

UNCLASSIFIED

AD NUMBER
AD039484
CLASSIFICATION CHANGES
TO: unclassified
FROM: restricted
LIMITATION CHANGES
TO: Approved for public release; distribution is unlimited.
FROM: Distribution authorized to DoD only; Administrative/Operational Use; 10 AUG 1953. Other requests shall be referred to Bureau of Ships, Washington, DC 20350. Pre-dates formal DoD distribution statements. Treat as DoD only.
AUTHORITY
E.O. 10501 dtd 5 Nov 1953; NAVEXOS ltr dtd 1 Apr 1968

THIS PAGE IS UNCLASSIFIED

Armed Services Technical Information Agency

Because of our limited supply, you are requested to return this copy WHEN IT HAS SERVED YOUR PURPOSE so that it may be made available to other requesters. Your cooperation will be appreciated.

AD

39484

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

Reproduced by
DOCUMENT SERVICE CENTER
KNOTT BUILDING, DAYTON, 2, OHIO

UNCLASSIFIED

AD/NO-39484

FILE COPY



**THE UNIVERSITY OF TENNESSEE
DEPARTMENT OF ELECTRICAL ENGINEERING**

**DEVELOPMENT
OF A
HIGH FREQUENCY
STEERABLE ANTENNA**

Classification changed from "Secret" to "Confidential" with
Executive Order 9835, dated November 1953

Nina B Weaver

9/23/54

Directed by the Chief
Armed Forces Tech. Info Agency

**Navy Department
Bureau of Ships
Electronics Divisions**

**Interim Development
Report No. 11**

**Contract No. NObar-57448
Index No. NE-091035 ST7
10 August 1953**

**A PROJECT OF THE ENGINEERING EXPERIMENT STATION
THE UNIVERSITY OF TENNESSEE COLLEGE OF ENGINEERING**

Knoxville 16, Tennessee

~~RESTRICTED~~

INTERIM DEVELOPMENT REPORT
FOR
DEVELOPMENT OF A HIGH FREQUENCY
STEERABLE ANTENNA

This report covers the period
1 July 1953 to 31 July 1953

ENGINEERING EXPERIMENT STATION
THE UNIVERSITY OF TENNESSEE
KNOXVILLE, TENNESSEE

Navy Department

Electronics Divisions

Bureau of Ships

Contract No. NObsr-57448

Index No. NE-091035 ST7

10 August 1953

WARNING: This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws Title 18, U.S.C., Sections 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law. Reproduction of this document in any form by other than activities of the Department of Defense and the Atomic Energy Commission is not authorized unless specifically approved by the Secretary of the Navy or the Chief of Naval Operations.

Copy No. 12

~~RESTRICTED~~

~~SECRET~~

ABSTRACT

This report covers work done on Contract No. NObsr-57448, Index No. NE-091035 ST5, at The University of Tennessee during the month of July 1953.

The following was accomplished:

1. The revolving antenna mount was installed at the antenna facility. This facility is now complete, with the exception of the recorder which has not yet been delivered.
2. Further work of a mathematical nature was done on the traveling wave circular antenna.
3. Vertical patterns for a inclined V antenna were calculated for several combinations of height, leg length, and angle between wires.
4. The literature search for information concerning angle of arrival has been completed, and calculations are being made using this information together with the propagation results reported previously to determine the maximum possible fields for various transmission conditions.
5. Experimental study of models of some of the more promising antenna types has been initiated.

~~SECRET~~

1

~~RESTRICTED~~

PART I

Purpose

This project involves the development of a high frequency steerable antenna having the following characteristics:

1. It shall be operable throughout the frequency range of 4 to 32 megacycles per second.
2. It shall be capable of four, or more, simultaneous transmissions on different frequencies, and at different azimuth and elevation angles.
3. For each transmission, it shall be capable of being directed to any azimuth angle and to any elevation angle between the horizon and 30° above the horizon.

The communication system shall provide reliable 24-hour day-to-day communication with a 20-decibel signal-to-noise ratio. The ranges to be covered are from approximately 500 nautical miles to 4000 nautical miles.

The development consists of two phases:

Phase I. Theoretical and experimental studies.

Phase II. Development of design criteria.

~~RESTRICTED~~

RESTRICTED

General Factual Data

Personnel:

F. V. Schultz	Project Director	34 1/2	Man-hours
W. D. Leffell*	Assistant Engineer	15	Man-hours
J. D. Tillman	Assistant Engineer	8	Man-hours
W. J. Bergman	Junior Engineer	41	Man-hours
H. P. Neff	Junior Engineer	176	Man-hours
L. W. Ricketts*	Junior Engineer	141 1/2	Man-hours
G. R. Turner	Secy-Draftsman	21	Man-hours
W. H. Williams*	Technician	24	Man-hours
H. W. Knox	Student Computer	68 1/2	Man-hours
D. Marcum	Student Computer	33	Man-hours
N. Boyd	Typist	4	Man-hours
A. Rich	Multilith Operator	2	Man-hours

* Preparation of antenna test facility.

RESTRICTED

References

- Bruck, E. and Beck, A. C., "Experiments with Directivity Steering for Fading Reduction," Bell System Technical Journal, Vol. 14, p. 195, April 1935.
- Foster, Donald, "Radiation from Rhombic Antennas," Proceedings of the Institute of Radio Engineers, Vol. 25, p. 1327, October 1937.
- Harper, A. E., Rhombic Antenna Design, D. Van Nostrand Co., Inc., New York, 1941.
- Harrison, C. W., "Radiation from Vee Antennas," Proceedings of the Institute of Radio Engineers, Vol. 31, p. 362, July 1943.
- Harrison, C. W., "The Radiation Field of Long Wires, with Application to Vee Antennas," Journal of Applied Physics, Vol. 14, p. 537, October 1943.
- Harrison, C. W., "The Inclined Rhombic Antenna," Proceedings of the Institute of Radio Engineers, Vol. 30, p. 241, May 1942.
- "Ionospheric Radio Propagation," U. S. Department of Commerce, National Bureau of Standards Circular No. 462, June 1948, Washington, D. C.
- Knudsen, H. L., "The Field Radiated by a Ring Quasi-Array of an Infinite Number of Tangential or Radial Dipoles," Proceedings of the Institute of Radio Engineers, Vol. 41, p. 781, June 1953.
- Kraus, J. K., Antennas, McGraw-Hill Book Co., New York, 1950, Chapter 2.
- Sherman, J. B., "Circular Loop Antennas at Ultra-High Frequencies," Proceedings of the Institute of Radio Engineers, Vol. 32, p. 534, September 1944.
- Williams, H. P., Antenna Theory and Design, Pitman and Sons, Ltd., London, 1950.

RESTRICTED

Detail Factual Data

1. Construction of antenna test facilities has been continued. A rotary mount has been installed, and the selsyn system for transmitting the azimuth pointing to a high speed level recorder has been connected. These items have been tested, and their performance is satisfactory. A ground plane of adequate size has been constructed for use with this mount. The test site is now essentially complete, except for the level recorder which has not yet been delivered. This recorder is expected by the end of the month. The antenna test facilities are now being used in connection with the work on Contract No. NObsr-57032, Index No. NE-091035 ST5.
2. Only a relatively small amount of work was done on the circular traveling-wave antenna because the engineer involved, W. J. Bergman, was not available for a large part of the month. Efforts were made to rearrange the complicated expression for the radiation pattern of this antenna into a form more amenable to calculation and from which it would be easier to roughly predict radiation patterns without carrying out lengthy calculations. It was found that the original form appeared to be the simplest obtainable. In an attempt to obtain a usable radiation pattern two expedients were tried. One consisted of using a conductor phase velocity different from that in free space and no improvement resulted. The other approach was to obtain an expression for the pattern of a semicircular antenna. This line of attack is being expanded into a more general study of circular arrays and their applications to the present job.
3. The study of tilted V-antennas was continued. The antenna is assumed to consist of two inclined wires suspended between the top of a supporting pole and ground, with the feed point at the top of the pole. Perfectly conducting ground is also assumed. Vertical patterns were calculated for several combinations of leg length, height above ground, and angle between wires. These patterns are shown in Figures 1 to 9, inclusive. Several reports indicate that a gain of the order of 10 decibels over a half wave dipole in free space may be expected over a 2 to 1 frequency range. This gain falls to about 8 decibels when the antenna is used over a 3 to 1 frequency range. These preliminary calculations indicate that an antenna of this type may have an application to the present task.
4. The search of the literature for information concerning angle of arrival has been completed. The information on this subject is mea-

RESTRICTED

Detail Factual Data - Continued

ger and often contradictory. However, it appears that fluctuations of the order of $\pm 3^\circ$ in bearing and $\pm 6^\circ$ in elevation are to be expected for single hop modes, while for multi-hop modes the variations are greater, and occur at a higher rate. Work is now in progress to correlate this data with the propagation data previously reported. From the information on angle of arrival minimum feasible beamwidths may be assigned, and from these beamwidths an upper limit on the available gain can be calculated. This may be added to the field intensities already calculated for one kilowatt effective radiated power to give an upper limit on the possible field intensity for that communication link. These results will be reported when the calculations are complete.

5. Experimental work has recently been initiated to obtain the patterns of models of some of the more promising antennas. The effort thus far has been directed toward the construction of a feeding and matching system.

RESTRICTED

DEPARTMENT OF ELECTRICAL ENGINEERING
ENGINEERING EXPERIMENT STATION
THE UNIVERSITY OF TENNESSEE

PROJECT PERFORMANCE AND SCHEDULE

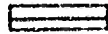
Index No. NE-091035 ST7

Contract No. NObsr-57448

Date: 10 August 1953

Legend:  Work Performed

Period Covered: 1/7/53 to 31/7/53

 Schedule of Projected
Operation

Subject	1952				1953											
	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	
1. Development of Field Test Facilities.																
2. Study of Propagation Problem.																
a. Investigation of paths lying entirely in night region.																
b. Investigation of paths lying entirely in day region.																
c. Investigation of paths lying partly in day and partly in night region.																
d. Investigation of auroral refraction.																
e. Investigation of angles-of-arrival.																
3. Determination of Suitable Antenna Type or Types.																
a. Search of literature.																
b. Theoretical study.																
4. Detailed Theoretical and Experimental Investigation of Most Promising Antenna Types.																
5. Development of Network System Suitable for Driving Array.																
6. Experimental Study of Final Array.																
7. Preparation of Phase Report.																

RESTRICTED

RESTRICTED

Conclusions

1. No final conclusion has yet been reached concerning the circular traveling wave antenna, but the results so far obtained are not particularly promising.
2. The use of inclined radial wires to form a "Maypole" antenna seems to give patterns suitable to the present task.
3. Calculations of maximum possible field intensities for a given communication link have not progressed far enough to allow any conclusions to be drawn.

RESTRICTED

RESTRICTED

Program for Next Interval

1. The work on the circular traveling-wave antenna is being expanded into a general investigation of the application of circular antennas, or arrays, to the present job.
2. The calculation of maximum possible field intensities for a given communication link will be completed.
3. The study of the "Maypole" antenna will be continued, and additional patterns will be calculated.
4. The experimental work on a model basis will be continued.

RESTRICTED

RESTRICTED

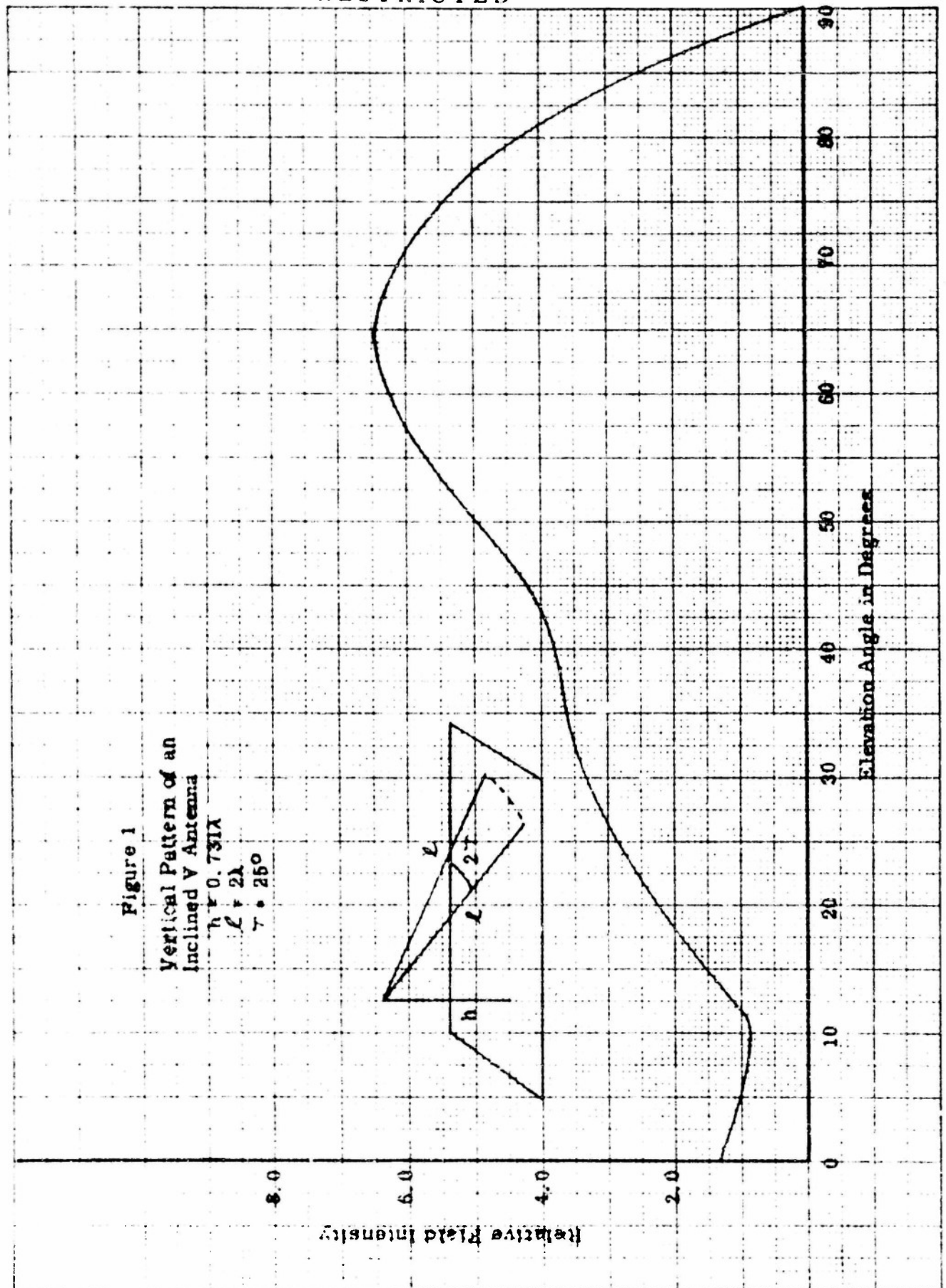
Figure 1

Vertical Pattern of an
Inclined V Antenna

$h = 0.731\lambda$

$L = 2\lambda$

$\gamma = 25^\circ$



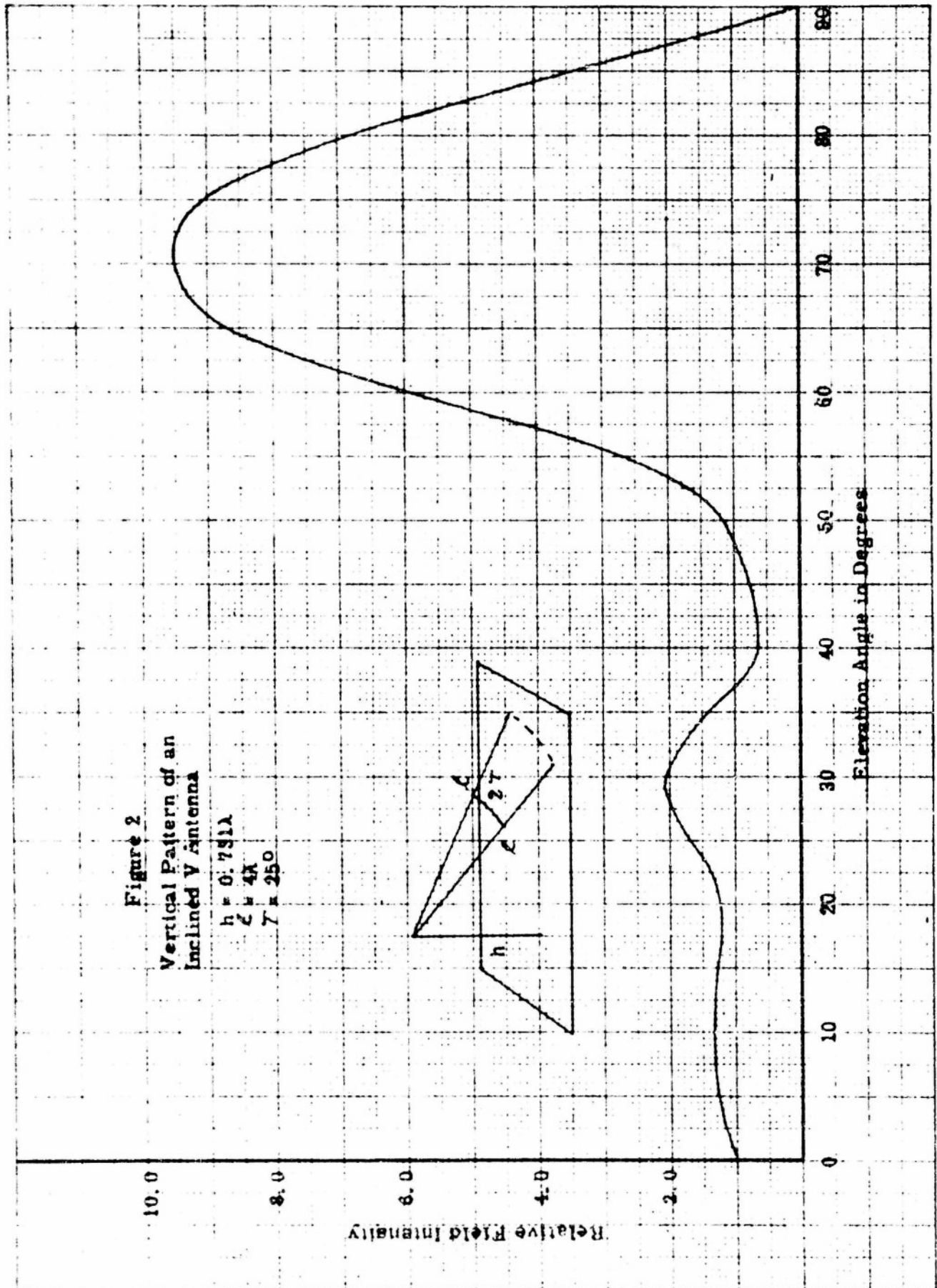
RESTRICTED

Figure 2
Vertical Pattern of an
Inclined V Antenna

$h = 0.751\lambda$
 $\angle = 4^\circ$
 $\gamma = 25^\circ$

Relative Field Intensity

Elevation Angle in Degrees

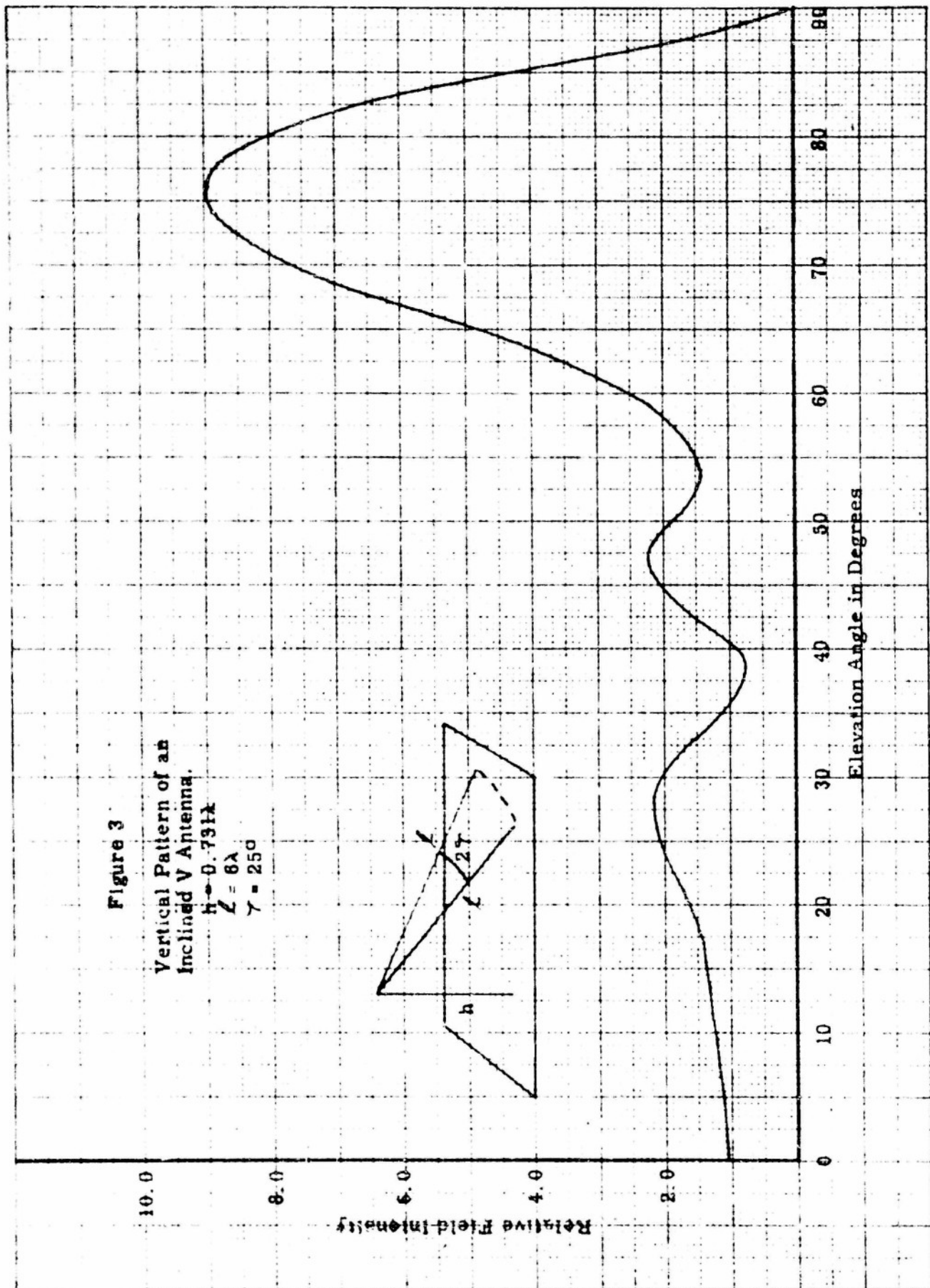


RESTRICTED

Figure 3
Vertical Pattern of an
Inclined V Antenna.
 $h = 0.731\lambda$
 $L = 8\lambda$
 $\gamma = 25^\circ$

Relative Field Intensity

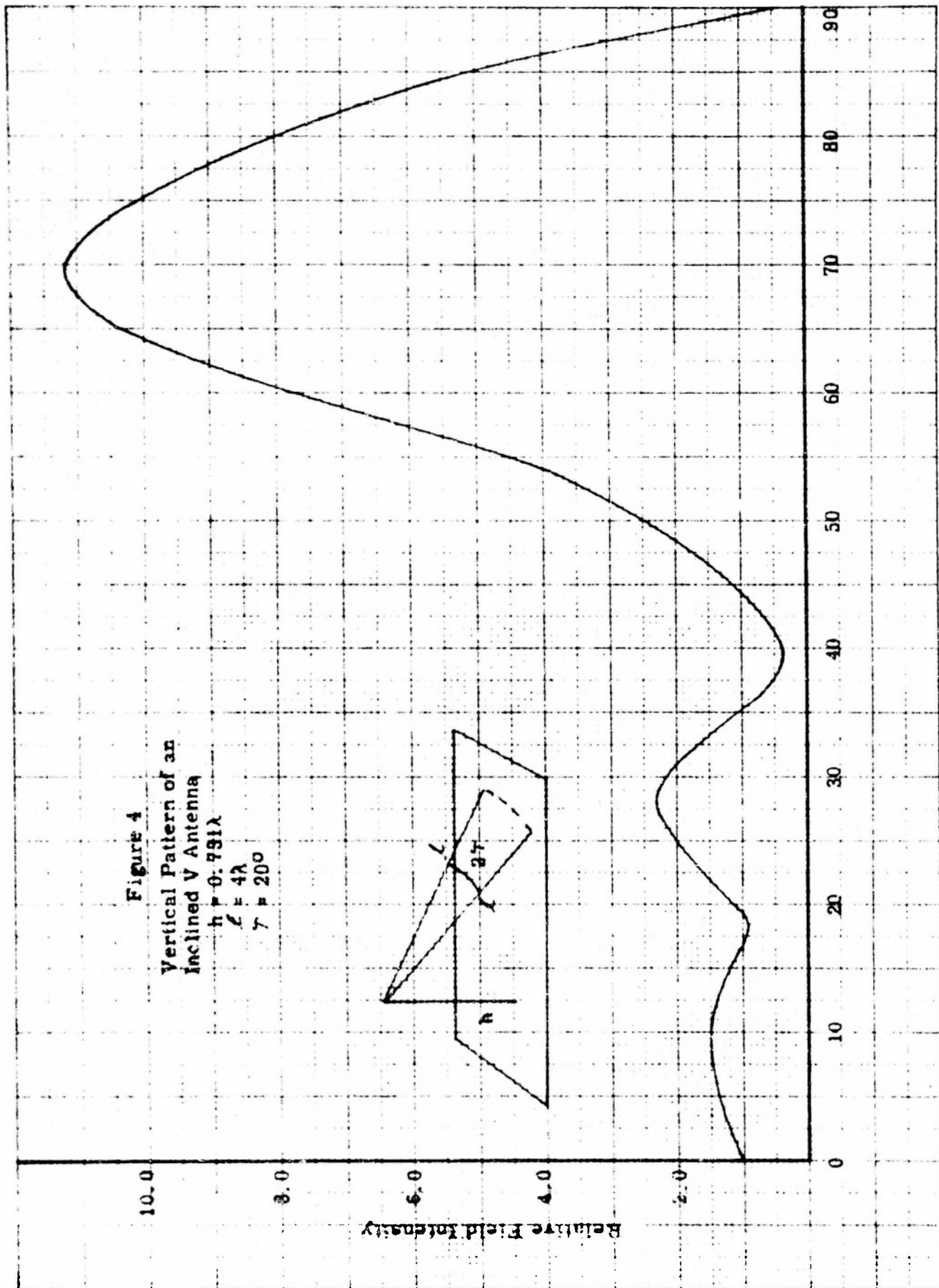
Elevation Angle in Degrees



RESTRICTED

RESTRICTED

Figure 4
Vertical Pattern of an
Inclined V Antenna
 $h = 0.791\lambda$
 $L = 4\lambda$
 $\gamma = 20^\circ$



RESTRICTED

RESTRICTED

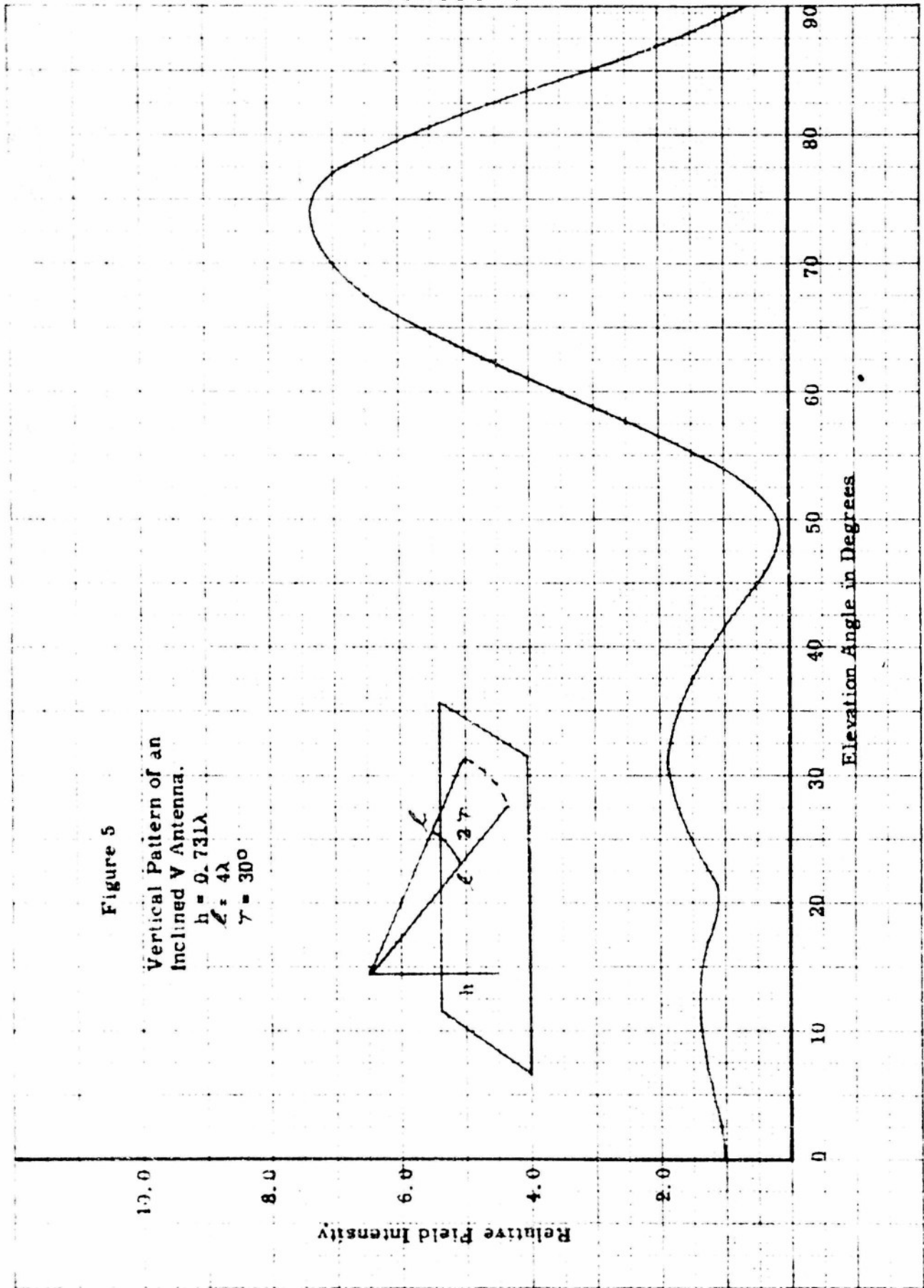
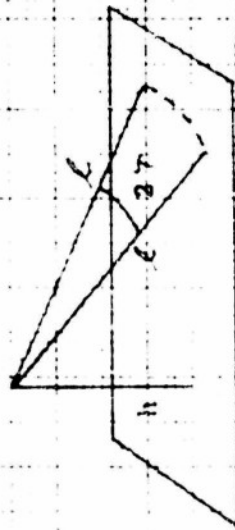
Figure 5

Vertical Pattern of an
Inclined V Antenna.

$$h = 0.731\lambda$$

$$\ell = 4\lambda$$

$$\gamma = 30^\circ$$



RESTRICTED

RESTRICTED

Figure 6

Vertical Pattern of an
Inclined V Antenna.

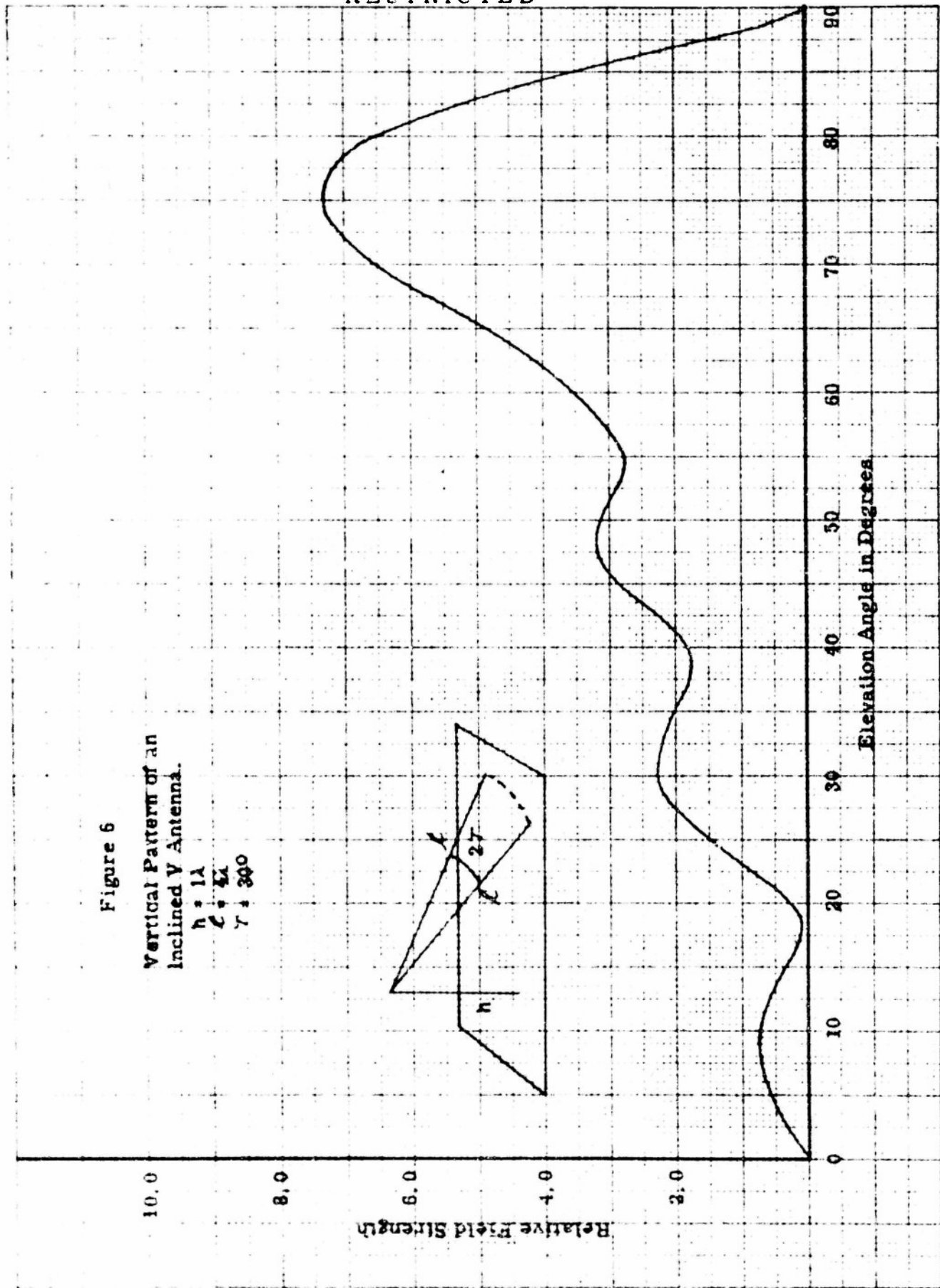
$h = 1A$

$\ell = 4A$

$\gamma = 300$

Relative Field Strength

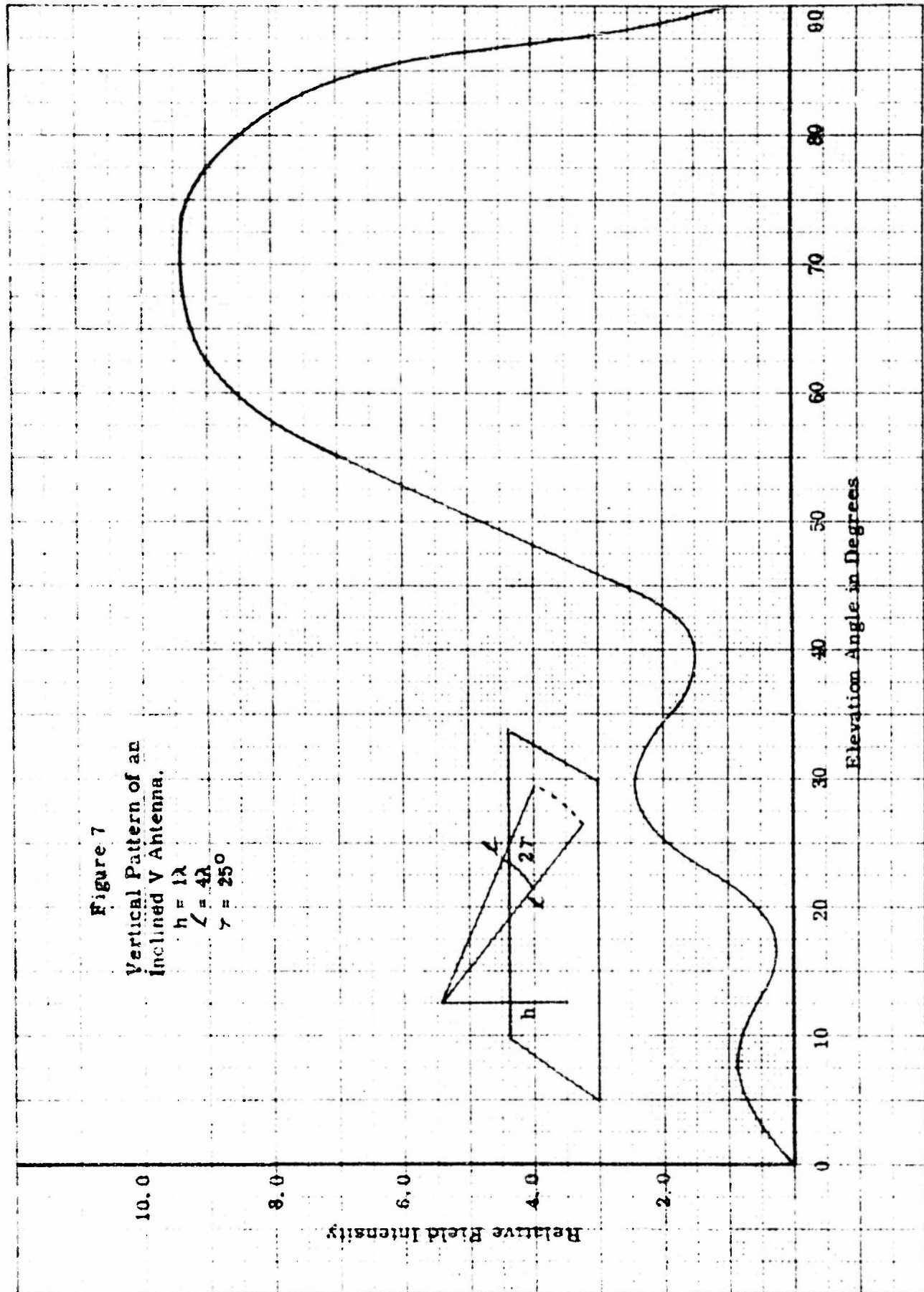
Elevation Angle in Degrees



RESTRICTED

RESTRICTED

Figure 7
Vertical Pattern of an
Inclined V Antenna.
 $h = 12$
 $L = 42$
 $\gamma = 25^\circ$



RESTRICTED

Vertical Pattern of an Inclined V Antenna

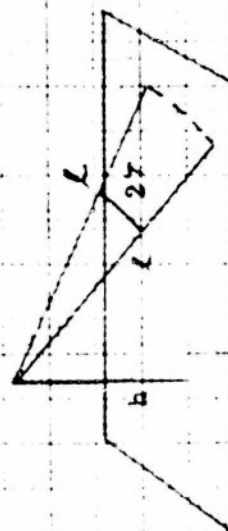
$$L = 6\lambda$$
 $\gamma = 150^\circ$ 

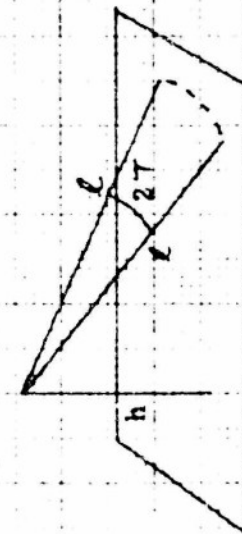
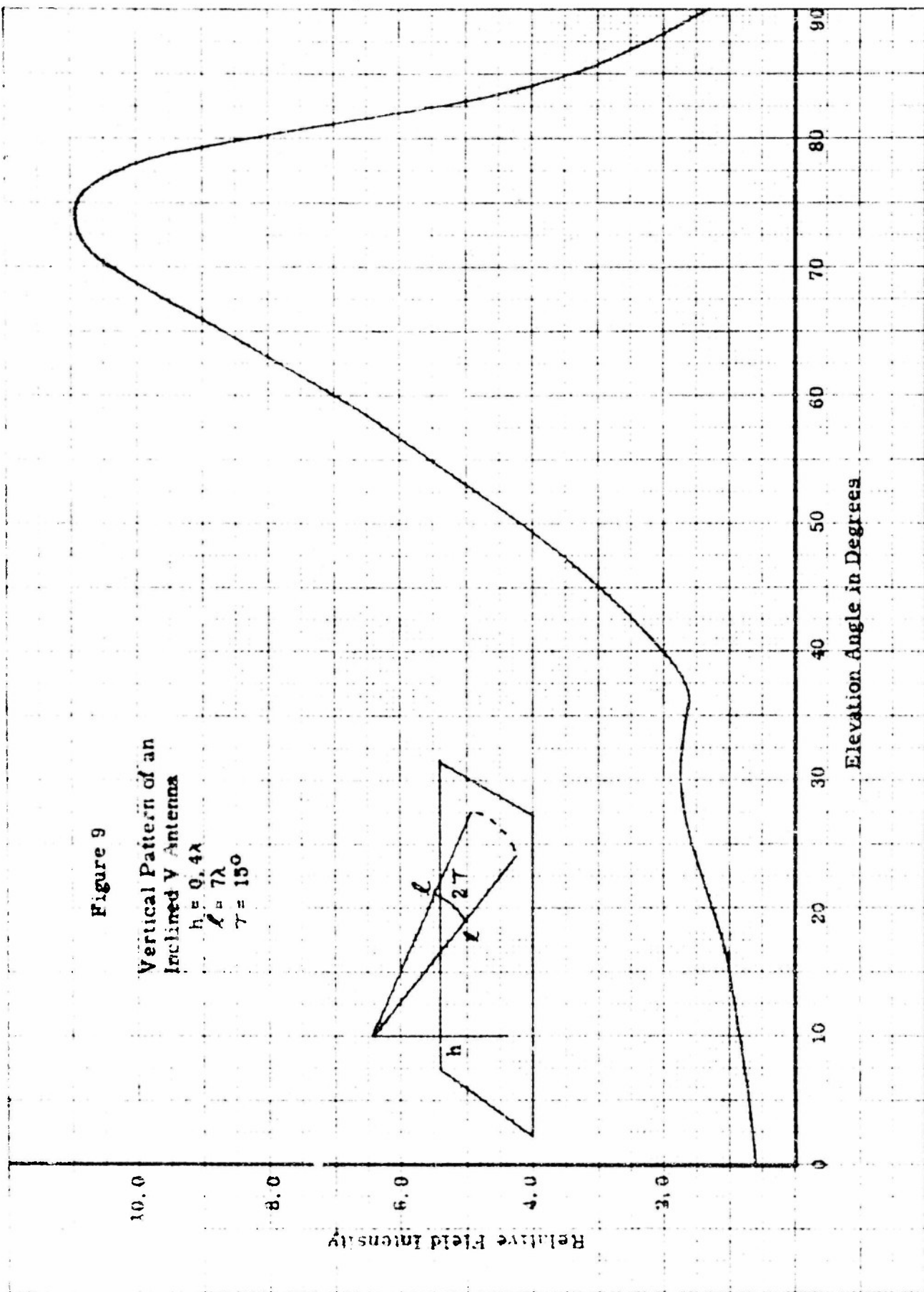
Figure 9

Vertical Pattern of an
Inclined V Antenna

$h = 0.4\lambda$
 $\ell = 7\lambda$
 $\gamma = 15^\circ$

Relative Field Intensity

Elevation Angle in Degrees



Armed Services Technical Information Agency

Because of our limited supply, you are requested to return this copy WHEN IT HAS SERVED YOUR PURPOSE so that it may be made available to other requesters. Your cooperation will be appreciated.

AD

39484

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

Reproduced by
DOCUMENT SERVICE CENTER
KNOTT BUILDING, DAYTON, 2, OHIO

UNCLASSIFIED