[redacted]

Matador [redacted]

Technical Memorandum

[redacted]

UNCLASSIFIED

SCTM - 127-53-51

EFFECT OF NON-STANDARD ATMOSPHERES UPON MATADOR TERMINAL TRAJECTORIES

W. H. Curry

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW

1st Review Date: 3/31/97	Declassification (Circle Numbers): 1. Classification Retained 2. Classification Changed to: U 3. Contains Classified Information 4. Contains UCNI? 5. Contains: Undossified
Authority: ADC Name: R B Craner	
2nd Review Date: 3-31-97	
Authority: ADD Name: W Layre	

RECORD COPY

Do Not Take From This Room

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW
DOWNGRADING OR DECLASSIFICATION STAMP

CLASSIFICATION CHANGED TO: U	AUTHORITY: W. C. Layre
Emelda Selph 4/21/97	RECORD ID: 97SN1131
PERSON CHANGING MARKING & DATE	
Carmela M Gallegos 5/5/97	
PERSON VERIFYING MARKING & DATE	DATED: 3-31-97

ABSTRACT

The effect of non-standard atmospheres upon the fuzing Mach range of the Matador missile is established. Consequent effects on barometric fuzing accuracies are discussed.

Case No. 409.03

August 17, 1953

[redacted]

[redacted]

UNCLASSIFIED

UNCLASSIFIED

SUMMARY

A study has been conducted to determine the effect of non-standard atmospheres upon the fuzing Mach range of the Matador missile. It is shown that the predicted fuzing Mach range of 0.96 to 1.01 in the NACA standard atmosphere becomes 0.96 to 1.06 in non-standard atmospheres which do possess some small probability of occurrence. The effect of this increased Mach range upon the accuracies of barometric fuzing systems utilizing body orifice and nose probe pressure sensing is discussed.

DISCUSSION

The atmospheres chosen for the investigation are considered representative of summer extremes in the lower latitudes and winter extremes in the upper latitudes. The temperature and pressure structures of these hypothetical atmospheres and the NACA standard atmosphere are shown in figures 1 and 2. The "cold" atmosphere, established in a study by R. L. Hendrick (Ref. 1), possesses some (small) probability of occurrence at polar regions above 55° N. Lat. ? how small is "small"? The "hot" atmosphere is elsewhere in the Corporation specified as "Atm. No. 10" and is somewhat characteristic of summer conditions at Salton Sea. Its unrealistic temperature structure in a local region near 38,000 feet altitude was assumed to have negligible effect upon Mach numbers in the fuzing altitude range 0 to 9,000 feet.

Combinations of missile weight, altitude, and velocity existing at the initiation of terminal dive for typical trajectories were obtained from the Glenn L. Martin Co. Of these, the combinations encountered in the minimum, the maximum,

UNCLASSIFIED

[redacted]

and some intermediate range missions from launch to target were used in the calculation of standard atmosphere trajectories. These three trajectories compared favorably with similar ones calculated by Martin (Ref. fig. 3). The small differences are attributed to slightly different initial conditions. Those suggested by Martin for use in the Sandia calculations are considered more realistic. Note that in the standard atmosphere, the total Mach range at fuzing altitudes, 0-9000 feet, is only about 0.96 to 1.01.

The two Sandia calculated trajectories yielding Mach number extremes at fuzing altitudes 0-9000 feet were then used in studying the effect of non-standard atmospheres. The results are illustrated in figures 4 and 5. The increase in Mach number caused by the cold atmosphere is appreciable. At altitudes near 25,000 feet the Mach increase amounts to 0.090. Near 10,000 feet it is 0.050, and at sea level it is about 0.015. The decrease in Mach number caused by the hot atmosphere is significant at high altitudes; however, it becomes almost negligible at sea level. Near 30,000 feet the Mach decrease is 0.050. Near 10,000 feet it is 0.008, and at sea level it is only about 0.002. From the nature of these Mach-Altitude curves, it is apparent that at fuzing altitudes, 0 to 9000 feet, hot atmospheres contribute little toward increasing the Mach range of the Matador missile. Cold atmospheres, however, may cause an increase of 0.05. Hence, the fuzing Mach range of 0.96 to 1.01 in the NACA standard atmosphere may become 0.96 to 1.06 in non-standard atmospheres.

The effect of this increased Mach range upon the accuracies of barometric

fuzing systems utilizing body orifice and nose probe pressure sensing is illustrated in figures 6-8. The data presented in these figures were derived from wind tunnel and theoretical studies, the results of which are summarized in Ref. 2. Shown in figure 6 is the capability of body orifices located at station 45. This is the method of pressure sensing presently employed to arm radars in the Mod C Matador warhead. Errors in feet of altitude at sea level and 9000 feet are plotted versus Mach number assuming zero error at Mach 0.99. Altitude effect is small, however, the Mach effect causes a uniform change in error from 600 feet low at Mach 0.96 to almost 1800 feet high near Mach 1.05. At Mach 1.06 the error is about 1300 feet high. The Mach number for zero error is arbitrary and could, of course, be redefined; this does not, however, alter the total spread in error over a given Mach range. In the standard atmosphere this total spread is 1100 feet; in non-standard atmospheres it may approach 2400 feet. An additional error of 100 to 300 feet may be caused by each degree angle of attack.

The performance of a 7-foot nose probe is shown in figure 7. Probes of this type are currently being flight tested on full scale Matador missiles. In the Mach range based on standard atmosphere, the total spread in error is 600 feet. Non-standard atmospheres, however, produce a Mach range which brackets the pressure discontinuity caused by the bow shock wave. The total spread in error then becomes almost 2000 feet. Angle of attack error is negligible for probes experiencing angles less than two degrees.

The performance of a 13-foot nose probe is shown in figure 8. An error spread

of 500 feet in the standard atmosphere Mach range is increased to 900 feet in the non-standard atmosphere Mach range. The increased Mach range again brackets the pressure discontinuity caused by the bow shock. This discontinuity could be eliminated by making the probe short enough to insure its occurrence at a Mach number in excess of the upper limit of 1.06; however, according to Ref. 3, the prediscontinuity pressure-Mach gradient would then reflect a total spread in altitude error of almost 2000 feet.

Cursory tests conducted in the Wright Field Transonic Wind Tunnel lend doubt that an alternate body port exists on Matador which will perform as well as the 13-foot nose probe. Present contention is that only a trailing device will yield pressures having a smaller degree of Mach sensitivity. Results of trailing probe tests on an F-86 aircraft in the Mach range 0.8 to 1.04 are presented in Ref. 4. Variations, due to Mach effect, of 500 feet were obtained. Smaller variations are considered possible with minor revisions in probe design.

CONCLUDING REMARKS

It has been shown that in non-standard atmospheres the fuzing Mach range of the Matador missile may become 0.96 to 1.06. In this particular range of Mach numbers, neither body orifices, for which data are available, nor nose probes of practical length yields a pressure which can be considered Mach insensitive. Extending the length of the nose probe to 13 feet only reduces the total spread in altitude error to 900 feet. A thorough pressure survey may reveal a less Mach sensitive port or a combination of ports which may be manifolded to gain Mach

UNCLASSIFIED

insensitivity. This, however, would involve costly and time-consuming wind tunnel and flight test programs. Unless accuracy requirements are relaxed, a trailing device may be the only source yielding pressures acceptable for barometric fuzing of the Matador warhead.

WARREN H. CURRY - 5141

DISTRIBUTION:

1/15A - S. C. Hight, 5100
2/15A - G. E. Hansche, 5140
3/15A - C. H. DeSelm, 1310
4/15A - W. J. Howard, 1330
5/15A - W. C. Scrivner, 5240
6/15A - L. D. Smith, 1311
7/15A - S. H. Dike, 5133
8/15A - M. L. Favia, 1313
9 thru 13/15A - W. H. Curry, 5141
14,15/15A - G. M. Byrne, 1925-3

UNCLASSIFIED

UNCLASSIFIED

REFERENCES

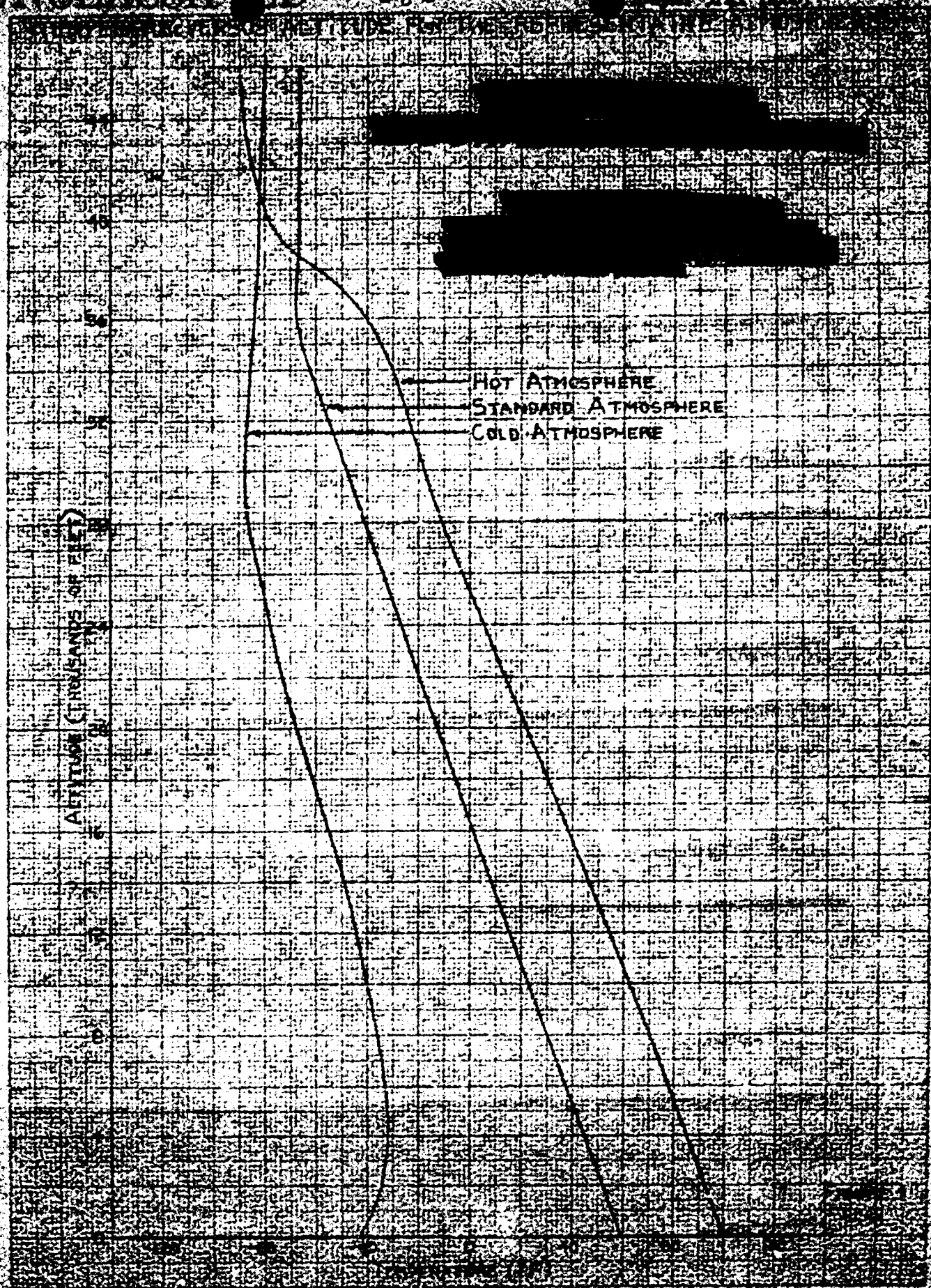
1. "Selection of a Very Cold Arctic Atmosphere", Sandia Corporation Memo to W. H. Curry, 5141 from R. L. Hendrick, 5243-2 dtd May 22, 1953.

2. "Matador Pressure Sensing" by W. H. Curry, Sandia Corporation Memo, Ref. Sym: 5141 (340), dtd Dec. 10, 1952.

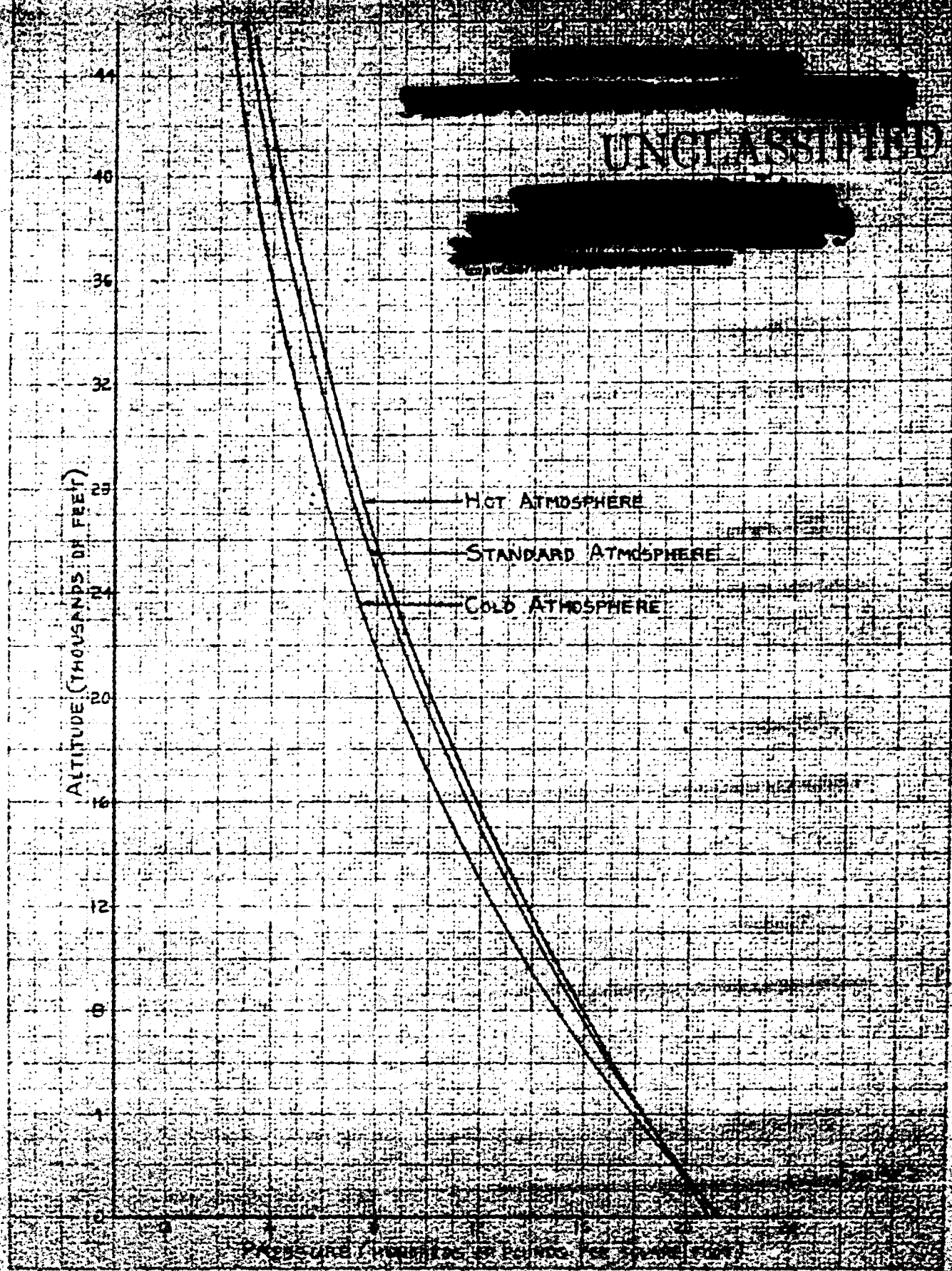
3. "Matador Pressure Sensing" by W. H. Curry, Sandia Corporation Memo, Ref. Sym: 5141 (264), dtd June 30, 1952.

4. "Preliminary Results of F-86 Dive Tests with Belly Probe Pressure Installation" by W. B. Pepper, Sandia Corporation Memo, Ref. Sym: 5141 (404) dtd June 16, 1953.

UNCLASSIFIED


[redacted]
HOT ATMOSPHERE
STANDARD ATMOSPHERE
COLD ATMOSPHERE
ALTITUDE (THOUSANDS OF FEET)

PRESSURE VERSUS ALTITUDE FOR THE [redacted]



[redacted]

UNCLASSIFIED

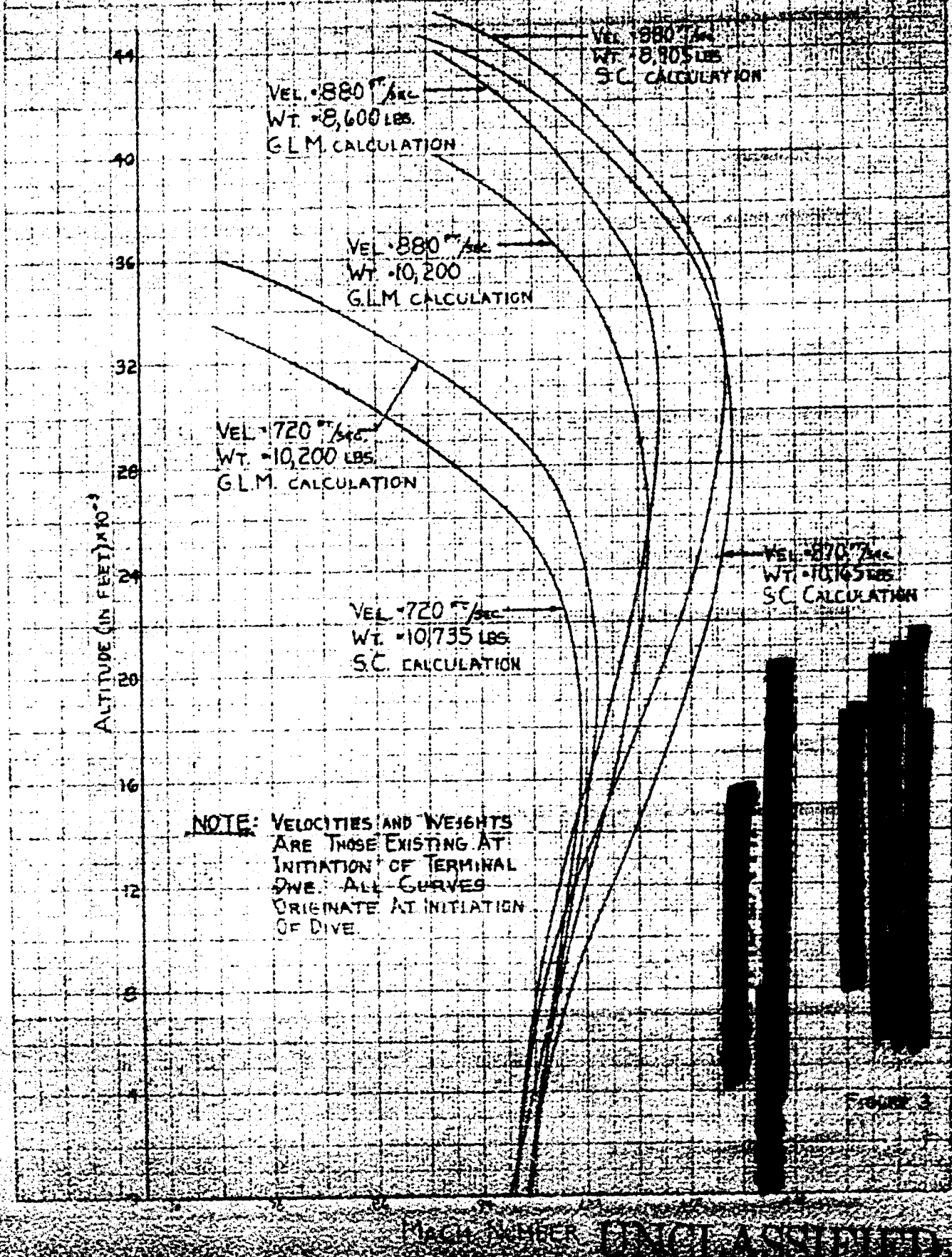
[redacted]

UNCLASSIFIED

MATADOR TRAJECTORY EXTREMES IN THE NACA STANDARD ATMOSPHERE

COMPARISON OF GLENN L. MARTIN COMPANY AND SANDIA CORPORATION CALCULATIONS

UNCLASSIFIED



[redacted]

FIGURE 3

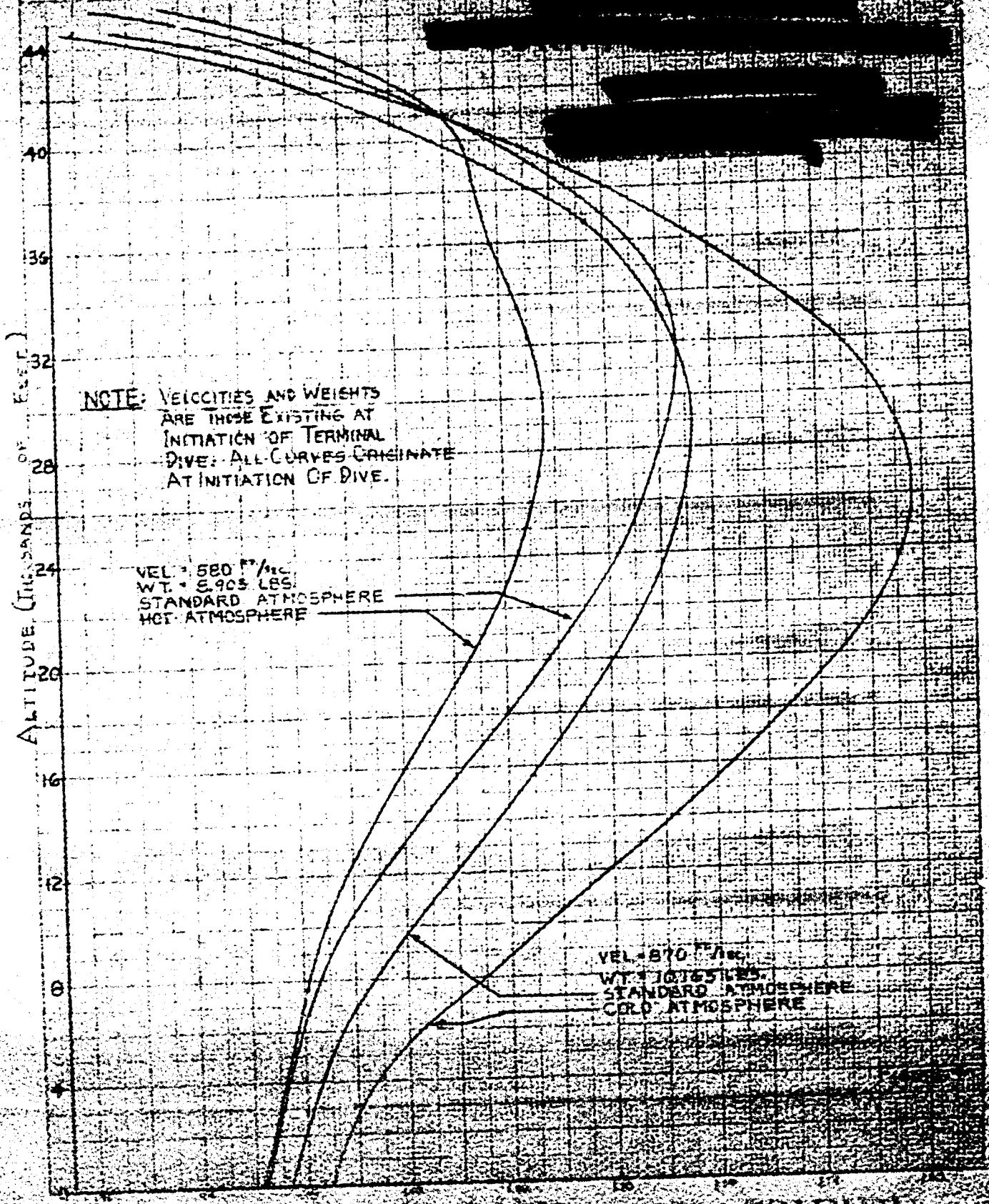
UNCLASSIFIED

[redacted]

COMPARISON OF MATADOR TRAJECTORIES IN STANDARD AND NON-STANDARD ATMOSPHERES

UNCLASSIFIED

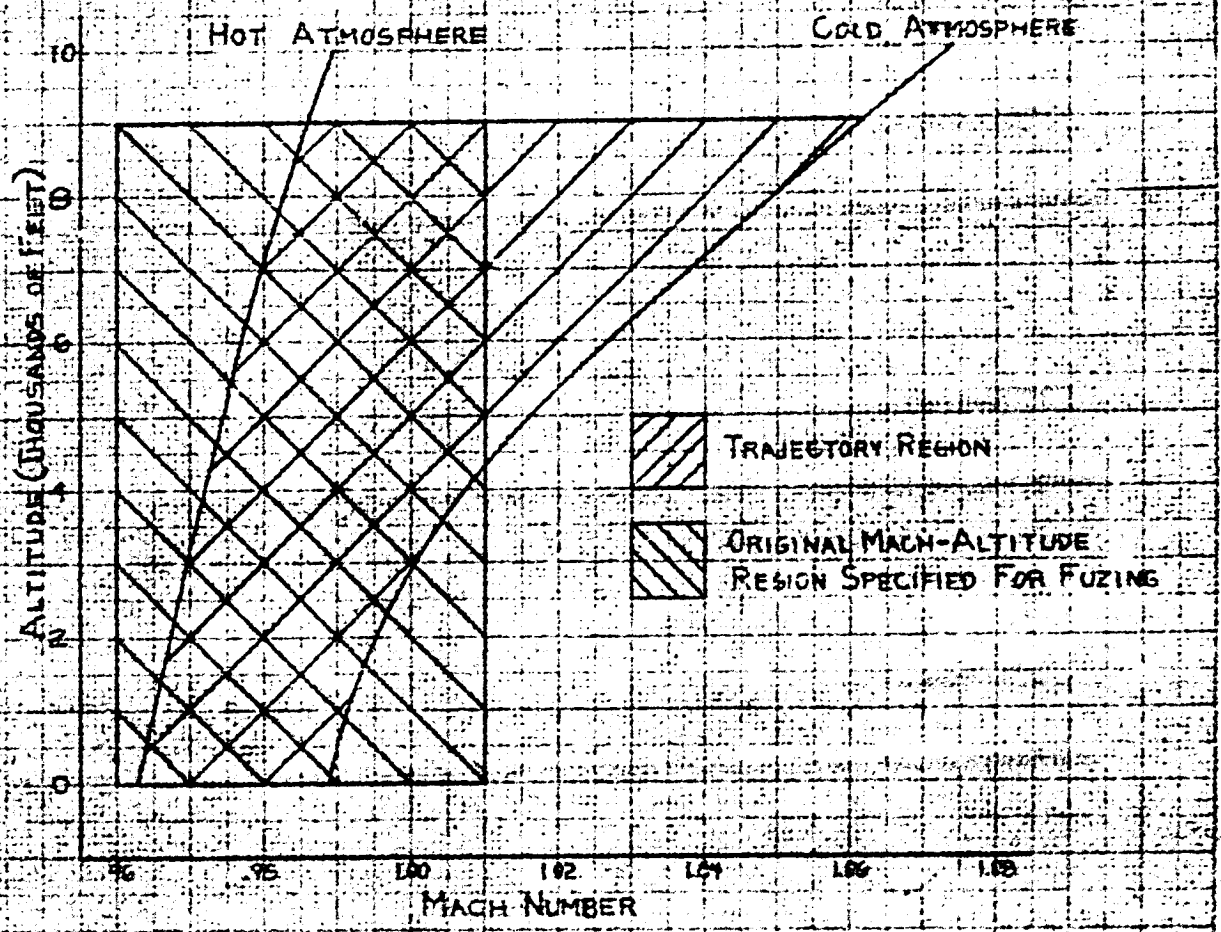
[redacted]



UNCLASSIFIED

UNCLASSIFIED

MATADOR TRAJECTORY EXTREMES AT FUZING ALTITUDES IN NON-STANDARD ATMOSPHERES



[redacted]

FIGURE 3

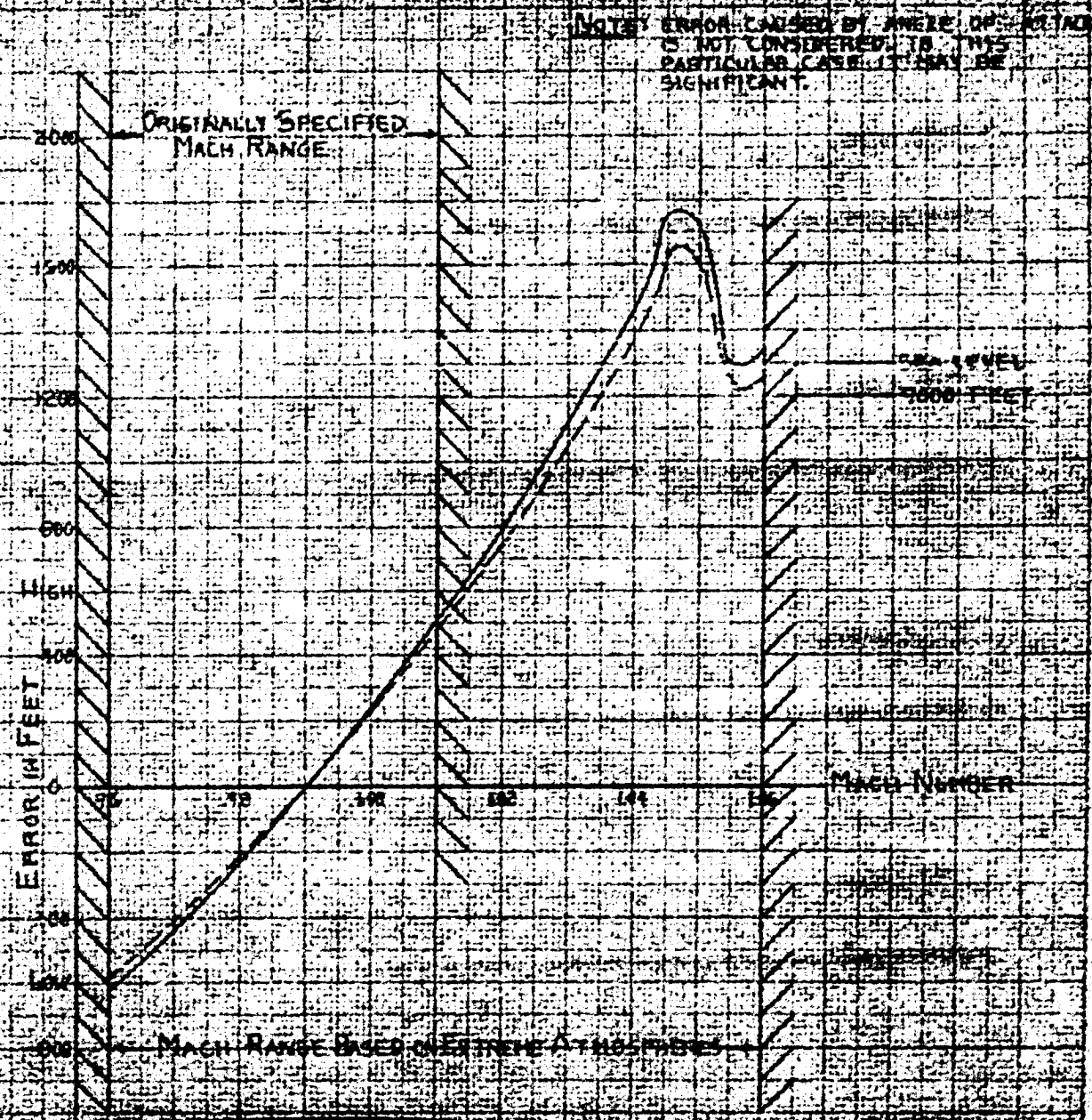
UNCLASSIFIED

UNCLASSIFIED

MATADOR FUZING ERROR [illegible]
ZERO ERROR [illegible]

SENSING DEVICE - BODY ORIFICES AT STATION 4.5

DATA DERIVED FROM FIGURE 3 REFERENCE 2



[redacted]

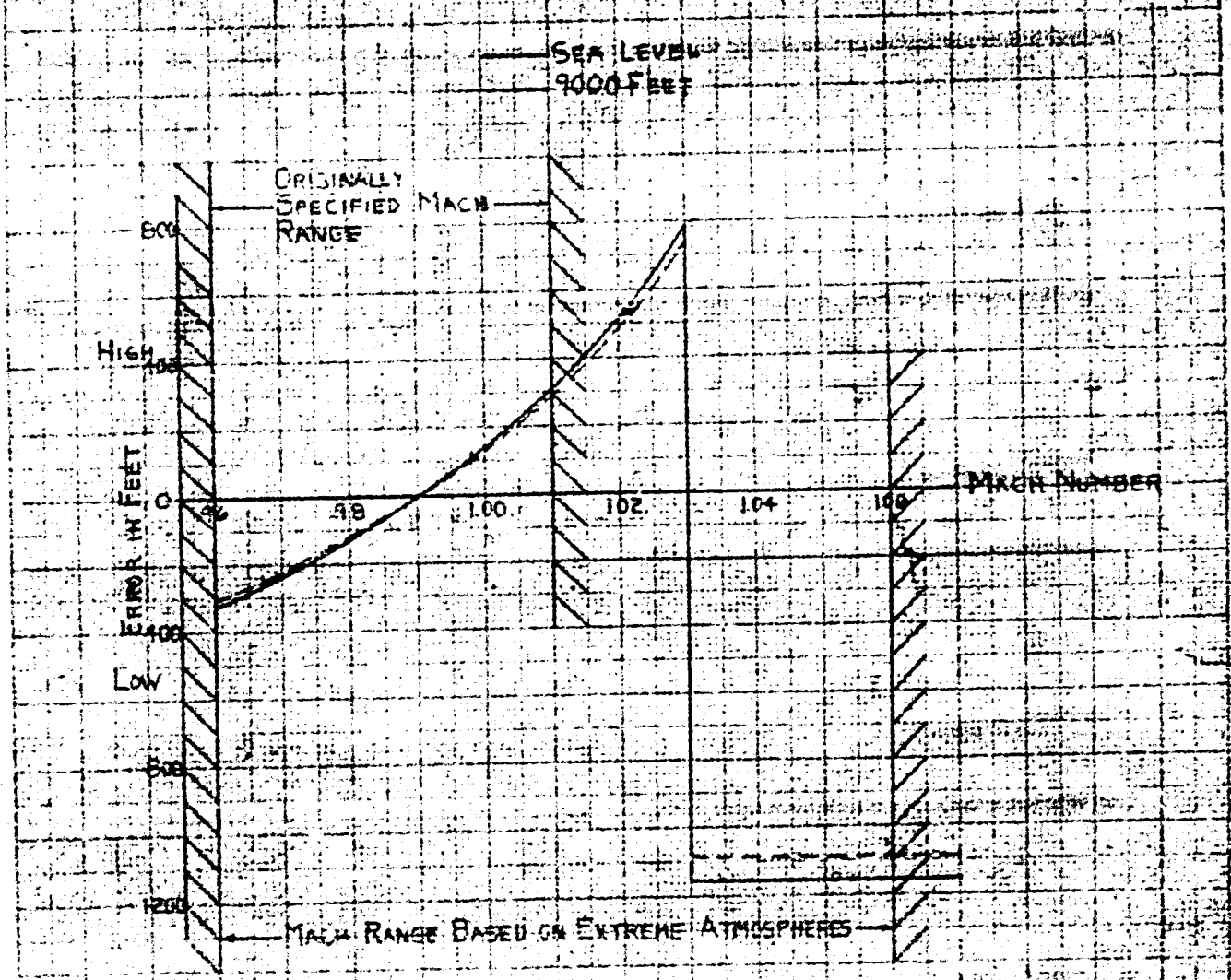
UNCLASSIFIED

UNCLASSIFIED

MATADOR FUZING ERROR VERSUS MACH NUMBER
ZERO ERROR AT MACH 1.03

SENSING DEVICE - 7 FOOT NOSE PROBE WITH ORIFICES LOCATED
5.85 FEET FORWARD OF THE MISSILE NOSE

DATA DERIVED FROM FIGURE 2
OF REFERENCE 2



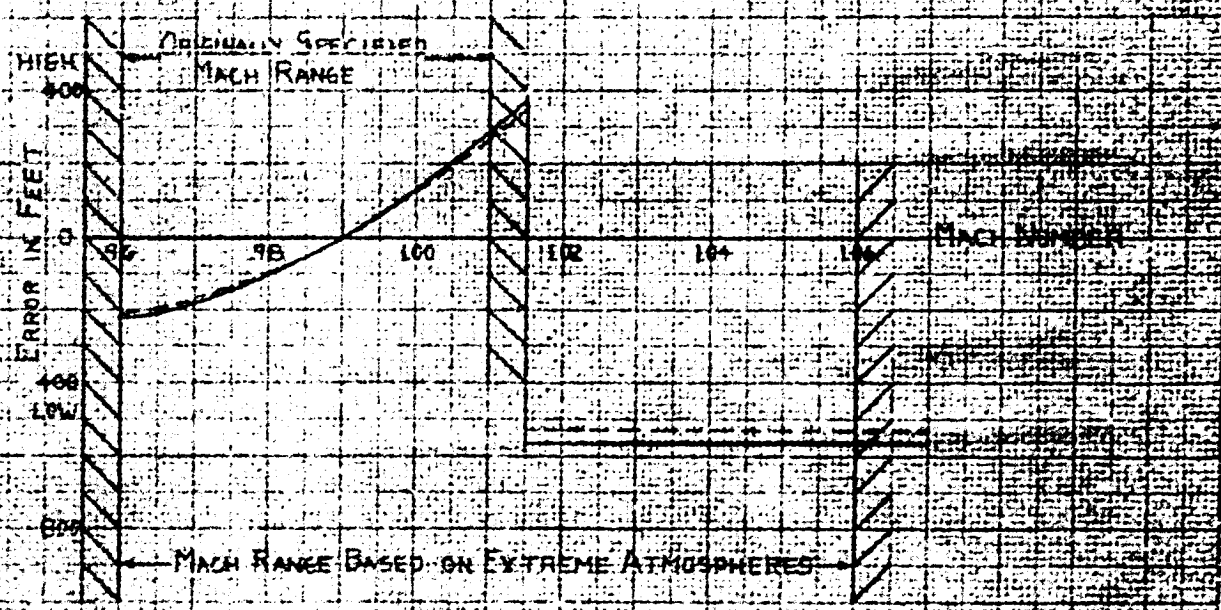
[redacted]

UNCLASSIFIED

MATADOR FUZING ERROR VERSUS MACH NUMBER [redacted]
ZERO ERROR AT MACH [redacted]

SENSING DEVICE - 13 FOOT NOSE PROBE WITH ORIFICES LOCATED
1.85 FEET FORWARD OF THE MISSILE NOSE

DATA DERIVED FROM FIGURE 1 OF REFERENCE 2



[redacted]

[redacted]

UNCLASSIFIED