c) PT 202.

TABLE 11. PERFORMANCE DATA FOR TEST ANTENNAS ON 1978 LINCOLN MARK V

PERFORMANCE COMPARISON						
PARAMETER	ANTENNA TYPE					
	MT			PT		
	95	123	202	95	123	202
AM Sensitivity (dB/m)						
0.76 MHz	-66	-64	-59	-63	-65	-62
1.10 MHz	-76	-71	-68	-71	-73	-70
1.60 MHz	-84	-81	-76	-81	-82	-78
Relative FM Sensitivity (dB)						
88 MHz	-1.1	0	-4.0	+1.0	0	0
98 MHz	-1.2	0	0	+0.7	0	+4.5
108 MHz	-1.0	0	0	+0.8	0	-1.2
Relative CB Sensitivity (dB)						
CH 1	-0.5	0	-0.8	+1.2	0	-0.9
CH 19	-0.9	0	-2.0	+0.2	0	-2.0
CH 40	-1.1	0	-0.2	+0.5	0	-0.5
FM VSWR						
88 MHz	8.89	7.89	15.6	15.0	17.92	12.33
98 MHz	3.87	3.25	4.9	10.6	10.74	4.59
108 MHz	3.89	3.0	5.22	1.72	1.51	1.68
CB VSWR						
CH 1	2.43	2.52	2.50	2.53	2.40	2.42
CH 19	1.31	1.11	1.15	1.22	1.34	1.32
CH 40	2.19	2.47	2.29	2.33	2.44	2.42
Isolation (mv)						
CH 1	245	215	720	175	190	208
CH 19	128	109	460	100	230	238
CH 40	160	195	360	170	400	228
AM Capacitance						
0.5 MHz	98.7	125.2	209.8	98.7	125.2	209.8
1.0 MHz	99.4	127.0	212.1	99.4	127.0	212.1
1.5 MHz	112.5	130.0	215.5	112.5	130.0	215.5
AM Q						
0.5 MHz	1334	741	511	1162	1032	1457
1.0 MHz	1814	1082	404	902	680	1052
1.5 MHz	2251	1141	243	640	485	694

VII. STUDY OF SPLITTER BOX

This chapter presents the results of a study to evaluate the impedance characteristics of the AM/FM and CB ports (ports 1 and 2 respectively in Figure 4) of the splitter boxes associated with the tri-band antennas. The measurements were carried out without cars and following the procedure outlined in section 2.5. One manual entertainment (ME) antenna of length 32 1/4" and two base-loaded tri-band antennas (MT and Motorola), each of length 40", and mounted on a 4 foot - square ground plane were used as test antennas. The loading coil of each tri-band antenna had a tuning slug which could be adjusted for a desirable VSWR at the CB frequencies. During the measurement the tuning post was placed at the top, middle and bottom positions, and at each position the effects on the VSWR at the CB and FM ports were studied.

Impedance properties of four splitter boxes, referred to as Box 1 (square type), Box 3 and 6 (round type: they are similar) and Motorola Box, were used. As shown in Figure 5 , each splitter box circuit consists of two distinct branches. One (the AM/FM branch) consists of a parallel tuned circuit, tuned to the CB frequency, whose purpose is to isolate the CB signal from the AM/FM radio. The second branch, called the CB branch, consists of a series L-C circuit tuned to a frequency in the CB band, and guides the signal from the antenna to the CB port and vice versa. The tuning frequencies of these two circuits can be adjusted with the help of two tuning slugs, referred to as the FM and CB slugs, respectively.

7.1. Results

Figure 66 shows the CB and FM band impedances of the MT antenna as a function of the position of the tuning slug in the loading coil. Observe that the position of the tuning slug does not appreciably change the FM impedance, but has considerable effect on the CB impedance of the antenna.

Figure 67 shows the FM and CB band impedances at the appropriate ports (1 and 2, respectively) of splitter box 6, obtained with the antenna port (port 3) terminated with 100 Ω load. While obtaining the FM and CB

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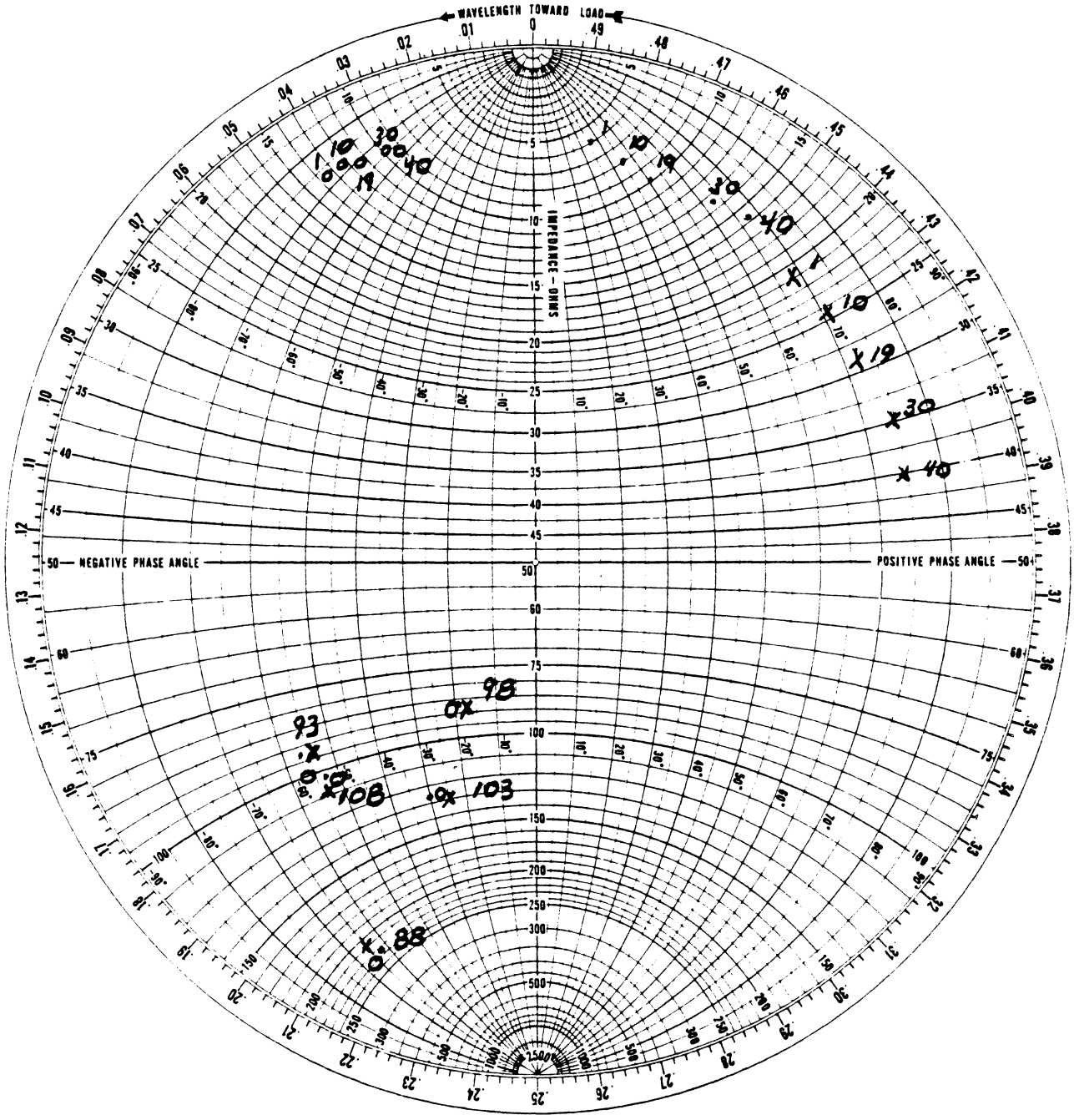

Figure 66. Effects of the antenna tuning slug positions on the test antenna impedances at FM and CB frequencies.

o slug at top, • Slug at middle, x slug at bottom.

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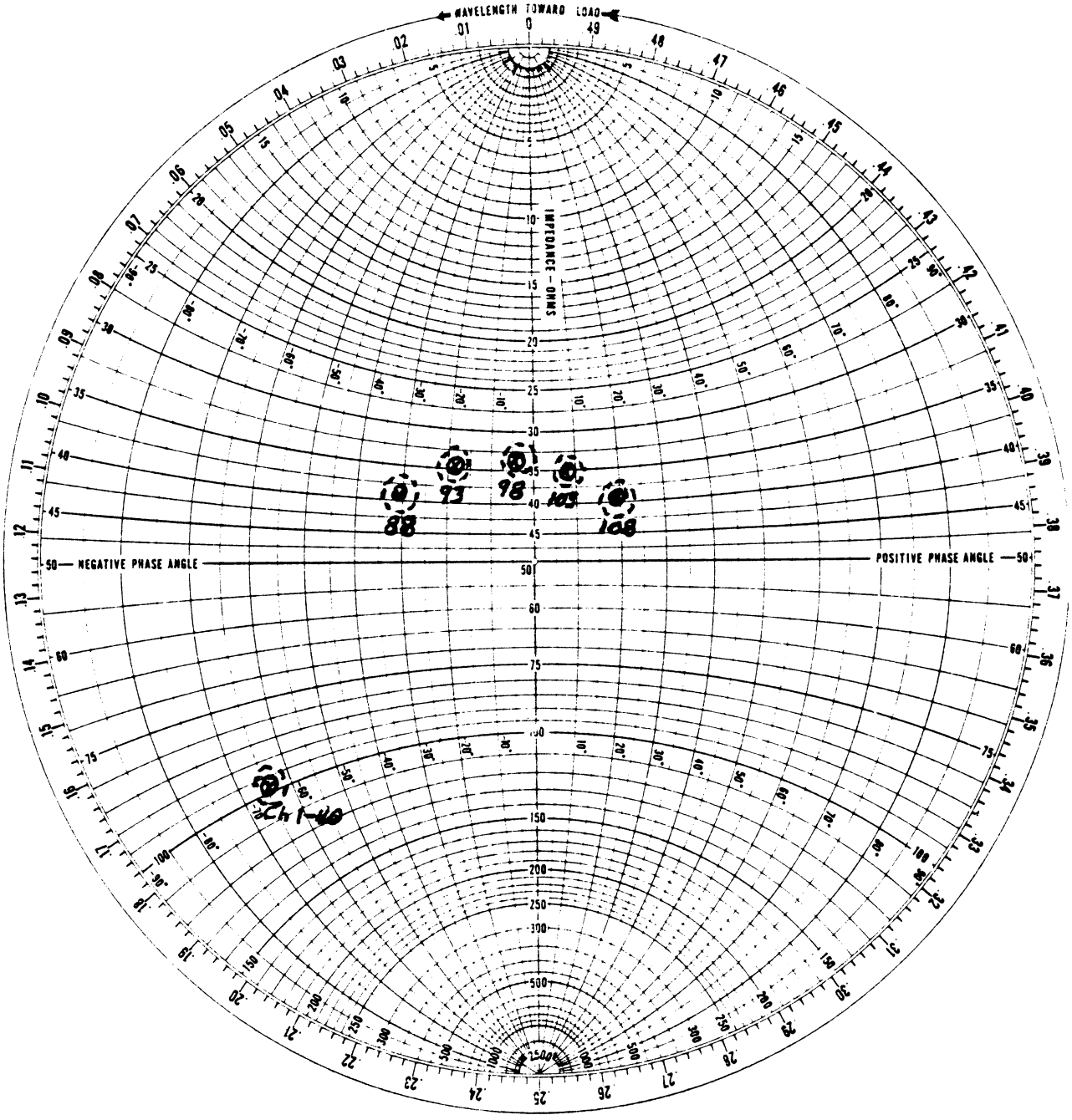

Figure 67. Effects of FM tuning slug position on the CB and FM band impedance of the test antenna connected to the splitter box 6 with CB slug in all the way.

◌ slug at top, O slug at middle, x slug at bottom.

results, the CB and FM ports were terminated by 50 Ω and 100 Ω loads, respectively. The results shown in Figure 67 were measured with the CB tuning slug in all the way and with three positions of the FM tuning (or isolation) slug. The data indicate that the adjustment of the FM tuning slug has no effect on the impedances at the FM and CB ports of the splitter box.

Figure 68 shows the effects of the CB tuning slug position of the impedance on CB channel 19 at port 2 of the splitter box 3 with ports 1 and 3 terminated by 100 Ω and 50 Ω, respectively. Note that the positions of the CB tuning slug are represented by 1, 2 . . . 8 in Figure 68 with 1 signifying that the slug is all the way in and 8 signifying that the slug is completely out. From these results it is possible to obtain the effective impedance of the series L-C circuit of the CB branch of the splitter box.

Figures 69(a)-(b) show the FM band and CB impedances of the MT antenna connected to the splitter box 1. The corresponding impedances of the antenna without the splitter box are also shown in Figure 60 for comparison. The corresponding results obtained with the MT antenna connected to splitter box 3 are shown in Figures 70(a) and (b), and for the Motorola antenna and its associated splitter box in Figures 71(a) and (b). The results indicate that the splitter box generally transforms the CB port impedance towards matching, whereas the transformed impedances at the FM ports generally stay away from the matching condition.

Figure 72 shows the FM band impedance of the ME antenna which does not need a splitter box. The results are presented here to indicate that this antenna is far from matched at the FM frequency and hence would produce large VSWR.

7.2. Discussion

Based on the above results the following comments are made concerning the performance of the splitter box:

(i) The adjustment of the FM tuning slug does not affect the impedances at the FM and CB posts of the splitter box, and merely isolates the CB

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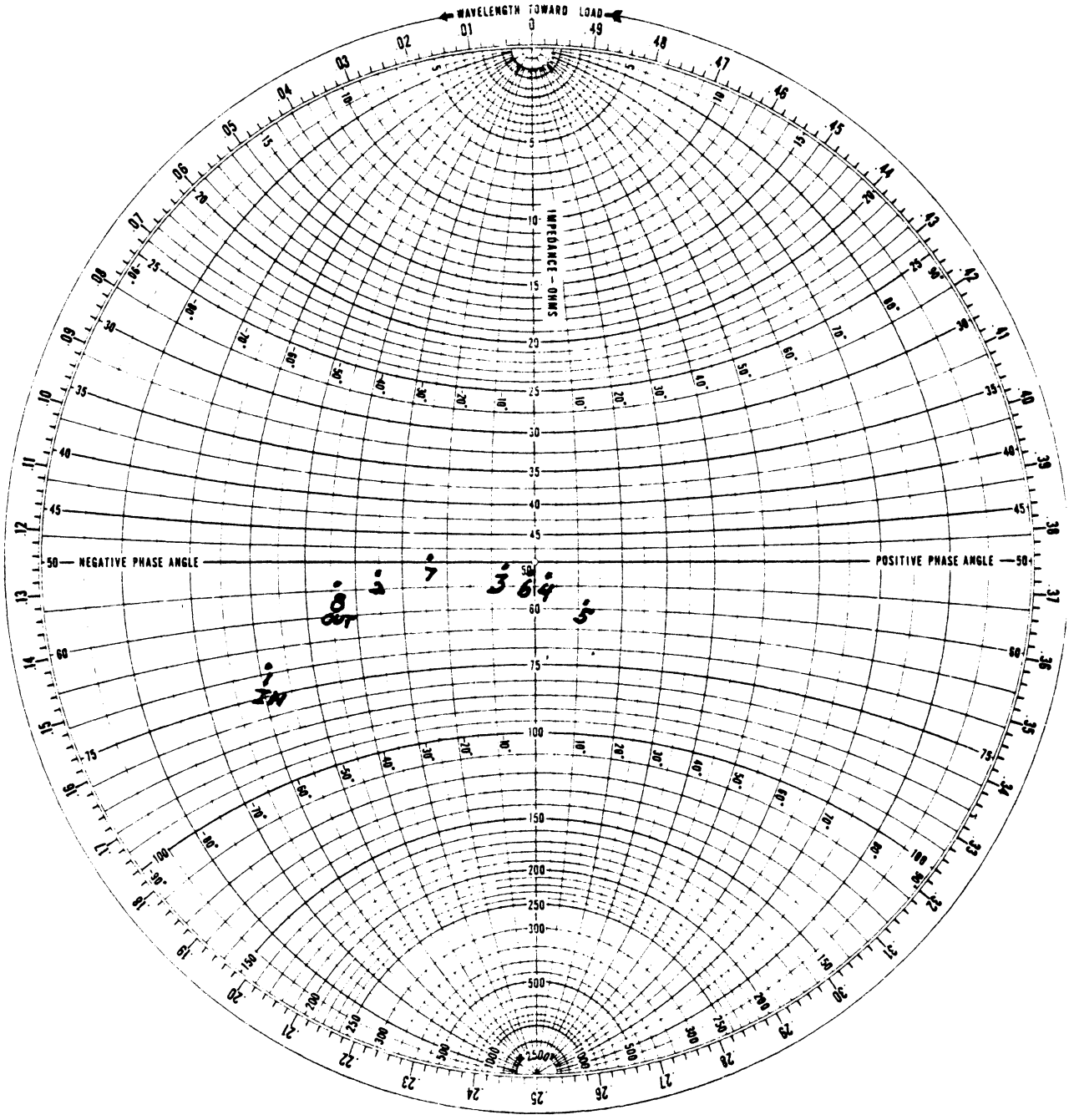

Figure 68. Effect of the CB tuning slug position on the impedance at Channel 19 for the test antenna connected to splitter box 3.

1 - slug in all the way, 8 - slug out all the way.

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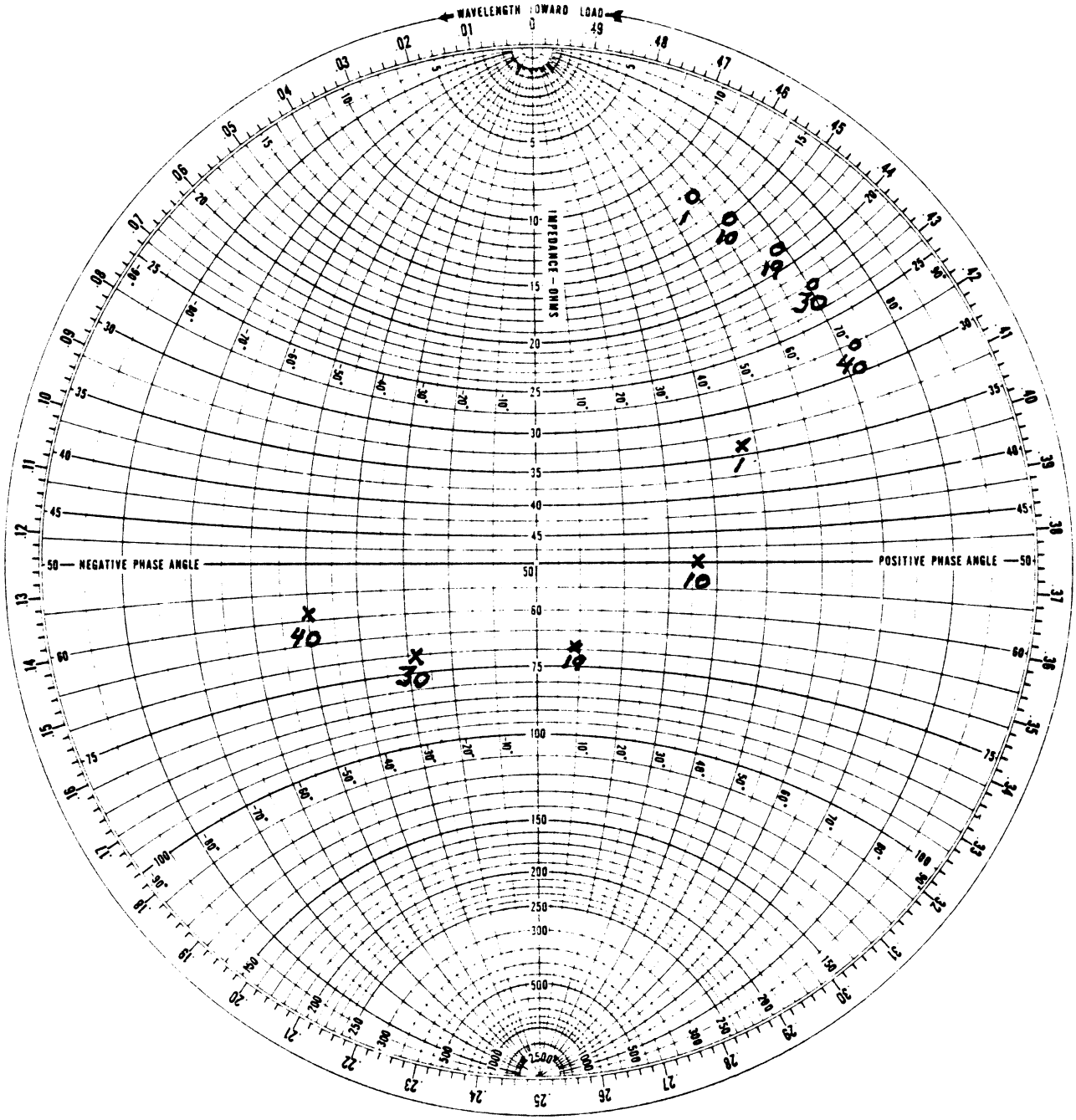

Figure 69(a). Impedance characteristics obtained with splitter box 1 and test antenna for CB band.

oooo antenna only, xxxx antenna + splitter box

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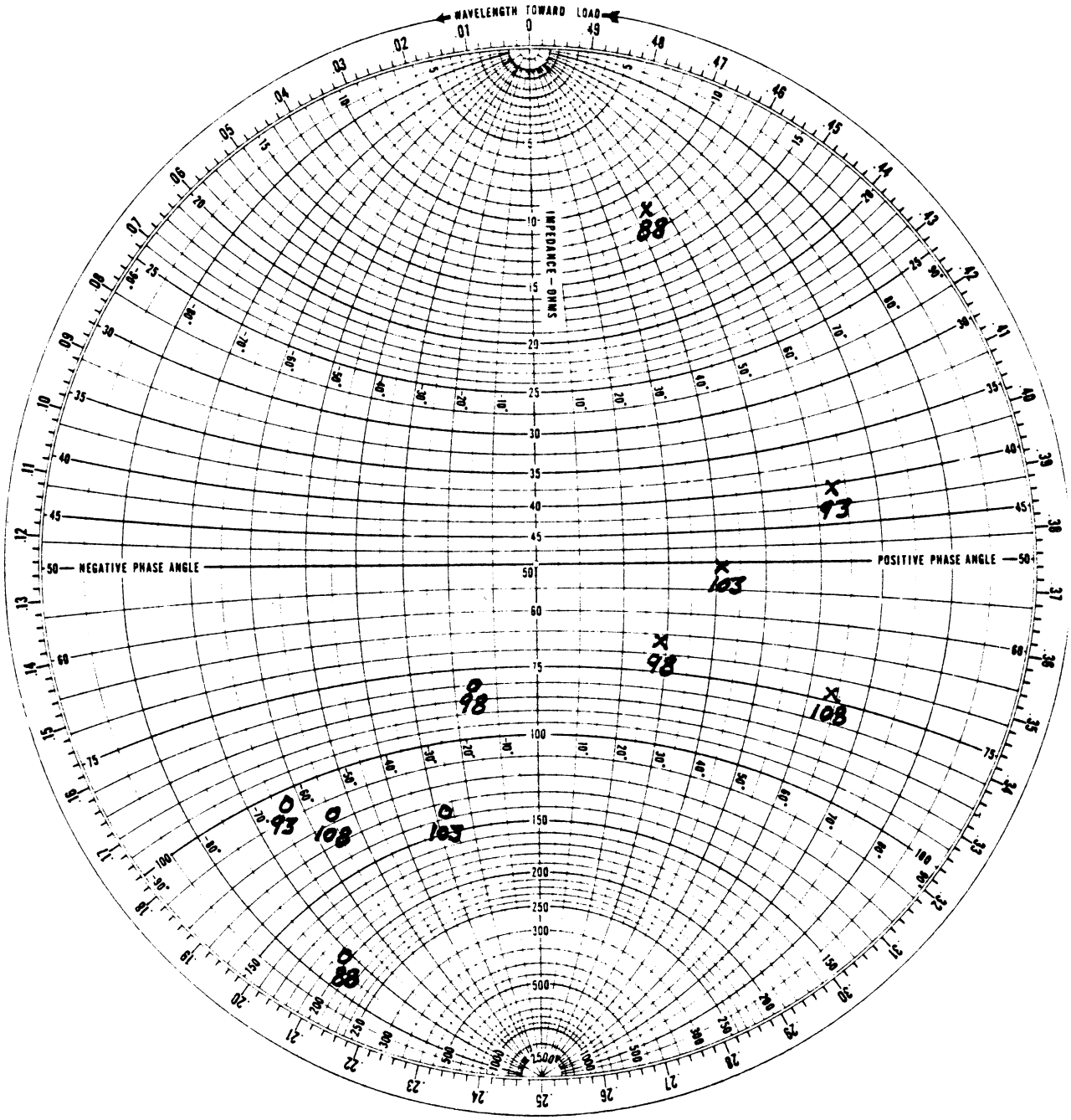

Figure 69(b). Impedance characteristics obtained with splitter box 1 and test antenna for FM band.

oooo antenna only, xxxx antenna + splitter box

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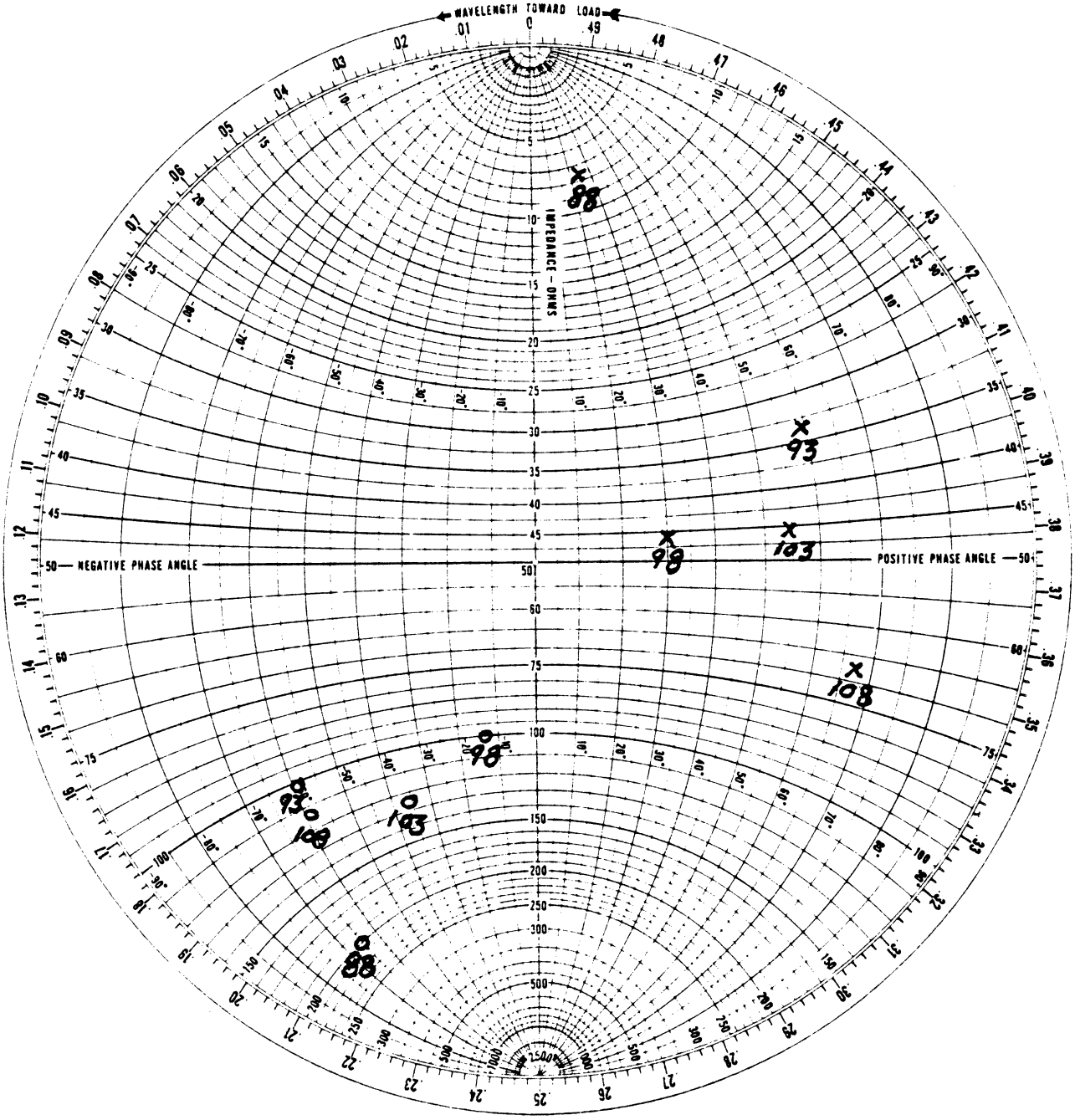

Figure 70(a). Impedance characteristics obtained with splitter box 3 and test antenna for FM band.

oooo antenna only, xxxx antenna + splitter box

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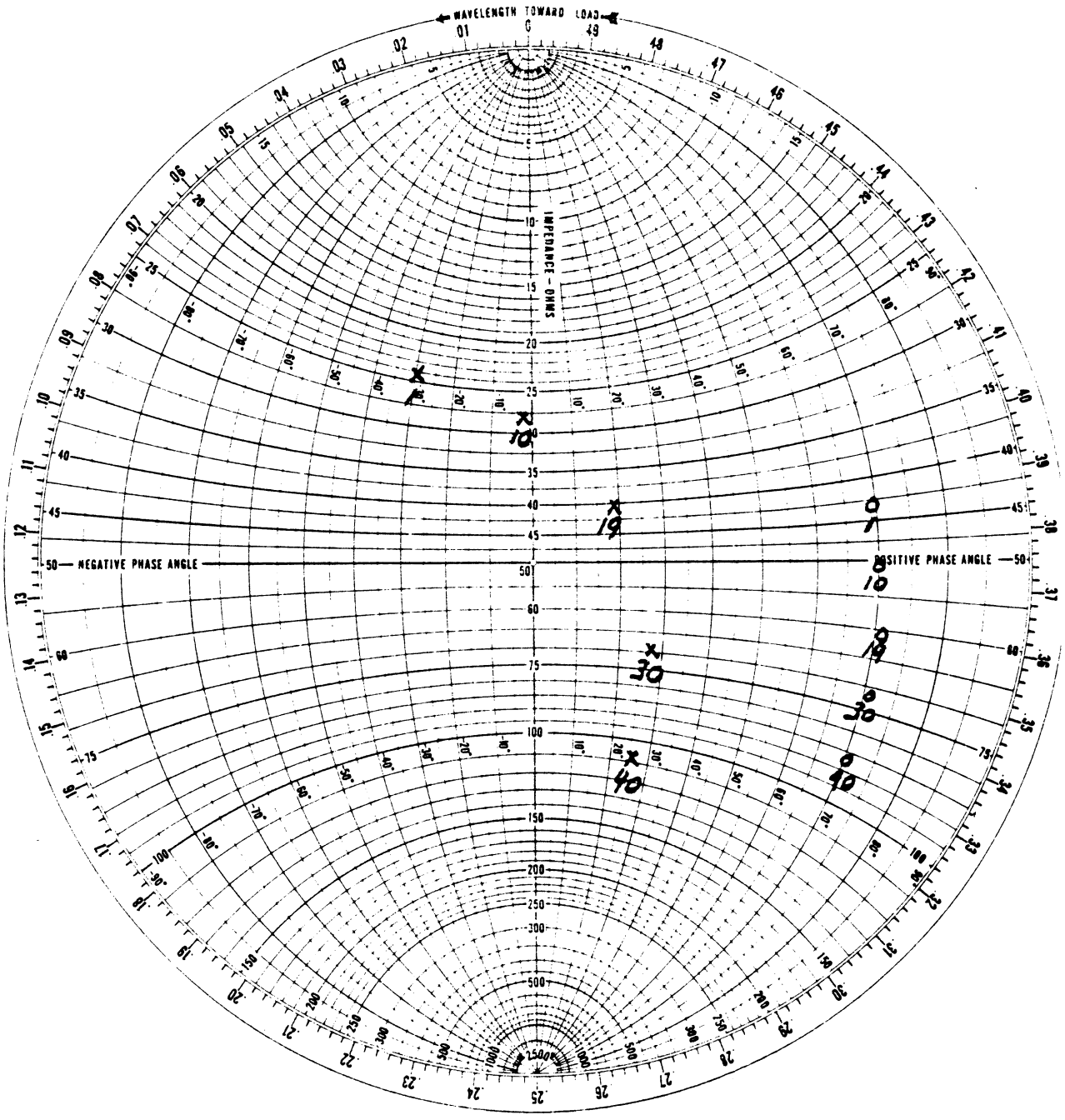

Figure 70(b). Impedance characteristics obtained with splitter box 3 and test antenna for CB band.

oooo antenna only, xxxx antenna + splitter box

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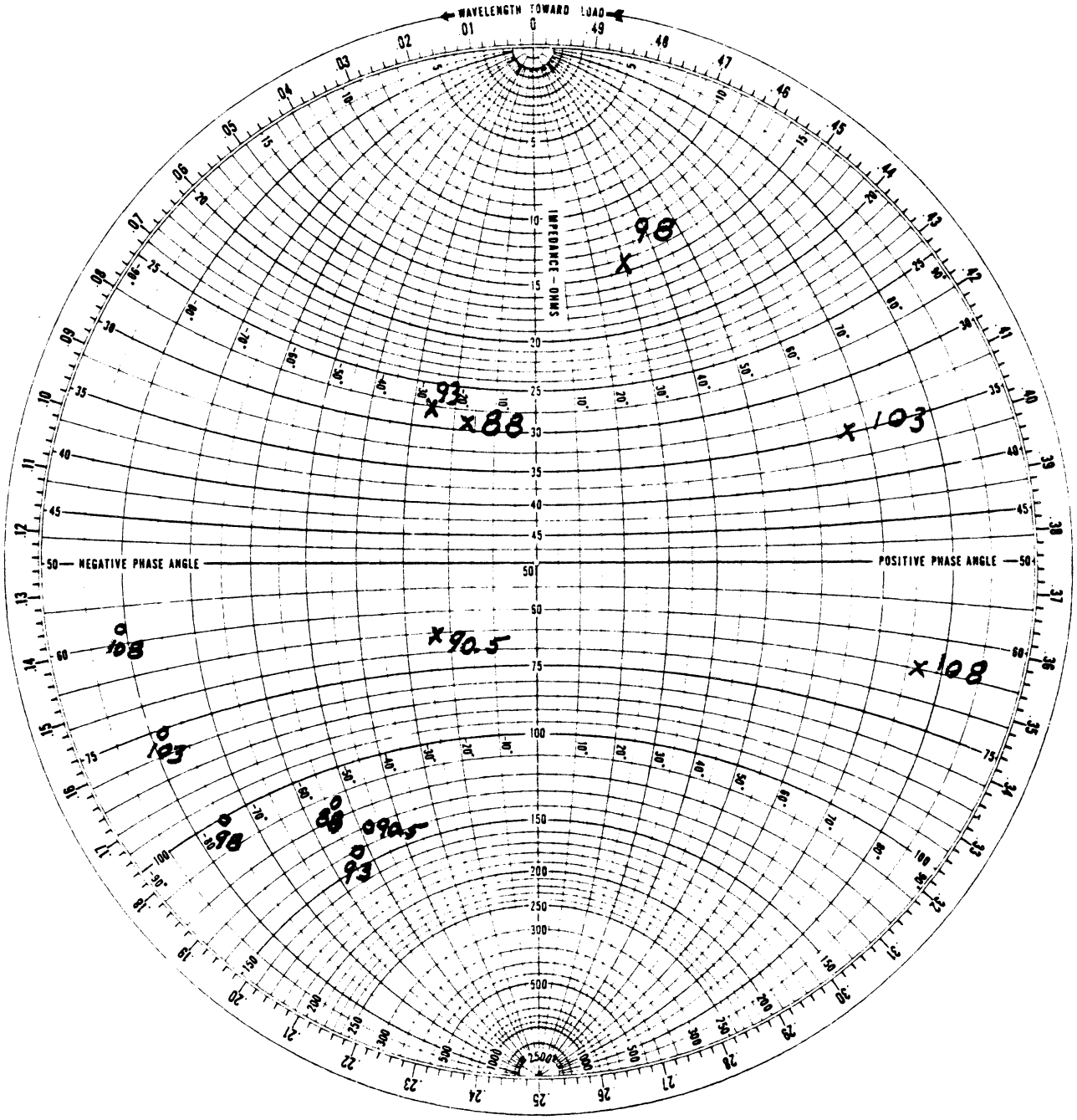

Figure 71(a). Impedance characteristics obtained with motorola splitter box and test antenna for FM band.

oooo antenna only, xxxx antenna + splitter box

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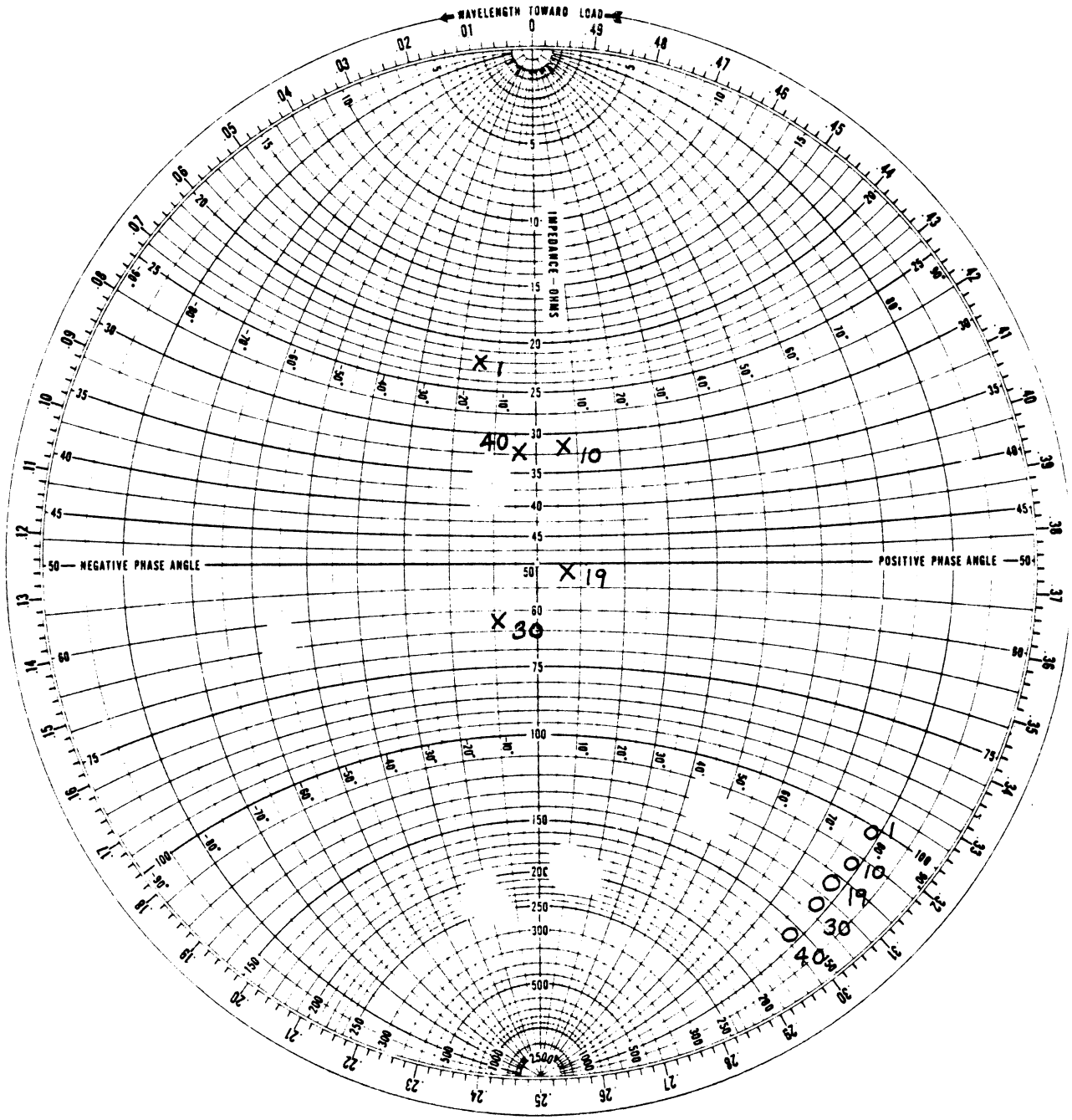

Figure 71(b). Impedance characteristics obtained with motorola splitter box and test antenna for CB band.

oooo antenna only, xxxx antenna + splitter box

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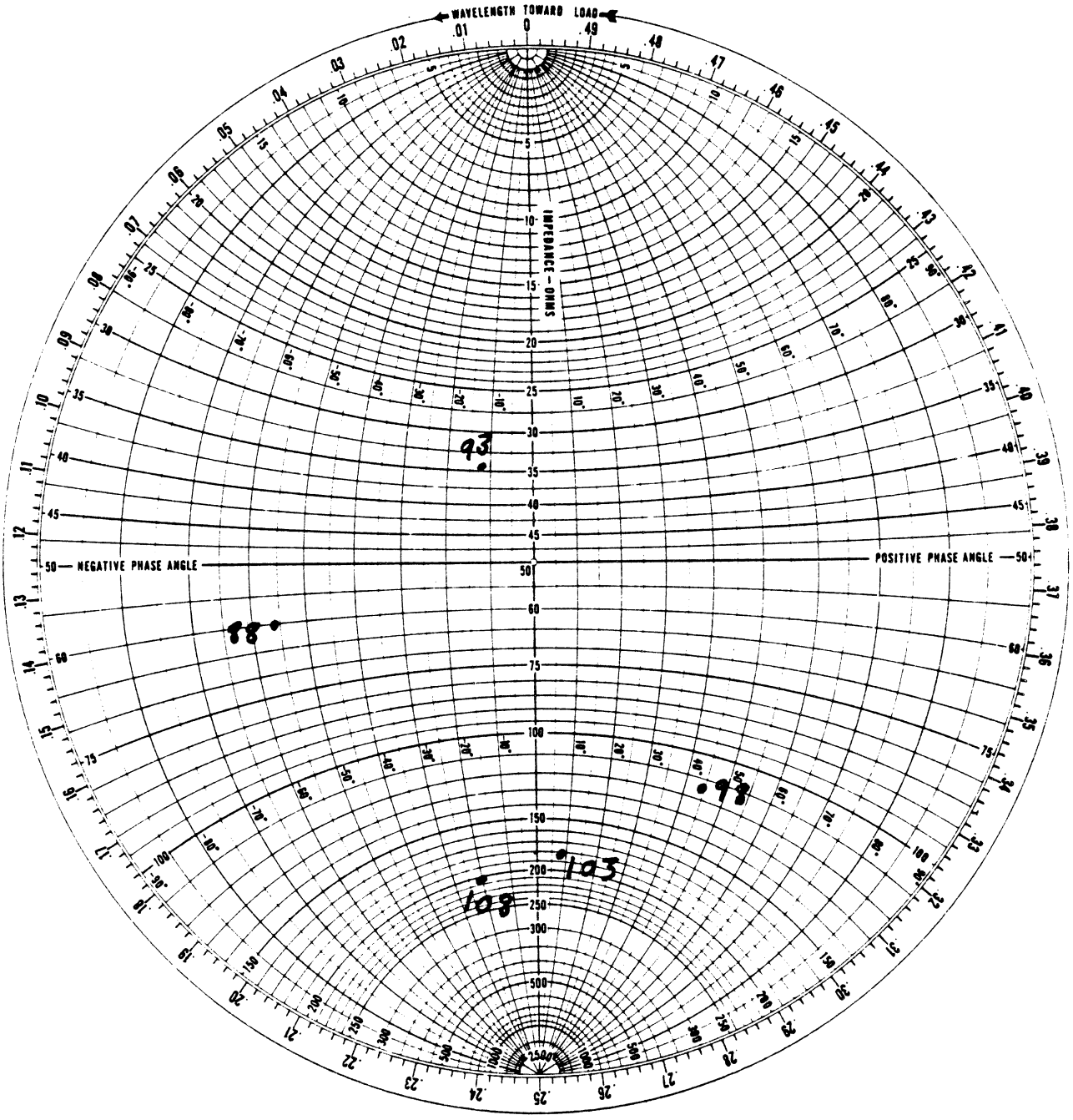

Figure 72. Impedance characteristics of the Manual Entertainment antenna ME 202 at FM frequencies, no splitter box used.

signals from the FM port.

(ii) The adjustment of the CB slug affects the impedance, and hence the CB VSWR, at the CB post only. As a result, with proper adjustment of the CB slug the VSWR at the CB post generally stays within acceptable limits, but the VSWR at the FM post can be fairly large.

(iii) The series L-C circuit at the CB branch is not necessarily required to be tuned exactly to the CB frequency at which a low VSWR is desired. Its function is, in fact, to provide the appropriate amount of reactance so that the combined impedance of the antenna system yields the desired VSWR.

7.3. Recommendation

At the present time the splitter box provides acceptable VSWR at the CB frequencies. There being no provision for impedance adjustment in the FM band, large VSWRs usually exist at the FM ports with consequent loss of FM sensitivity. Our study indicates that it may be possible to improve the FM sensitivity of tri-band antennas by introducing an extra variable reactance in series with the FM branch of the splitter box circuit without affecting the antenna performance at CB frequencies. It is recommended that a further study be initiated along this line.

VIII. ACKNOWLEDGEMENT

We are pleased to acknowledge the benefit of several discussions with Mr. Susheel Bery and Mr. Al Partington of the Ford Motor Company. We also wish to acknowledge with thanks the help of Mr. W.F. Parsons, Mr. T. Repucci and Mr. D. Brill during the measurements. Suggestions and counsel from Prof. T.B.A. Senior, Director of The Radiation Laboratory, are gratefully acknowledged.

The authors wish to express their sincere gratitude to Ms. Sandra Bowne for her expert and patient typing of the manuscript.

IX. REFERENCES

[1] D.L. Sengupta and J.E. Ferris, "A Study of CB, FM and AM Antennas for Automobiles," The Radiation Laboratory Technical Report No. 320626-1-T, Ann Arbor, Michigan 48109, September 1976.

X. APPENDIX A

MOTOROLA ANTENNA PERFORMANCE

The present Appendix gives results obtained with the Motorola tri-band antenna front mounted on a 1978 Cougar.

Figs. A. 1. (a) - (c) show the horizontal plane radiation patterns at selected CB frequencies obtained with the test and $\lambda/4$ CB-reference antennas.

The corresponding FM band patterns obtained with the test and the standard FM antennas are shown in Figs. A. 2 (a) - (e).

The impedance characteristics of the test antenna at CB and FM band frequencies are shown in Fig. A. 3.

The performance comparison chart for the Motorola antenna is shown in Table A. 1.

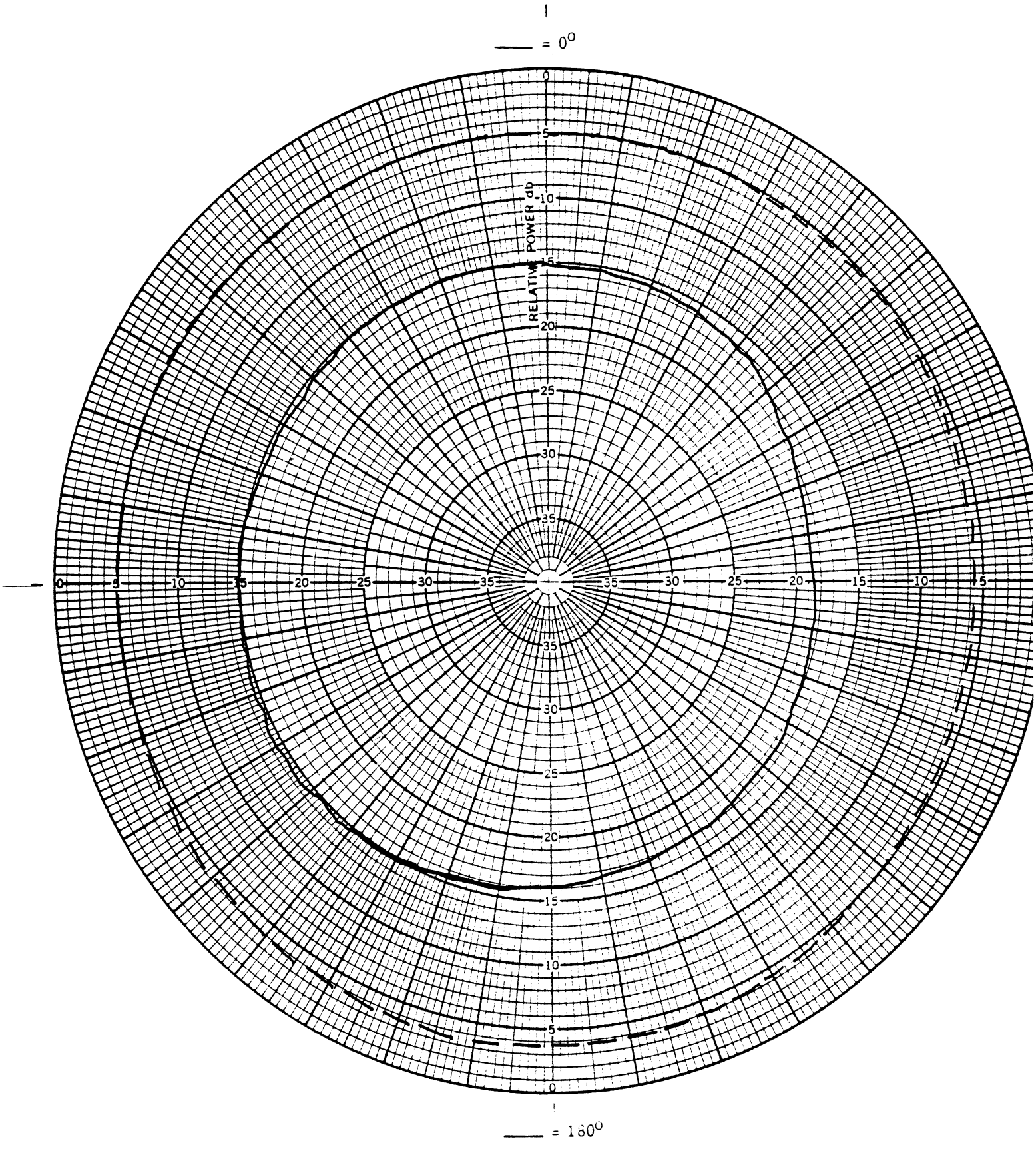

Figure A1 (a) Radiation patterns at CB channel 1 for Motorola and reference antennas on 1978 Cougar.

———— Motorola, ---------- λ/4 CB reference

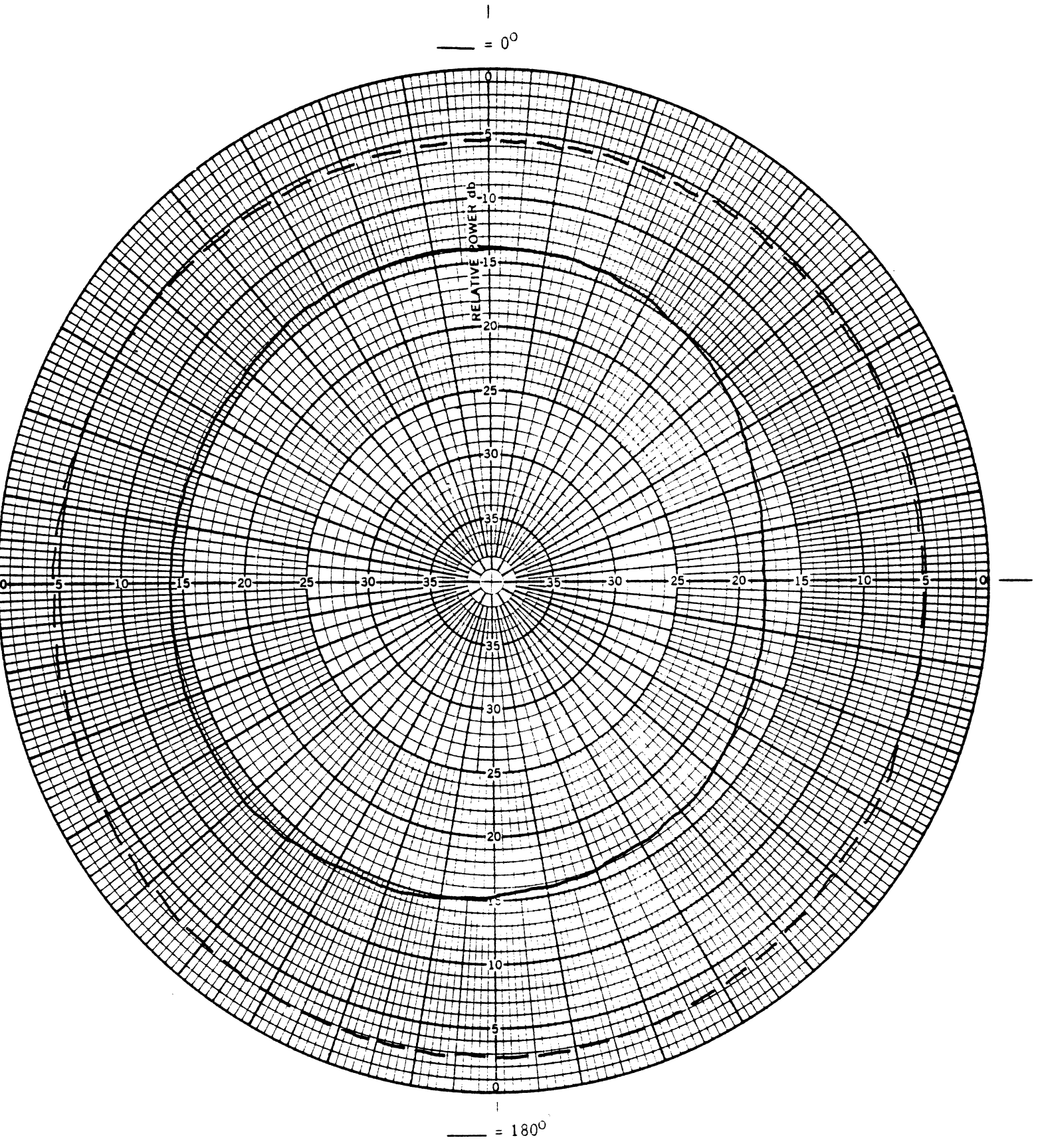

Figure A1 (b) Radiation patterns at CB channel 19 for Motorola and reference antennas on 1978 Cougar.

————————Motorola, ---------- λ/4 CB reference

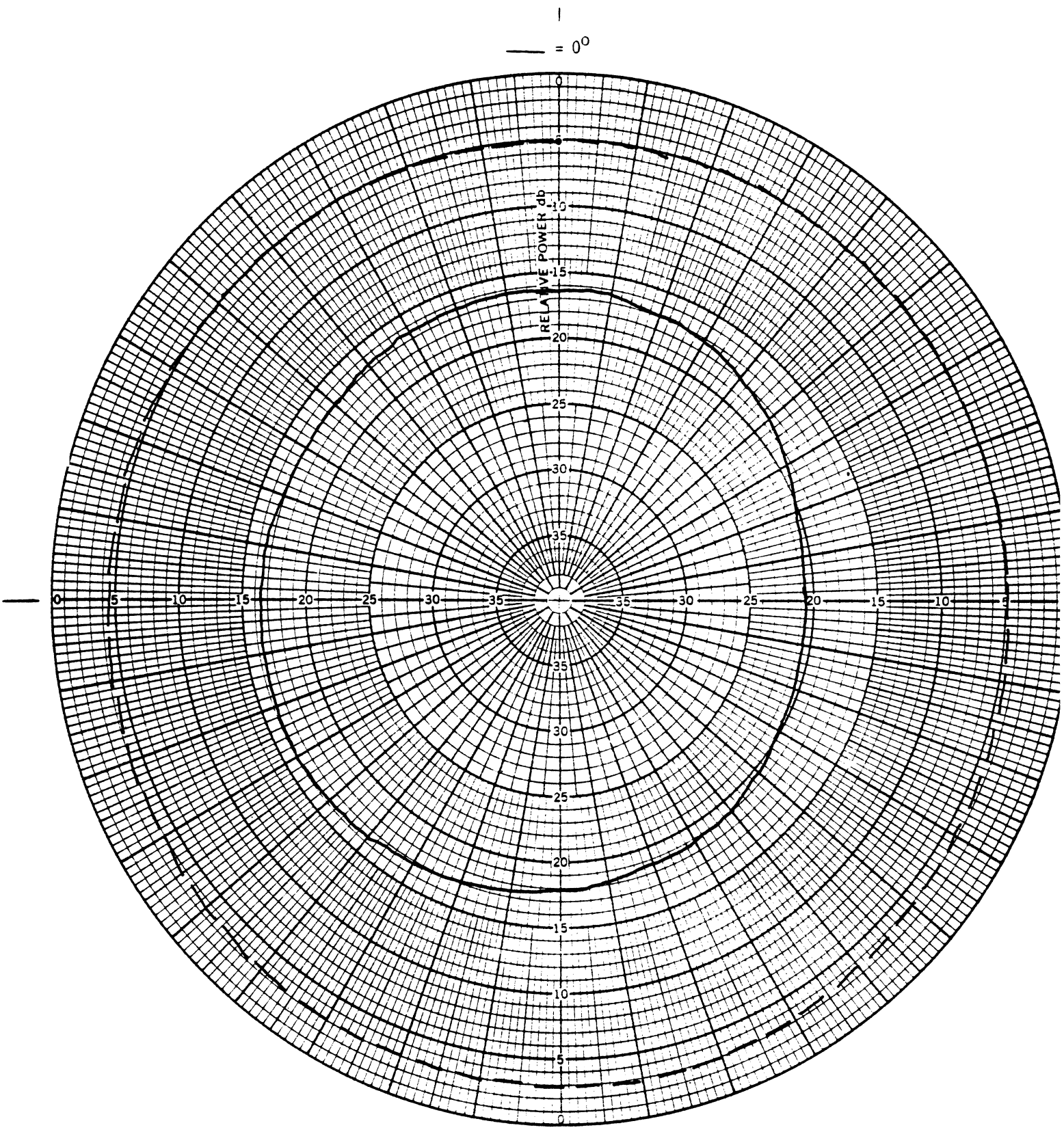

Figure A1 (c) Radiation patterns at CB channel 40 for Motorola and reference antennas on 1978 Cougar.

———— Motorola, ---------- λ/4 CB reference

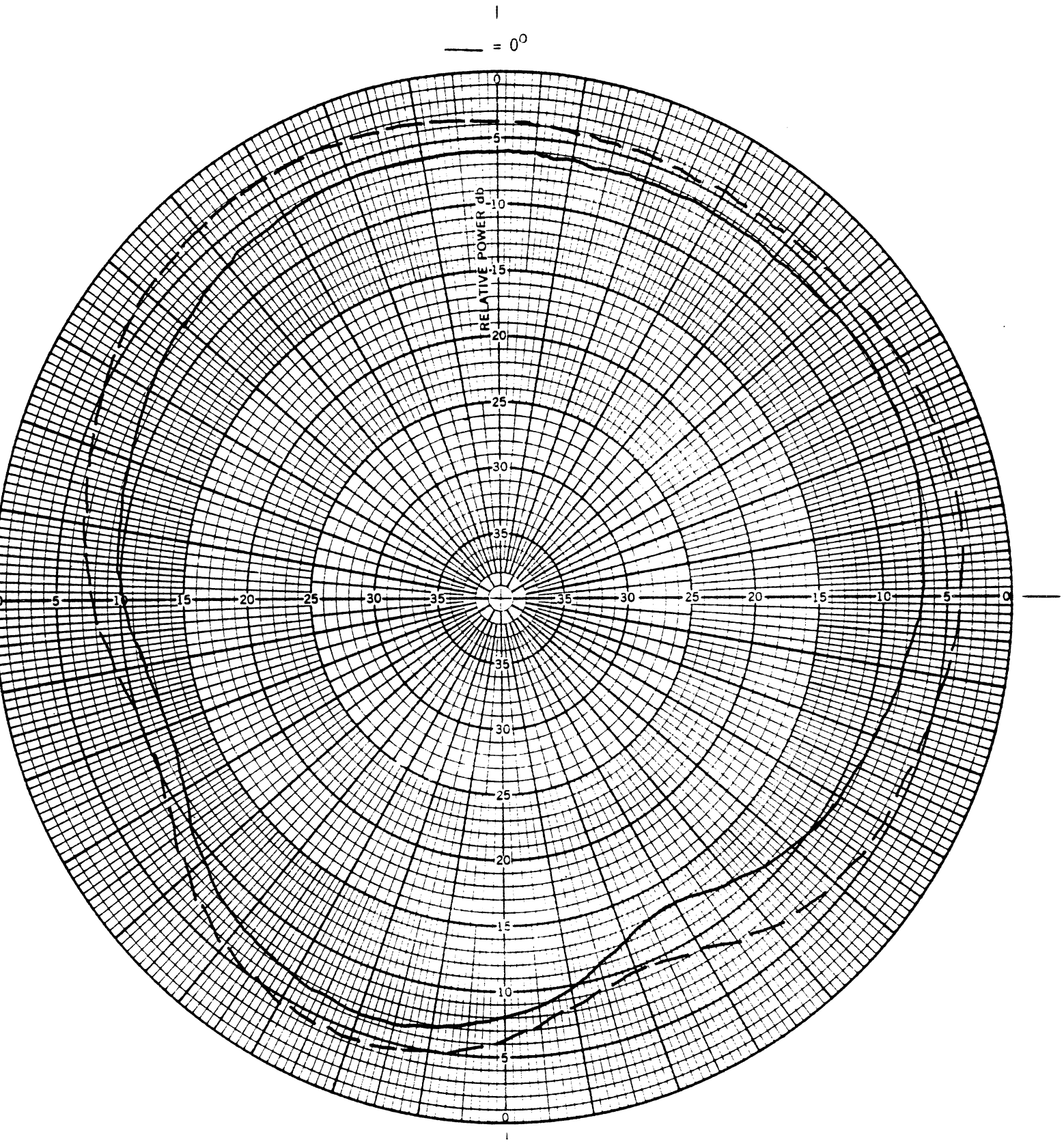

Figure A2 (a) Radiation patterns at 88 MHz for Motorola and FM reference antennas on 1978 Cougar

_____Motorola, ----------FM Reference

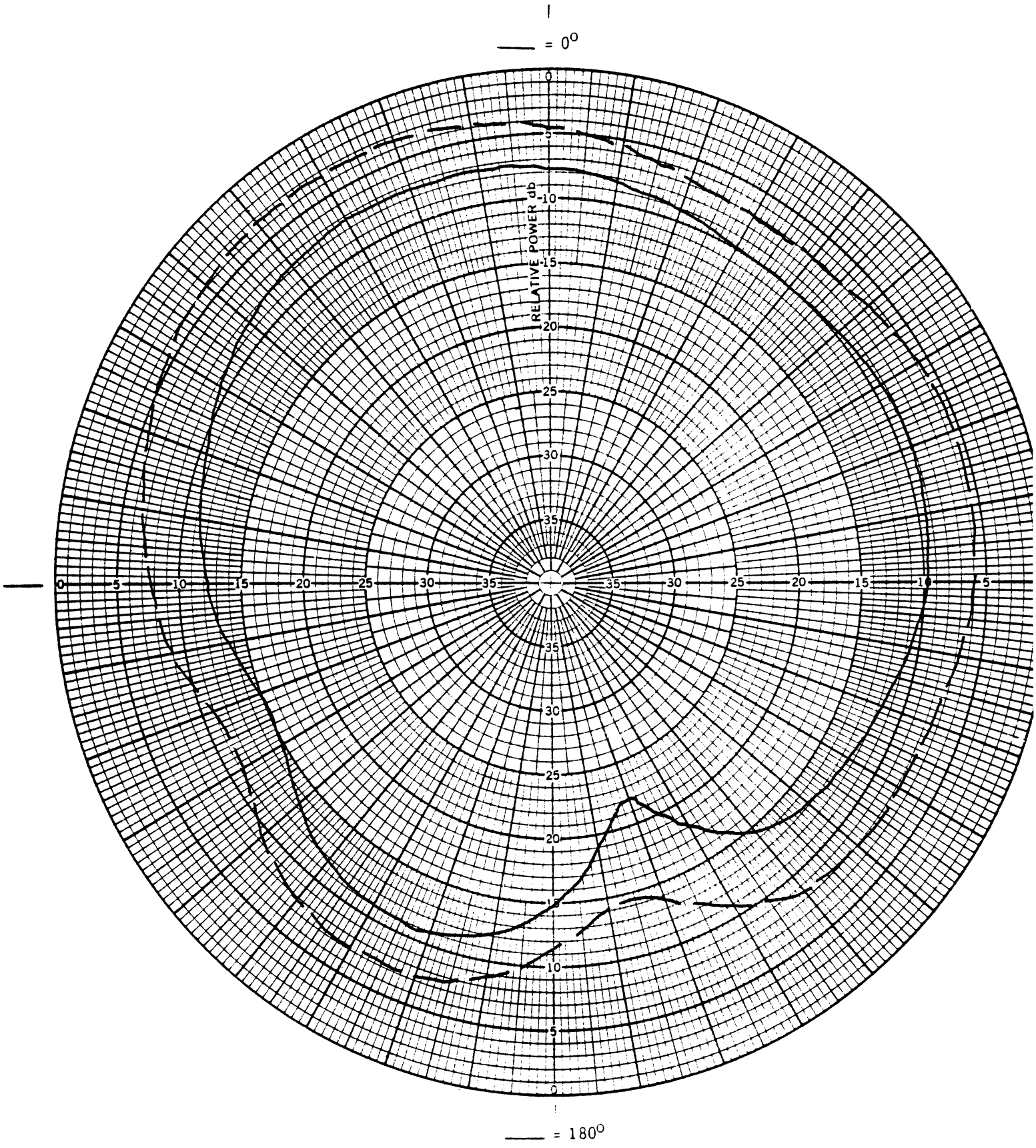

Figure A2 (b) Radiation patterns at 93 MHz for Motorola and FM reference antennas on 1978 Cougar

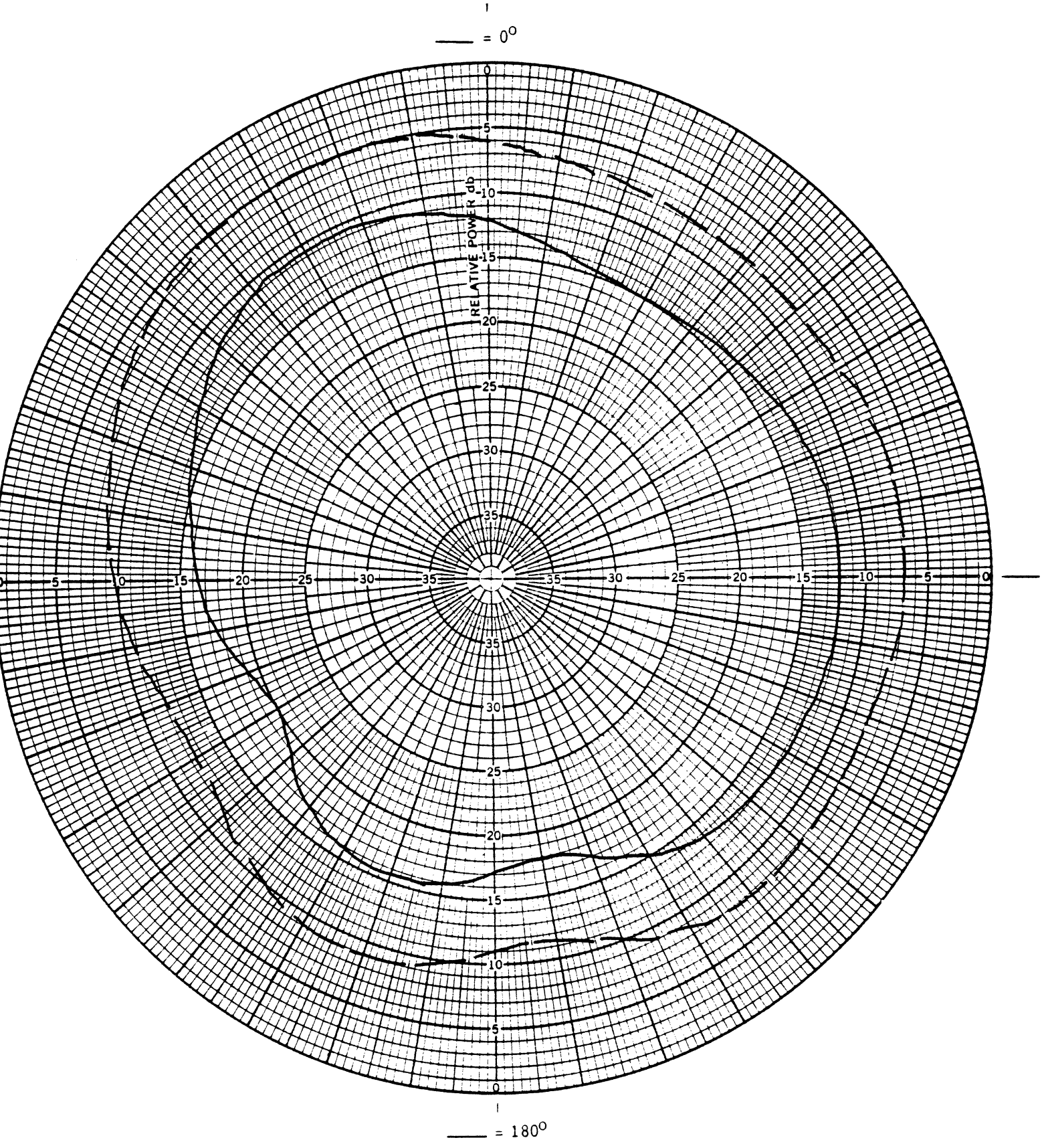

Figure A2 (c) Radiation patterns at 98 MHz for Motorola and FM reference antennas on 1978 Cougar

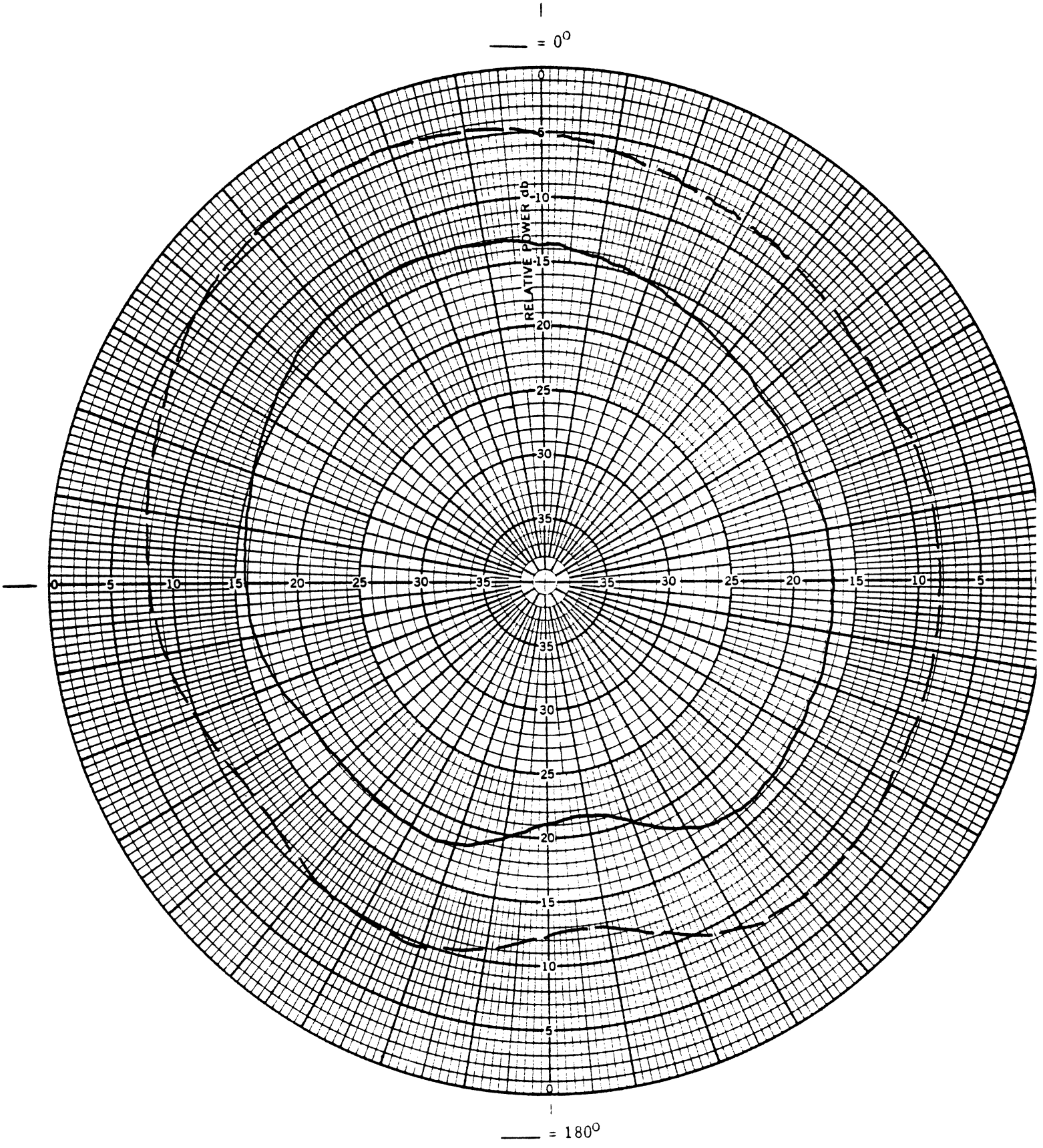

Figure A2 (d) Radiation patterns at 103 MHz for Motorola and FM reference antennas on 1978 Cougar

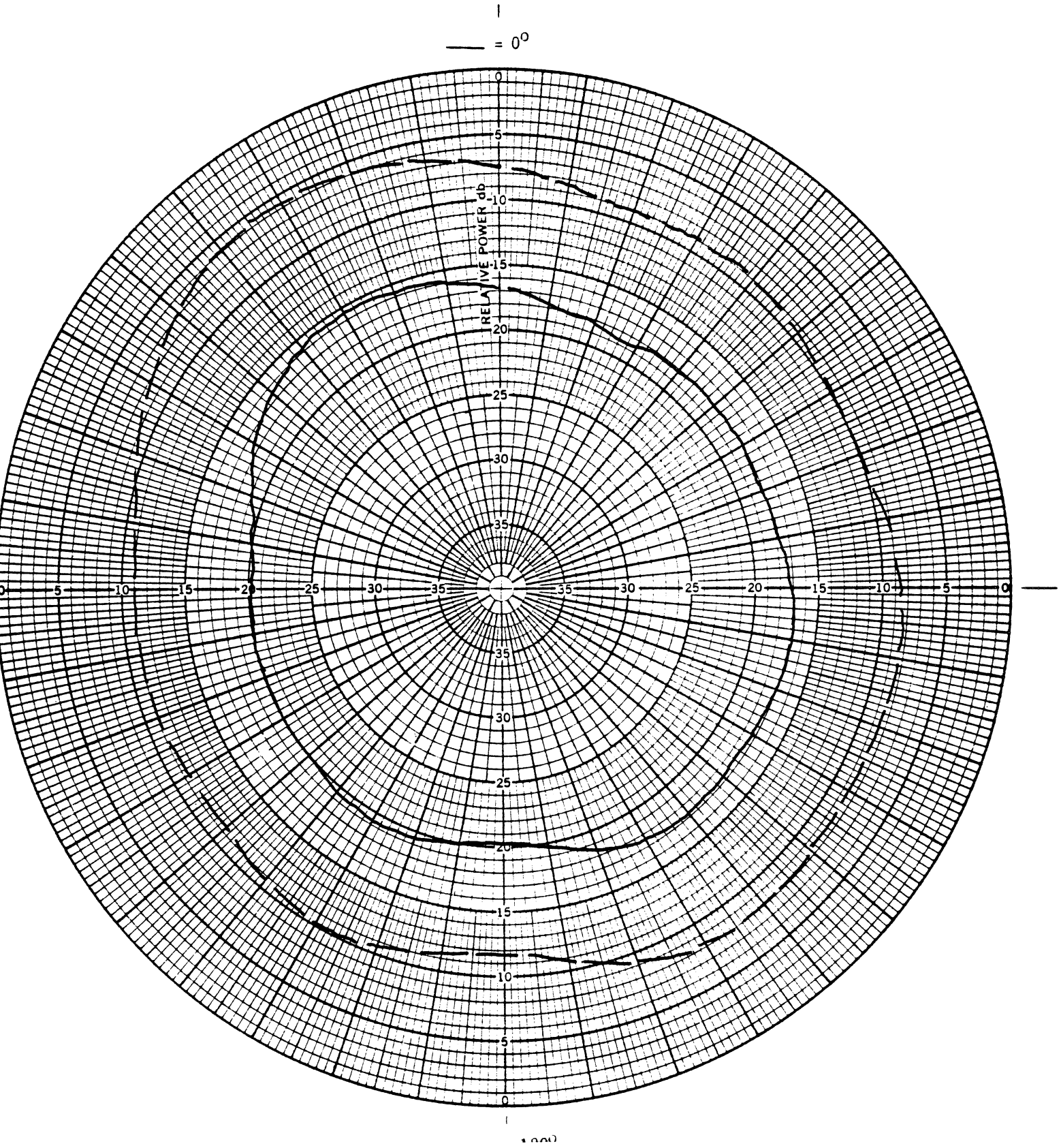

Figure A2 (e) Radiation patterns at 108 MHz for Motorola and FM reference antennas on 1978 Cougar

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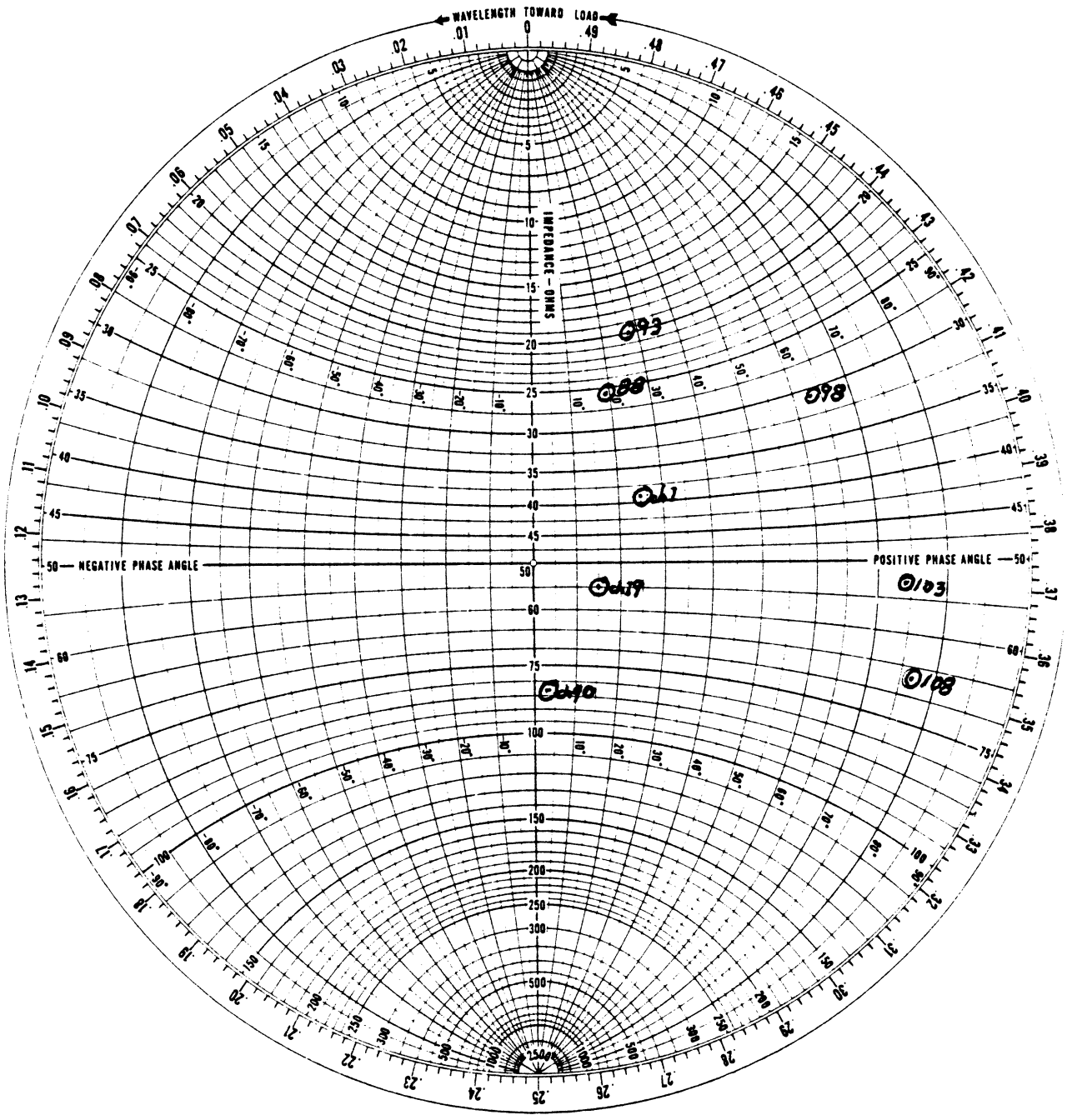

Figure A3 Impedance characteristics at CB and FM band frequencies for the Motorola antenna mounted on 1978 Cougar

PARAMETER	PERFORMANCE COMPARISON		
	MOTOROLA	FM STD. ENT.	λ/4 MONOPOLE
FM PERF			
88mHZ	-2.58	0.0	
93	-3.68	0.0	
98	-5.95	0.0	
103	-8.33	0.0	
108	-9.16	0.0	
CB PERF			
ch 1	-11.14		0.00
19	-9.51		0.00
40	-11.12		0.00
FM VSWR			
88mHZ	2.08	1.82	
93	2.85	1.63	
98	4.56	1.33	
103	7.33	1.53	
108	9.53	2.64	
CB VSWR			
ch 1	1.71		
19	1.31		
40	1.69		
ISOLATION			
ch 1	920m		
19	720m		
40	880m		
AM SENS.			
0.76mHZ	-67	-64	
1.10	-75	-70	
1.6	-83	-79	
AM - C			
0.5mHZ	121.9	94.6	
1.0	128.1	102.1	
1.5	119.2	92.1	
AM - Q			
0.5mHZ	212.52	1463.96	
1.0	213.83	1265.32	
1.5	198.42	943.47	

TABLE A1 PERFORMANCE DATA FOR MOTOROLA ANTENNA ON 1978 COUGAR