NRL Memorandum Report 871

THE CONICAL MONOPOLE ANTENNA

M. L. Leppert

RADIO DIVISION

6 November 1958

Distribution of this document is unlimited.

U. S. NAVAL RESEARCH LABORATORY
Washington, D.C.

NRL Memorandum Report
Number 871

THE CONICAL MONOPOLE ANTENNA

By
M. L. Leppert

Communication Branch
Radio Division

6 November 1958

U. S. NAVAL RESEARCH LABORATORY
Washington, D. C.

CONTENTS

ABSTRACT

The Naval Research Laboratory is engaged in continuing research leading to the development of antennas for both ship and shore station use which will have superior operational characteristics. Under this program, an antenna of the monopole type has been produced which provides a VSWR of 2.5 to 1 relative to 70 ohms over a 6.3 to 1 bandwidth. The peak amplitude of the radiation pattern in the vertical plane lies along the ground plane over a 4 to 1 frequency range. The electrical length of the antenna is 0.16 wavelengths at the lowest frequency, and, since the central supporting member is conductive from the ground to the top, obstruction lights or other small objects may be mounted atop the antenna without disturbing its characteristics.

PROBLEM STATUS

This is an interim report on one phase of this problem. Work on other phases is continuing.

AUTHORIZATION

NRL Problem 54R01-03
BuShips Problem S-1681
NE-120000

THE CONICAL MONOPOLE ANTENNA

INTRODUCTION

The conical monopole antenna has been produced to fulfill a need for an antenna having a simple mechanical design, short vertical height, good broadband impedance characteristics, good radiation patterns and efficiency, and the capability of operating with a grounded centerpole. The design described herein has been checked on models at UHF in the Laboratory and at HF, full size, in the field.

DESCRIPTION

Figure 1 shows the basic configuration of the antenna and gives the various dimensions in terms of wavelengths at the lowest operating frequency. It is seen to consist geometrically of two truncated cones mounted base to base and supported with the axis vertical at a short distance above ground plane. The upper cone may be electrically a solid, while the lower cone, for operation with a grounded metallic supporting structure, must be hollow. The external surfaces of the cones form a monopole type of antenna with some effects of a true conic contributed by the lower cone, particularly at the higher frequencies. The inner surface of the lower cone and the metallic supporting structure form a short section of transmission line which is in effect connected across the antenna terminals. The supporting structure forms the inner conductor of this section of line, the inner surface of the lower cone forms the outer conductor, and the disc (or spokes) at the common plane of the two cones forms the short circuit at the end of the line The antenna is therefore a stubbed conical monopole. This configuration may also be constructed as two (electrically) solid cones and mounted upon a base insulator; however, it must then be approximately a quarter wavelength in height if good impedance characteristics are to be obtained.

Figure 2 is a picture of an antenna of this type supported on a wooden pole. The total height of this structure is fifty-seven feet. The surfaces are simulated by sections of tubing and phosphor bronze cables. The metallic mounting structure at the top of the pole is connected to ground, for protection against lightning, by means of four copper strips one-inch wide by one-sixteenth inch thick. The surface of the pole from the "waist disc" (spokes) to ground is covered with one-half-inch-mesh galvanized hardware cloth to simulate a metal conductor for the "stub." The six-foot-square plywood platform at the base of the antenna is covered with 0.02-inch copper sheet, thereby providing an area of low loss in the field at the base of the antenna and a convenient anchorage for the ground radials which are necessary for any monopole antenna mounted on soil. For this antenna 120 ground radials, of approximately one-quarter wavelength at the lowest frequency, were installed. Sixty radials could be used but with somewhat higher ground loss resistance. Each radial is connected to a six-foot grounding rod at the "far" end. The seventy-ohm feed line is not shown in the picture. During the measurements, a section of four-inch-diameter brass pipe was secured to the copper base plate at a point directly below the periphery of the bottom hoop. The top of the pipe was about four inches from the hoop. The 70-ohm feed line was carried along the pipe and its outer conductor connected to the pipe at the top. The inner conductor was extended and connected to the hoop. The hoop and the top of the pipe therefore formed the antenna terminals, the pipe providing a low impedance from the end of the transmission line to ground. The small inner conductor had only a short distance to travel to make connection with the hoop. It should be noted that the 70-ohm line connects directly to the antenna - the antenna requires no transforming devices for matching it to the 70-ohm line. For operation using a 50-ohm line, a section of 70-ohm line which is 0.196 wavelengths at the lowest frequency of operation should be connected between the antenna and the 50-ohm feedline for improved VSWR.

Impedance Characteristics

Figure 3 is a Smith chart plot of the impedance of the antenna of Figure 2. This antenna is 0.16 wavelengths in height at 2.75 Mc. It is seen that the impedance, relative to 70 ohms, stays within the 2.5 to 1 VSWR circle from about 2.7 to 17 Mc, a bandwidth of 6.3 to 1. Insertion of a capacitor of 14 ohms reactance at 4.5 Mc between the antenna and the feed line would further improve the VSWR. Figure 4 is a Smith chart plot of the antenna impedance relative to 50 ohms, using a transforming section of 70-ohm cable 0.196 wavelengths long at 2.75 Mc inserted between the antenna terminals and the 50-ohm feed line. It is seen that the VSWR falls within 2.7 to 1 in this case.

Radiation Patterns

Since this is a vertical monopole type of antenna, the radiation pattern in the horizontal plane is omnidirectional. In common with vertical monopole antennas, the radiation pattern in the vertical plane begins to "lobe" at frequencies corresponding to 0.65 wavelengths and above, so that, when the antenna is to be used primarily for ground wave propagation, its operating frequency range should be limited to 4 to 1 or, for example, from 2.75 to 11.0 Mc for the antenna size of Figure 2.

Additional Features

Since the entire metallic structure of the conical monopole antenna is at d-c ground potential, and the center supporting member or structure can be constructed to shield cables and conduits, it is possible to mount objects which are small in comparison to the size of the antenna on top of it without disturbing either the impedance or the radiation pattern of the antenna. Thus, obstruction lights and UHF antennas may be mounted atop a 2 to 6 Mc antenna. In addition, the cables of the antenna can be designed and arranged so as to permit sleet melting during use as an antenna if this becomes necessary.

SUMMARY

In summary, this design of (conical monopole) antenna provides a relatively short antenna having good impedance, efficiency, and pattern chanacteristics over a 4 to 1 frequency range, and good impedance characteristics over a 6.3 to 1 frequency range. It has no insulation at high voltage, high impedance points, and is structurally large enough to handle easily hundreds of kilowatts. It is simple to construct and is amenable to the installation of obstruction lights and may be readily designed to accommodate sleet melting power during use as an antenna.

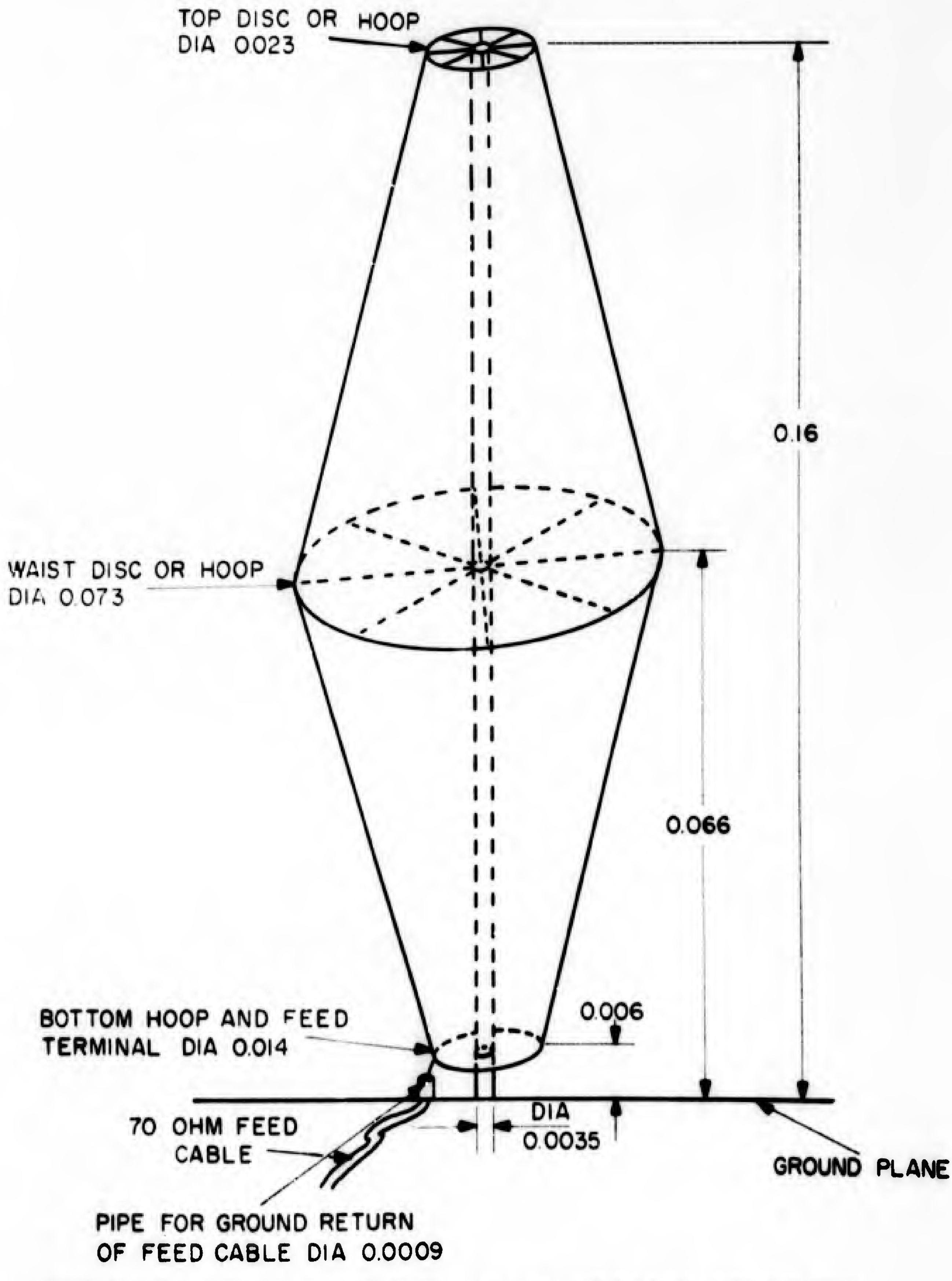

Fig. 1 - Conical Monopole Antenna

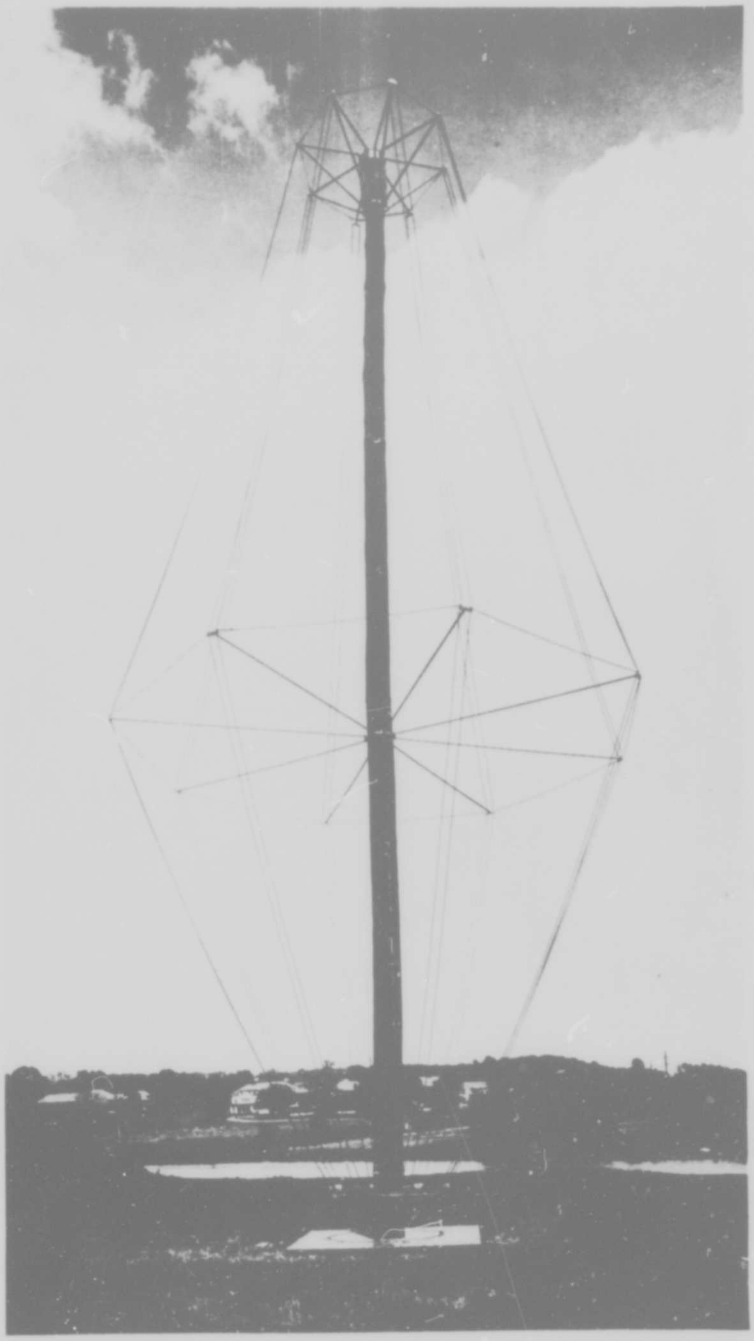

Fig. 2 - Conical Monopole Antenna 2.75 to 11.0 Mc 57 Feet High

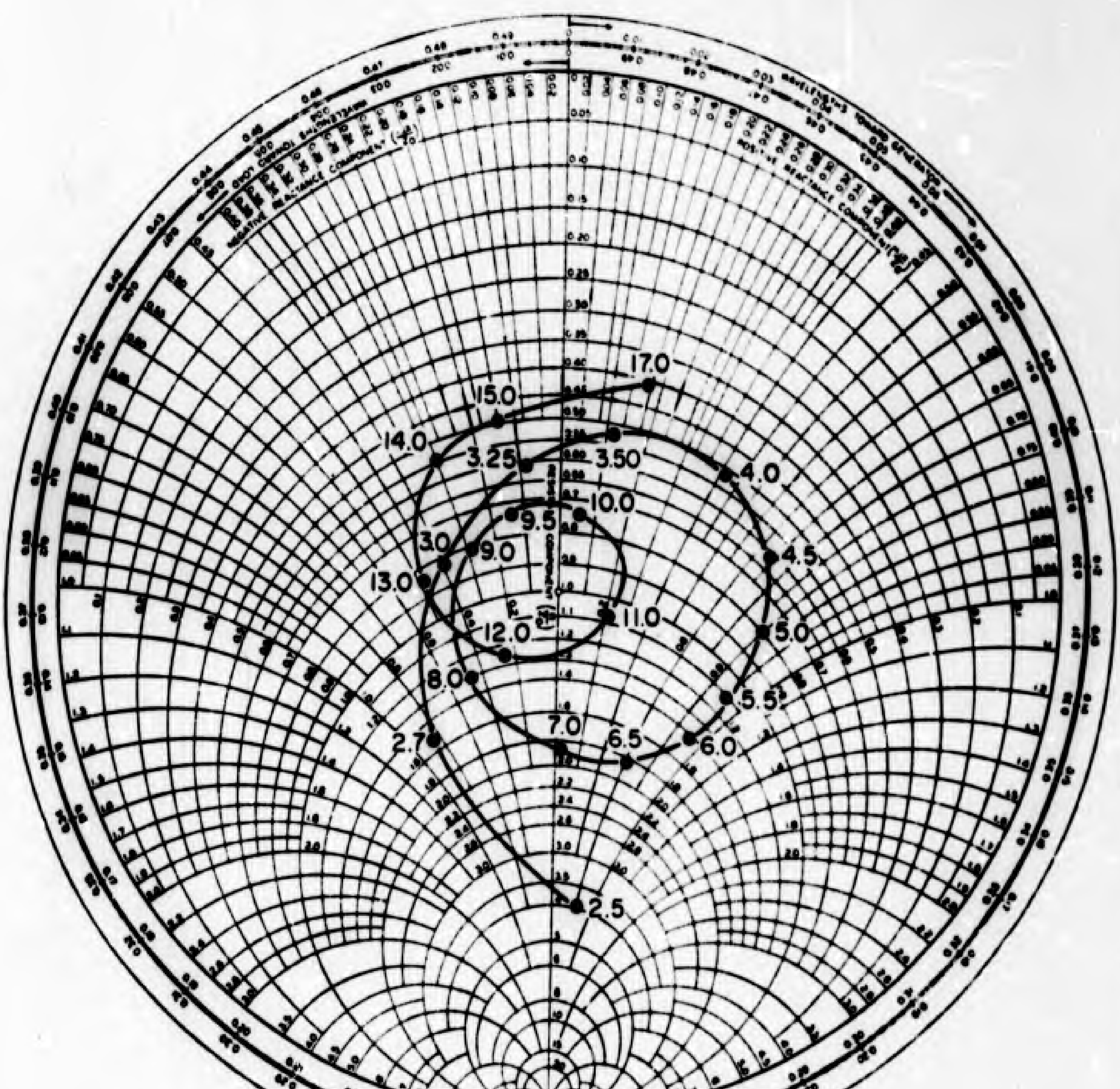

Fig. 3 - Conical Monopole Antenna Impedance Relative to 70 Ohms

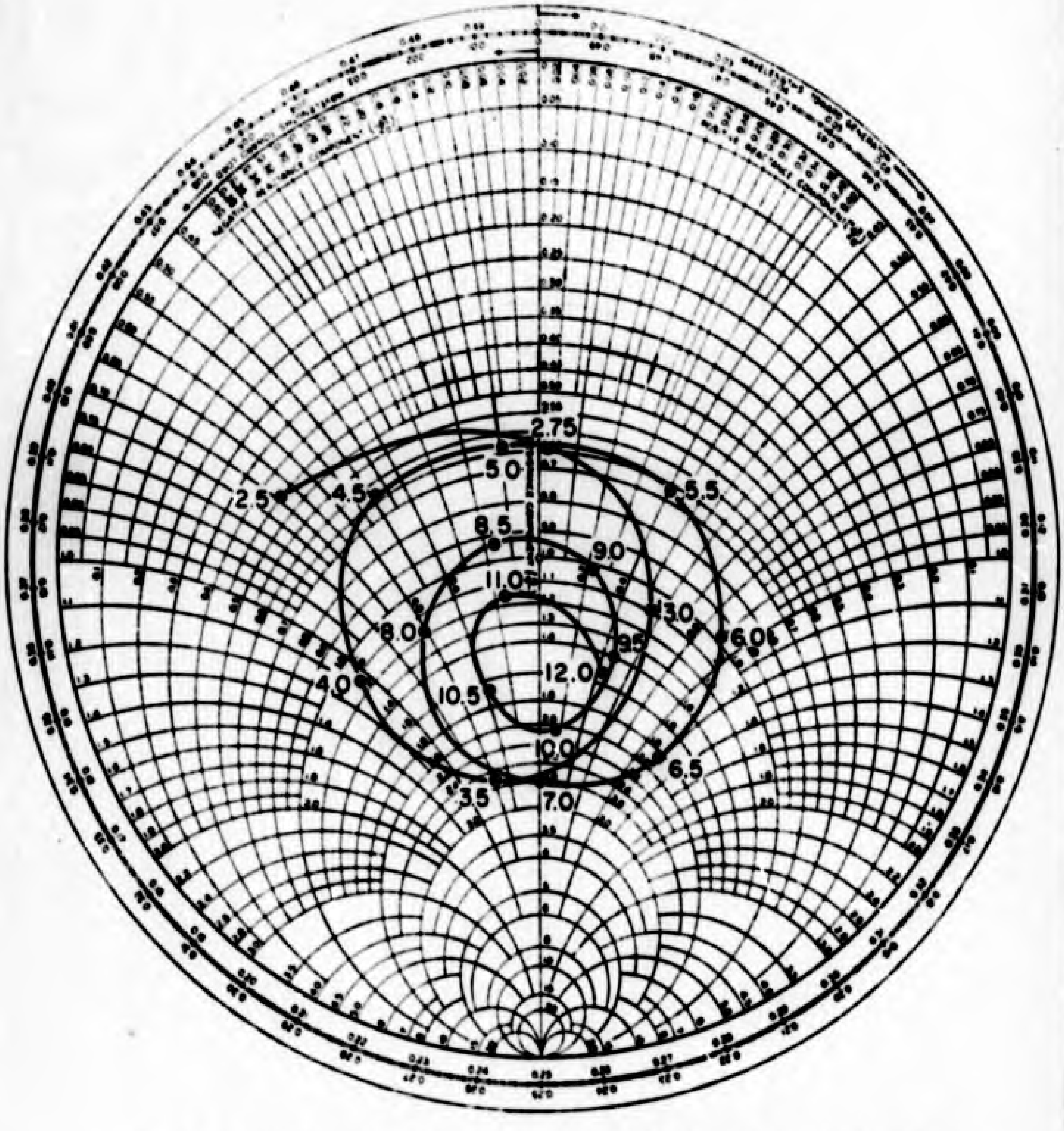

Fig. 4 - Conical Monopole Antenna Impedance Relative to 50 Ohms (0.196λ at 2.75 Mc transformer of 70 ohm line)