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GEORGE C. MARSHALL SPACE FLIGHT CENTER,

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FAR-FIELD ACOUSTIC LEVELS RESULTING FROM TITAN LAUNCHES

by

Richard N. Tedrick 17 Apr. 1962

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ABSTRACT

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Test Division personnel from Marshall Space Flight Center acoustically monitored the launch of Titan intercontinental ballistic missiles from CCMTA on October 6 and 24, 1961. This was done for operational check-out prior to the first Saturn launch and to obtain far-field data from a smaller booster of known size and thrust to compare with that from a Saturn vehicle launch.

The data generally shows the same pattern as that from the Saturn test. The peak energy was found to exist in the 50 cycle per second octave band. As in the Saturn data, atmospheric fluctuations were found to exist at ten miles range.

AUTHOR

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MEAS''''ING AND INSTRUMENTATION BRANCH
TEST DIVISION

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GEORGE C. MARSHALL SPACE FLIGHT CENTER

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SECTION I. INTRODUCTION

On October 6 and 24, 1961, Test Division personnel from the George C. Marshall Space Flight Center acoustically monitored the launch of two Titan intercontinental ballistic missiles from CCMTA. This monitoring was preformed for two reasons: (1) to check out equipment, personnel, and communications operations prior to the first Saturn vehicle launch, and (2) to obtain far-field acoustic data from a smaller booster of known size and thrust for comparison purposes.

Figures 1 and 2 show the locations monitored during the two tests. Three lines of sound measuring points were established which passed through the major population centers in northern Brevard County, Florida. Only two stations were manned during the October 6 tests, but all were operational on October 24. During this latter test, all stations except those at ranges exceeding 85,000 feet (16 miles) received signals above the background ambient noise level.

SECTION II. PRESENTATION OF DATA

Figure 3 shows the variation of the overall rms noise as a function of time at two measurement points during the October 24 test. The upper scale shows this time measured after the arrival of the ignition signal at the microphone. Since the velocity of sound at this time was somewhat over one thousand feet per second, the noise reached the microphone at 5,000-foot range about six seconds after the actual ignition.

The lower scale shows the approximate altitude at which the sound was produced. In order to calculate this, it was necessary to determine the slant range from the microphone to the missile at each altitude and to know at what time the missile was at that altitude. Assuming a constant velocity of sound to be one thousand feet per second and assuming that the sound traveled along a straight line from the missile to the microphone, the acoustic travel time was calculated. This, added to the missile flight time, gave the time at which sound from each altitude would have arrived at the monitoring point.

It was determined that the altitudes shown on the lower scale are valid within ten per cent, and while precise techniques for ray path calculations are available, these results are within other measurement uncertainties. Due to the rather high ambient noise caused primarily by the 15 to 20 mile per hour wind prevailing at the test times, data represents environments created only during the first 13,000 feet of the flight, the highest levels occur in this time period, and the sound steadily decreases for longer time periods.

Figures 4 through 10 show the variation of the noise in octave bands with time. As may be seen by comparing some of the records, the time when the curve peaks varies slightly for the different octave bands. This is attributed to either missile velocity or directivity of the source, but sufficient data to isolate the effect are not available.

Another point of interest in the Titan data is that they, like those from the Saturn launch, show the effect of atmospheric turbulence. This is evidenced by the large-scale fluctuations in the sound pressure levels measured at long range. These are apparently the result of local eddys and non-homogeneities in the atmosphere near the missile (Ref. 8 through 11). As more data are accumulated, better understanding of these effects will allow a more complete explanation of them.

The data are presented herein in a manner to give the reader the best opportunity to easily extract the information most pertinent to his interest. No effort has been made to determine octave or one-third octave spectra because the variation of sound pressure levels with time limits the accuracy of the averaging technique used in automatic processing of such data. However, it is always possible for the reader to construct a spectrum at any given point in time from the octave time-histories presented.

Much of the data collected during the Titan launches were collected upon commercially available sound level meters. These meters measure the overall sound pressure level (re: 0.0002 microbar) but, as constituted, do not record either time-history or frequency spectrum data. Therefore, the data shown in Table I from these meters are the peak values of the overall sound pressure level as measured at those points.

SECTION III. RESULTS

Examination of the octave band time-histories shows the general agreement between the shape of the spectrum recorded at 5000 feet range and that recorded at nearly ten miles range from ground zero. The difference in the spectra may be explained by (1) distance - the usual inverse square law attenuation plus the excess attenuation due to absorption and other atmospheric effects, (2) atmospheric fluctuation - the result of local inhomogeneities in assumed wind layers in the atmosphere, (3) Doppler shift - the shift in the apparent frequency of the received sound due to the relative motion of the source with respect to the receiver, (4) source directivity - the result of lobes of stronger, more intense sound which emanate from the engine between 50 and 70 degrees from the exhaust stream. Since this lobe would pass over the receiving points at different times, depending upon the range of the points from the launch, the directivity would have the effect of changing the shape of the time-history plot.

The octave band time-histories (Figs. 4 through 10) generally show the broad peak of energy to exist below 100 cycles per second as was found to occur during the Saturn launch. The maximum energy occurred in the 50 cycle per second octave bands both at one and ten miles range and appeared to result during the lobes passage over the monitoring point. Since this energy peak is lower in frequency than would be expected from a theoretical consideration of the vehicle size and thrust and since the 50 cycle peak did not show up during the on-pad portion of the firing it may be presumed that it was a characteristic of the lobe.

The peak overall sound pressure levels shown in Table I occurred at different times and are largely the results of the major acoustical lobe passing over the measuring point. These values should not, therefore, necessarily be considered as representative of the attenuation due to distance of a single sound from a fixed source. However, they do generally fall along the curve which might be expected from such a sound source (Fig. 10).

The velocity of sound profile has been calculated for each azimuth along which sound level measurements were taken (Fig. 12). However, no unusual variations in overall sound pressure level are noticeable in Figure 10. The approximate value during this test of the excess attenuation appeared to be two decibels (re: 0.0002 microbar) per mile. Because of the very large role in sound propagation played by meteorology, these data should not necessarily be considered to be representative of the levels which may reasonably be expected from other launches of Titan vehicles.

Table I

OVERALL SOUND PRESSURE LEVELS

STATION	RANGE (ft)	OA RMS SPL* Oct. 6, 1961	OA RMS SPL* Oct. 24, 1961
A	86,750		-
B	33,250		90
C	8,700	116	114
D	14,780		108
E	51,750		89
F	70,200		88
G	81,300		84
H	91,800		-
I	71,250		89
J	54,300		95
K	3,400	122	123
L	5,100		120

* In decibels ref. 0.0002 microbar

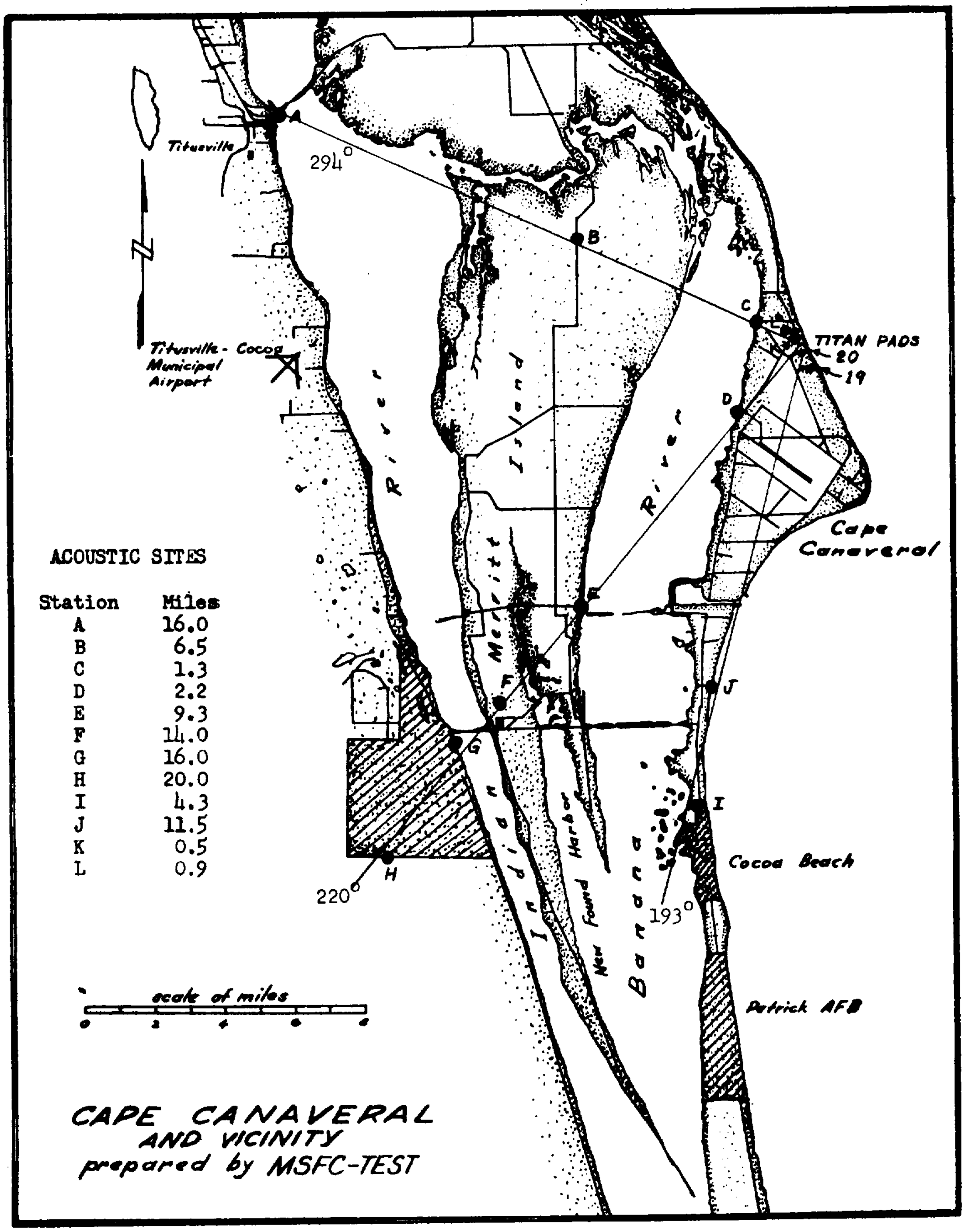

FIGURE 1. FAR-FIELD ACOUSTIC MEASUREMENT LOCATIONS

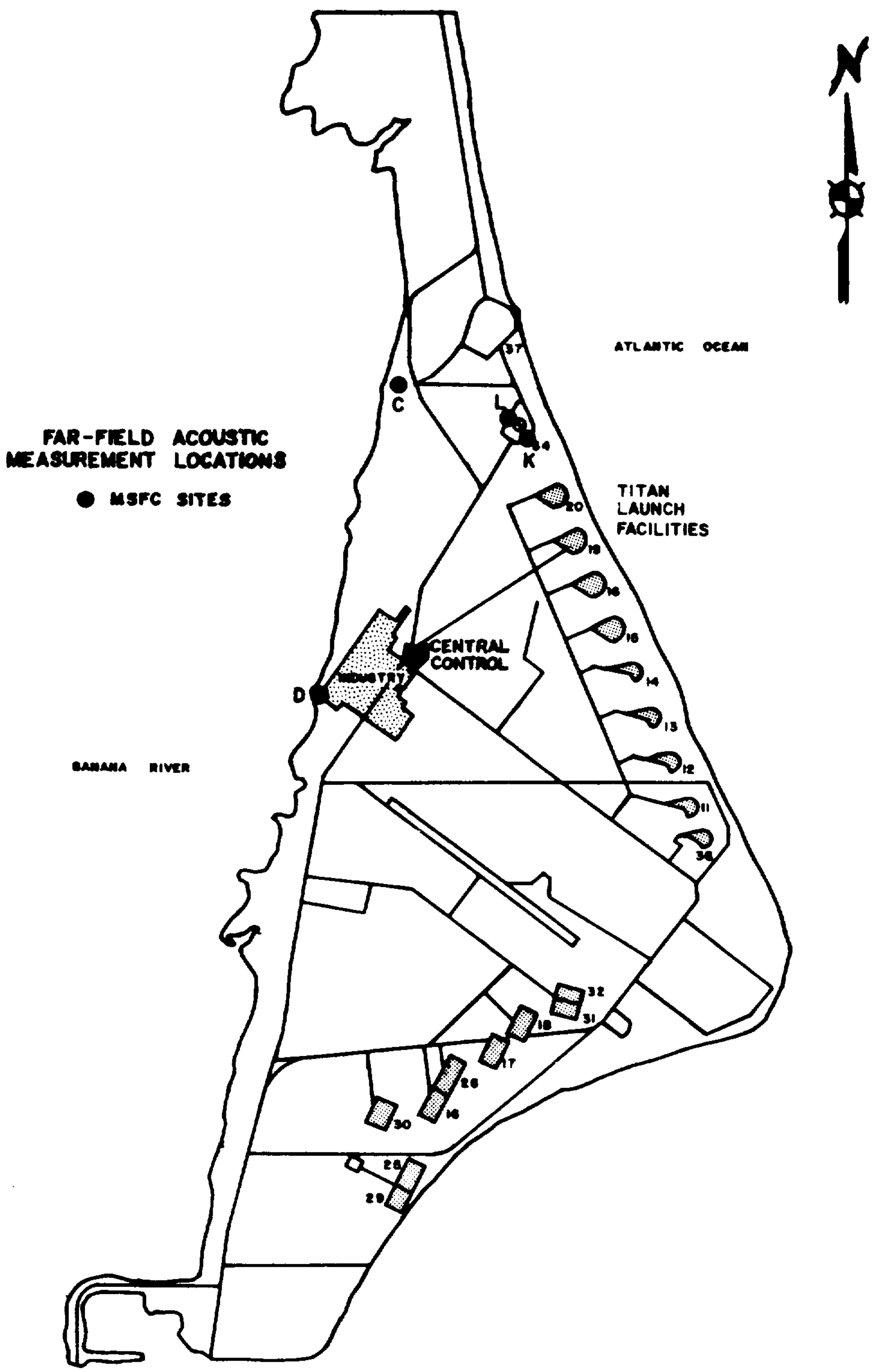

FIGURE 2. FAR-FIELD ACOUSTIC MEASUREMENT LOCATIONS ON CCMTA

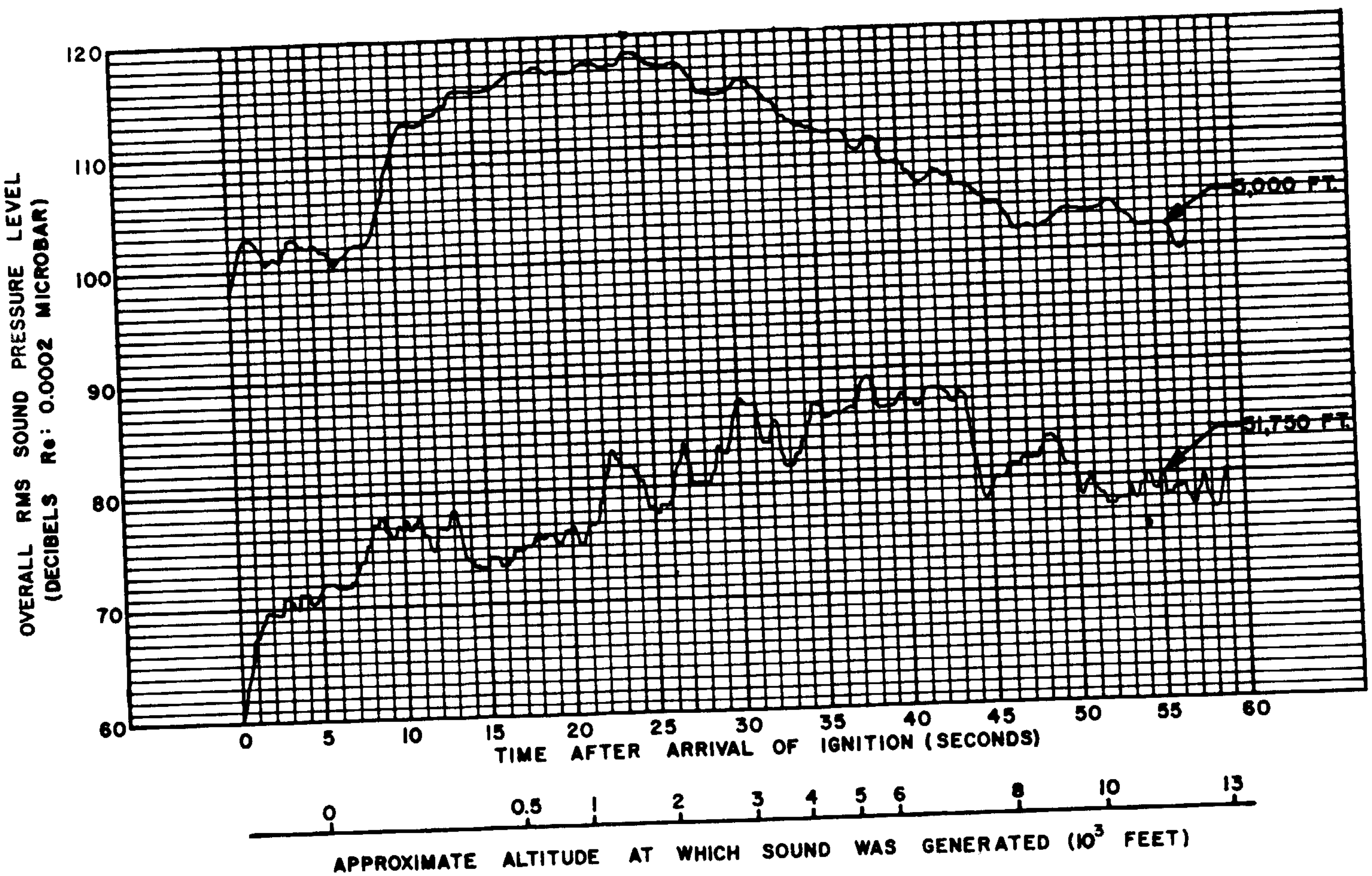

FIGURE 3. OVERALL RMS NOISE LEVEL TIME-HISTORY OF THE TITAN MISSILE

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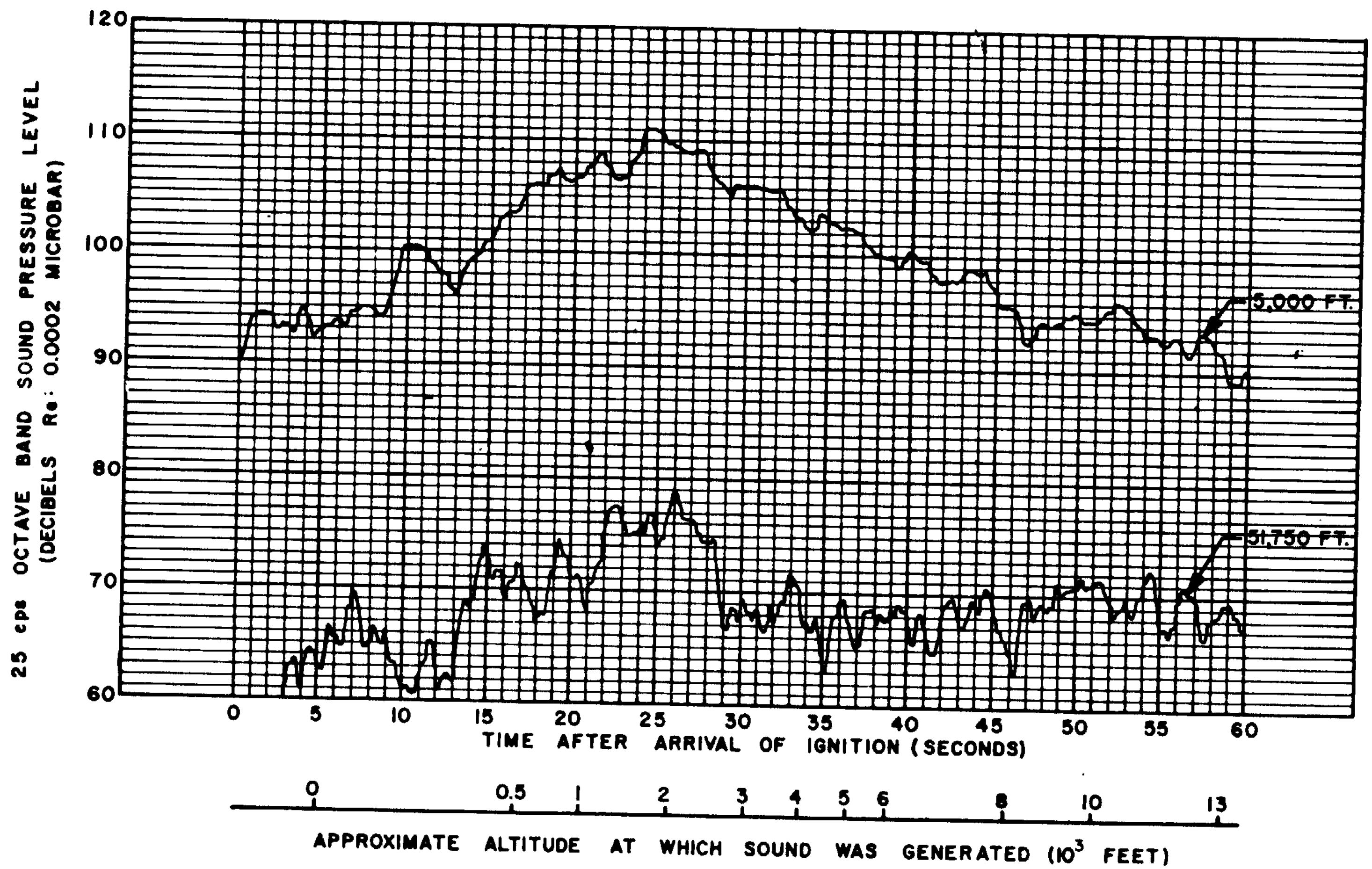

FIGURE 4. 25 CPS OCTAVE BAND TIME-HISTORY OF THE TITAN MISSILE

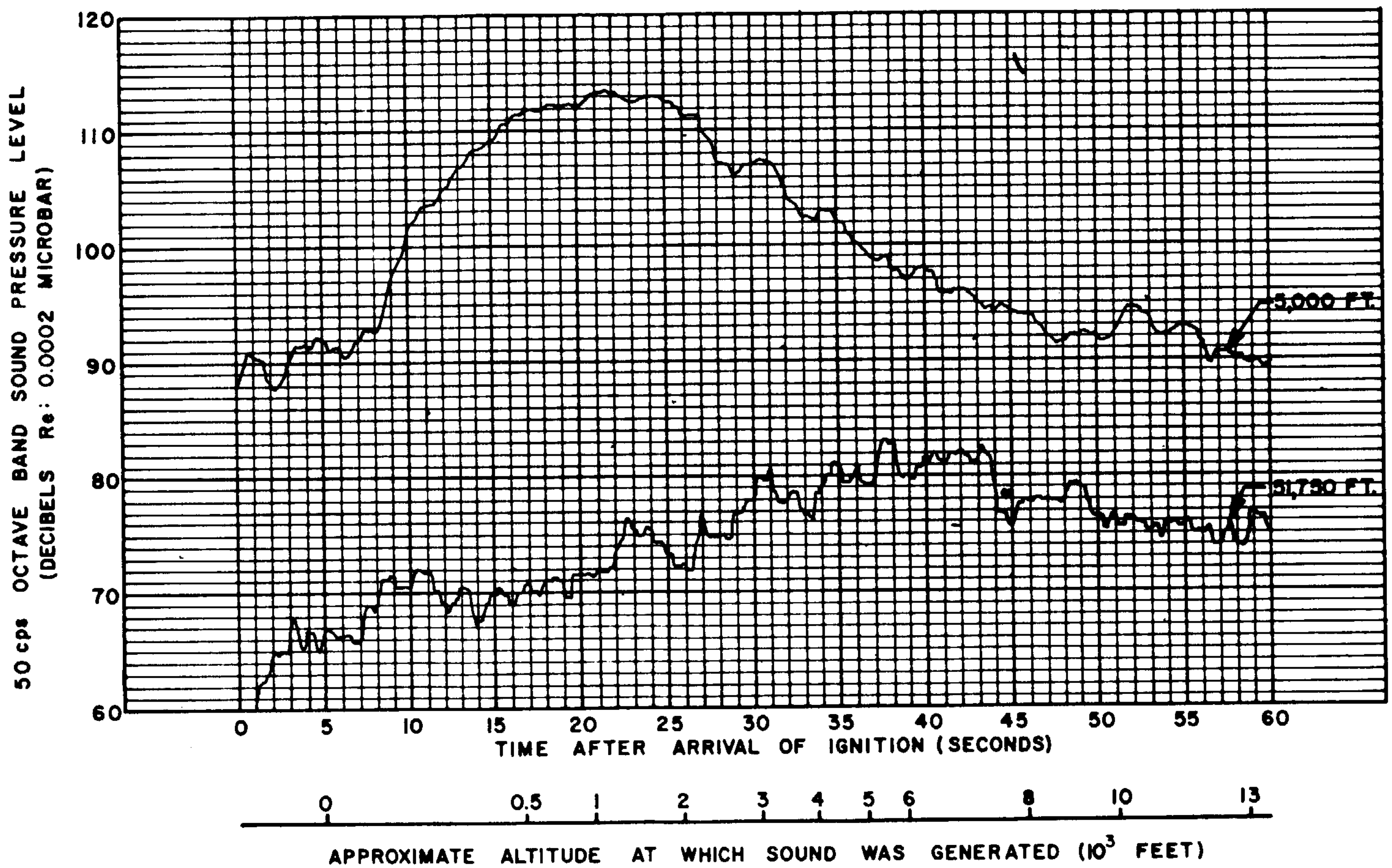

FIGURE 5. 50 CPS OCTAVE BAND TIME-HISTORY OF THE TITAN MISSILE

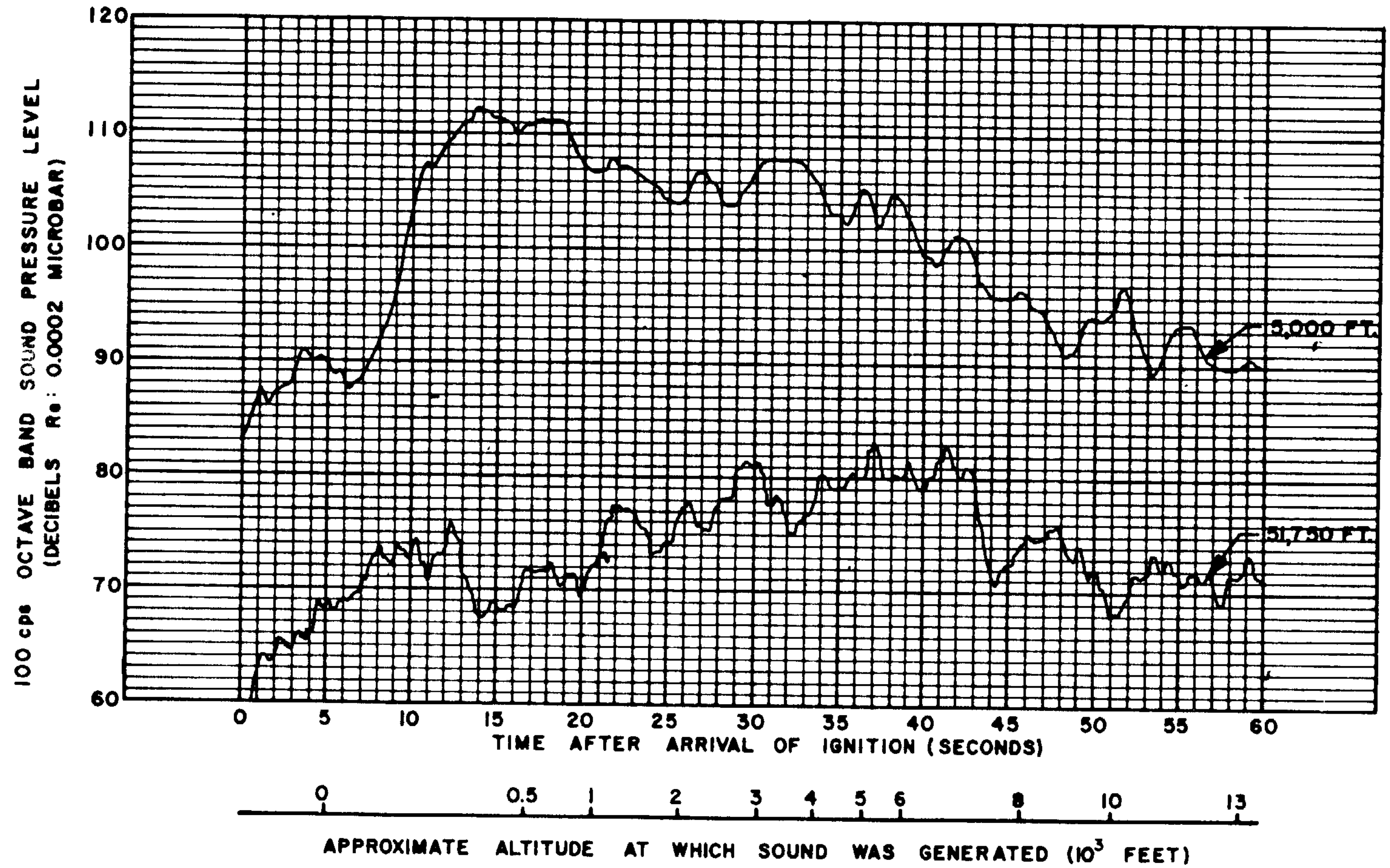

FIGURE 6. 100 CPS OCTAVE BAND TIME-HISTORY OF THE TITAN MISSILE

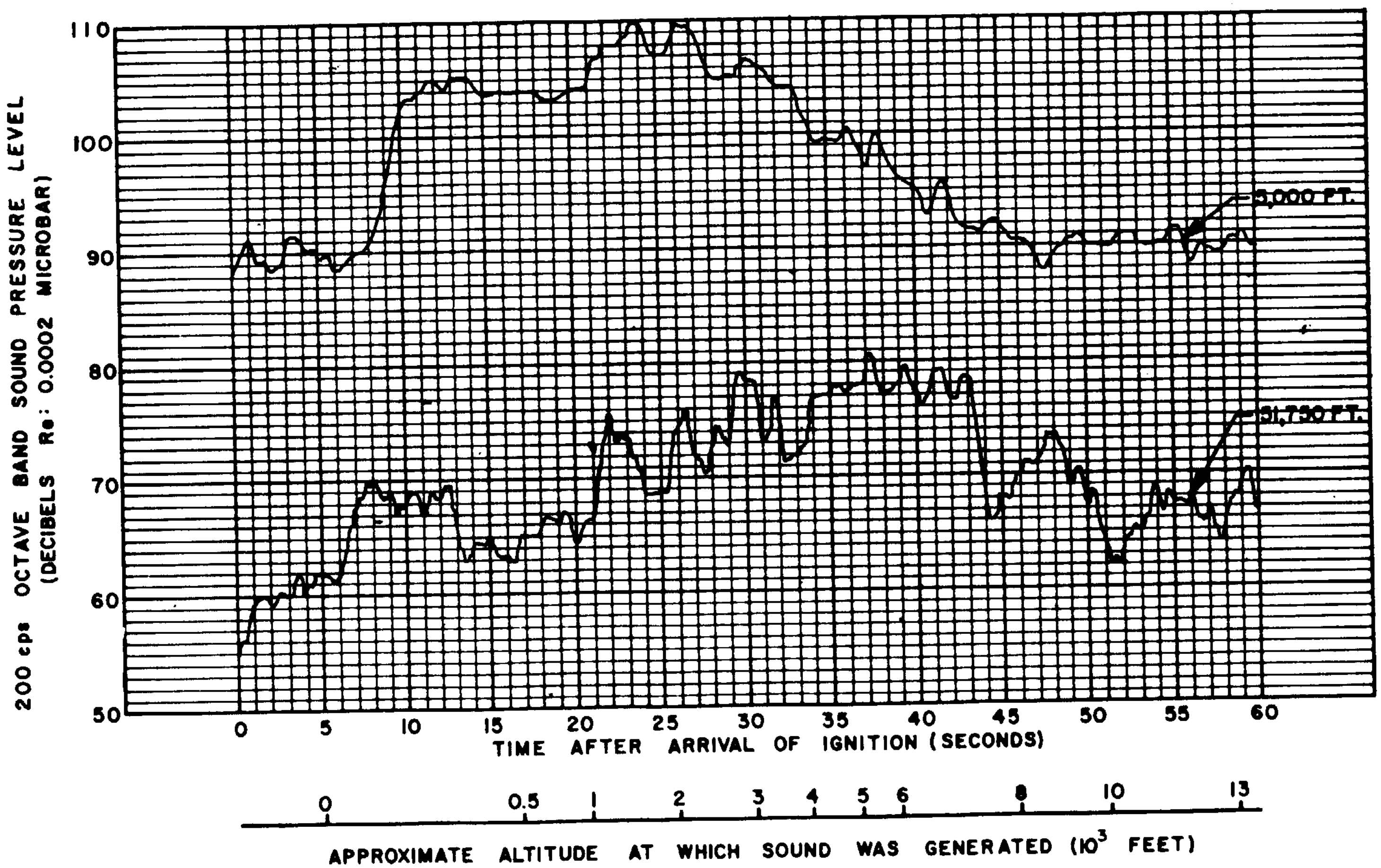

FIGURE 7. 200 CPS OCTAVE BAND TIME-HISTORY OF THE TITAN MISSILE

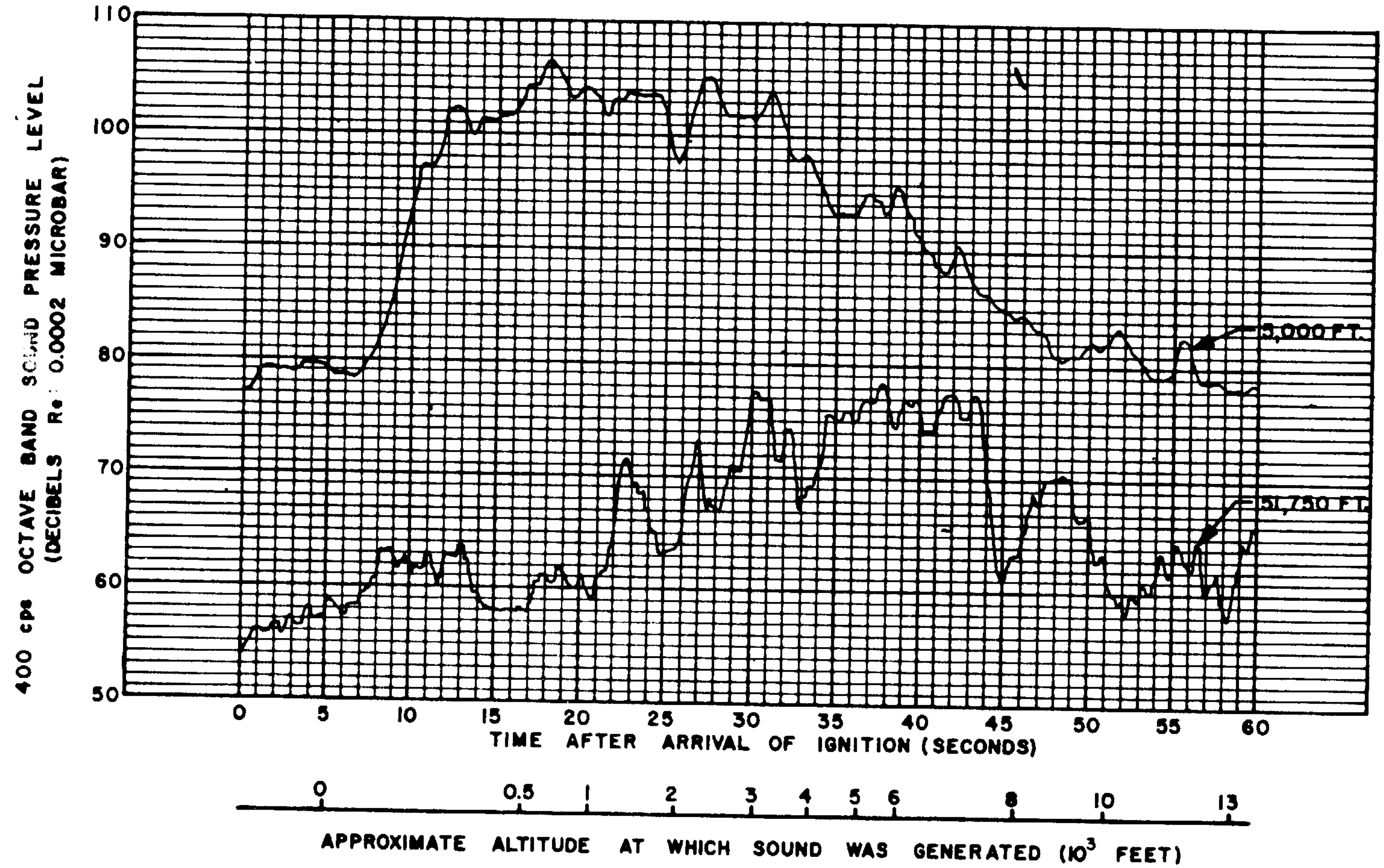

FIGURE 8. 400 CPS OCTAVE BAND TIME-HISTORY OF THE TITAN MISSILE

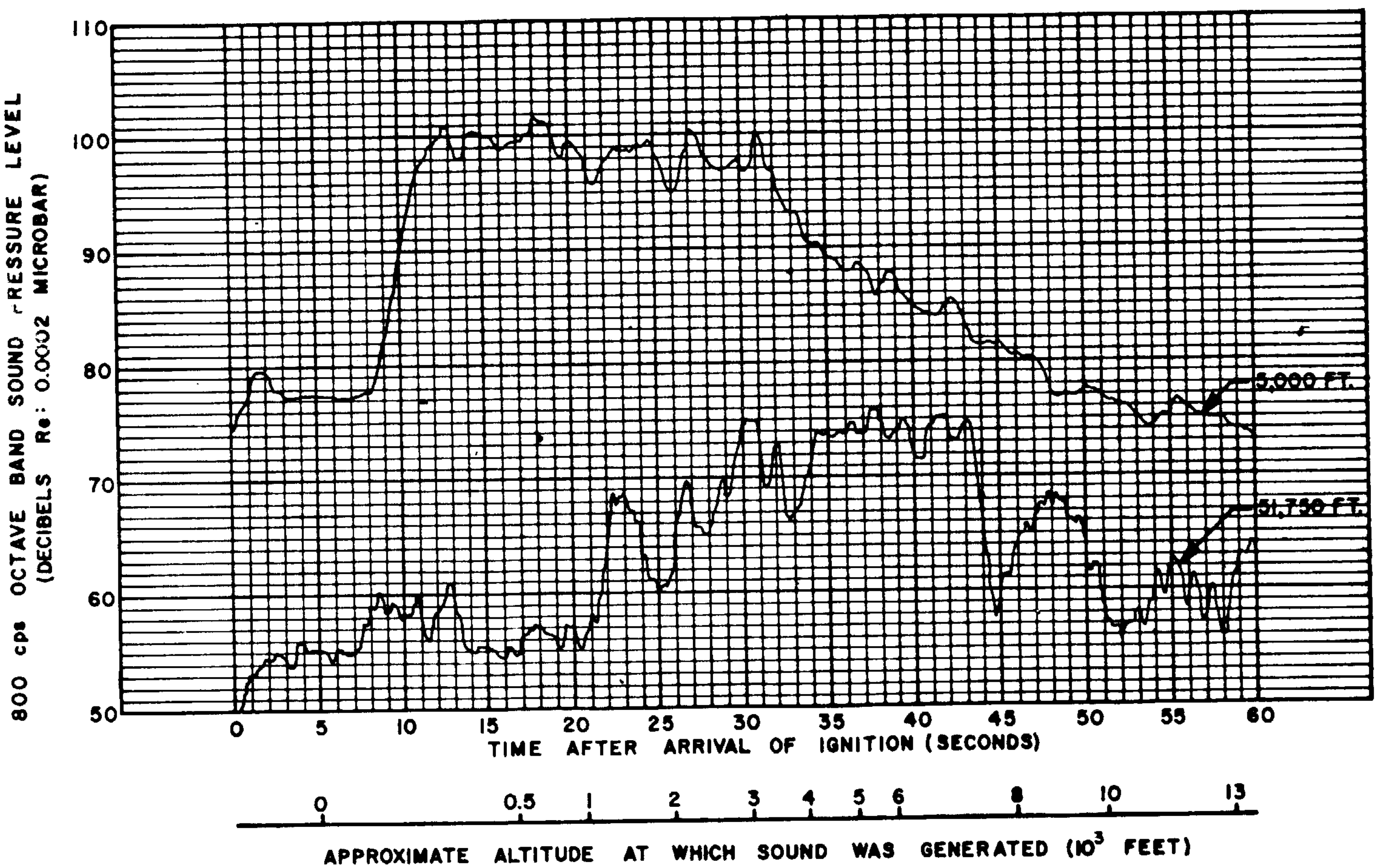

FIGURE 9. 800 CPS OCTAVE BAND TIME-HISTORY OF THE TITAN MISSILE

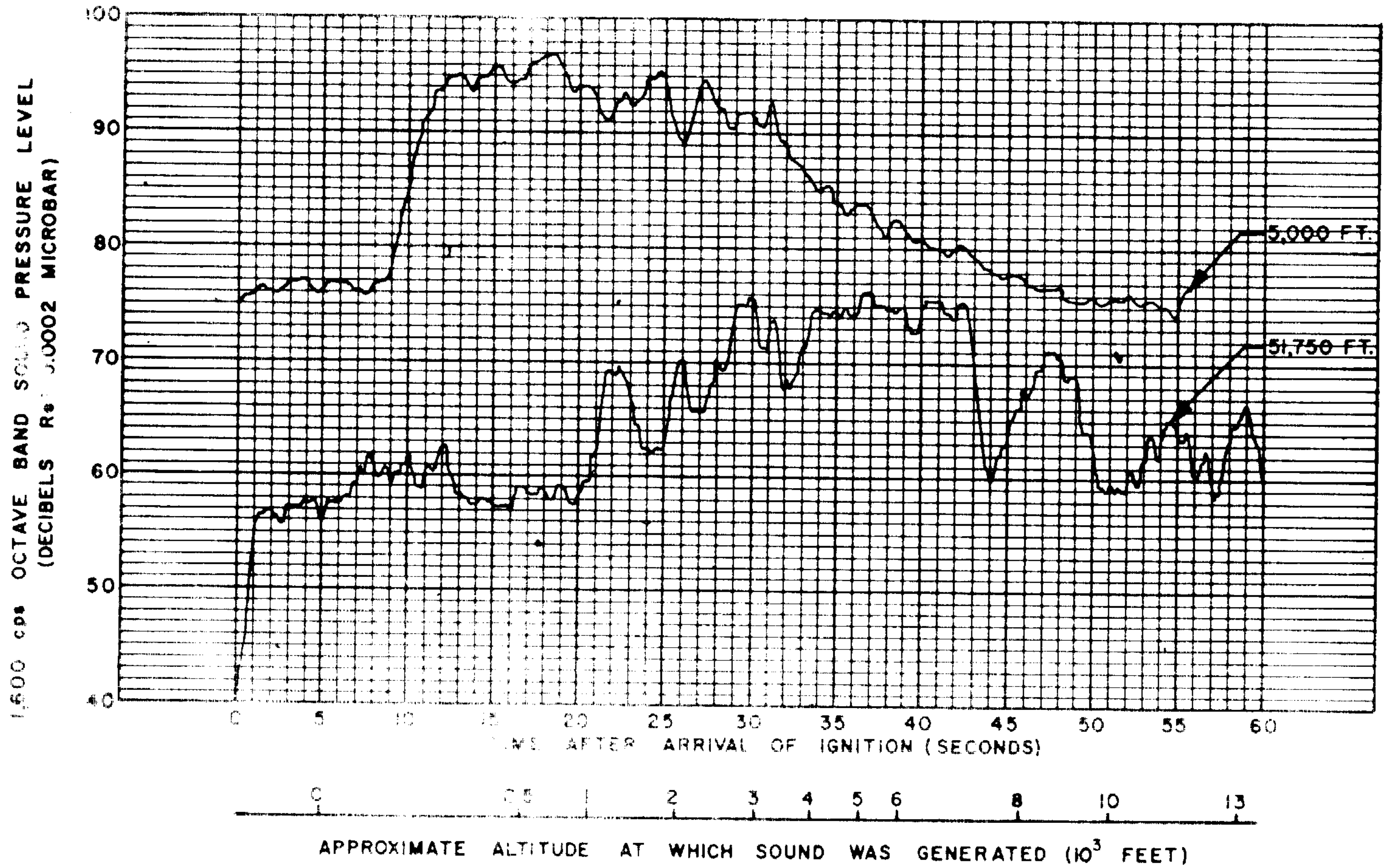

FIGURE 10. 1,600 CPS OCTAVE BAND TIME-HISTORY OF THE TITAN MISSILE

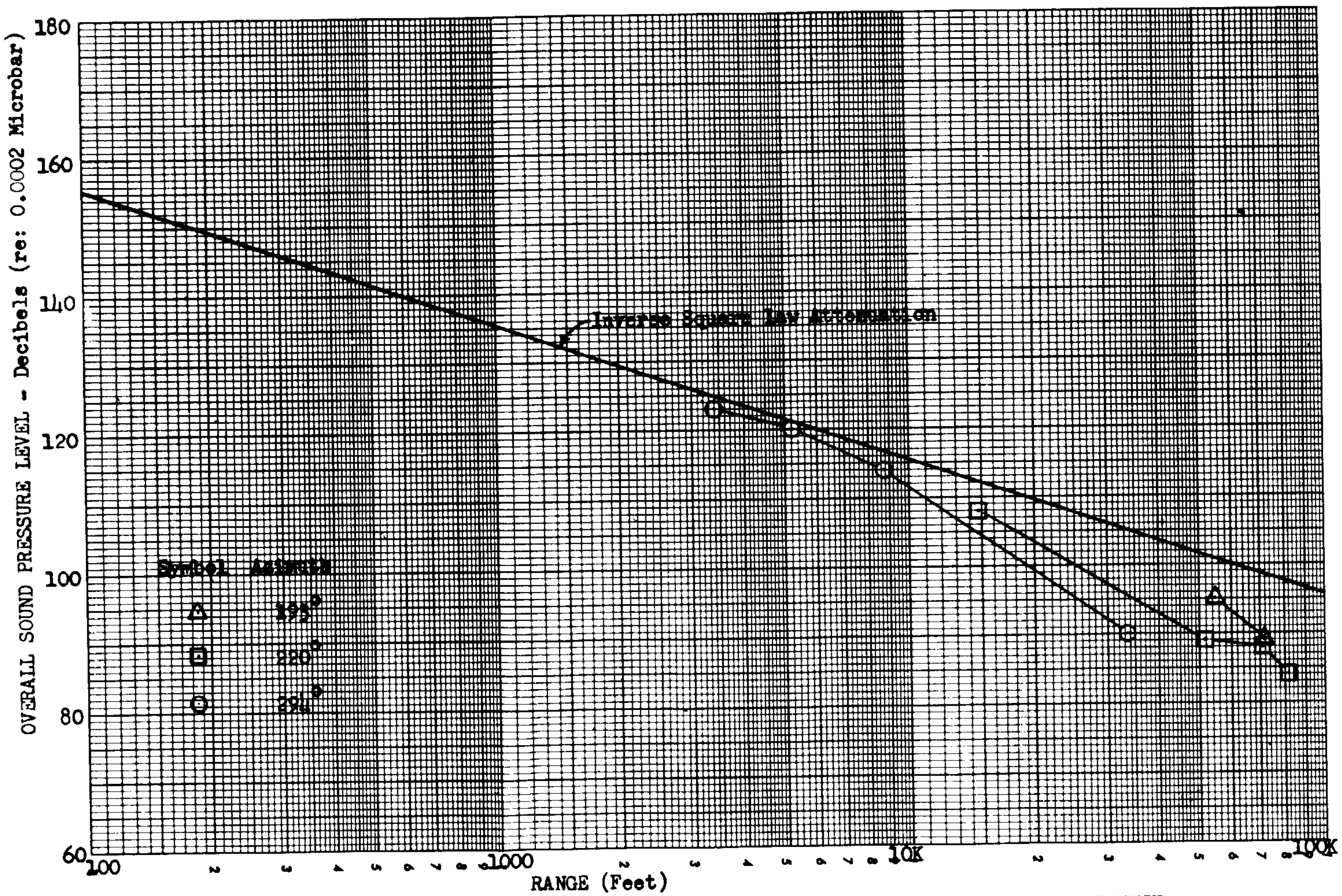

FIGURE 11. OVERALL SOUND PRESSURE LEVELS AS A FUNCTION OF RANGE FROM TITAN MISSILE LAUNCH

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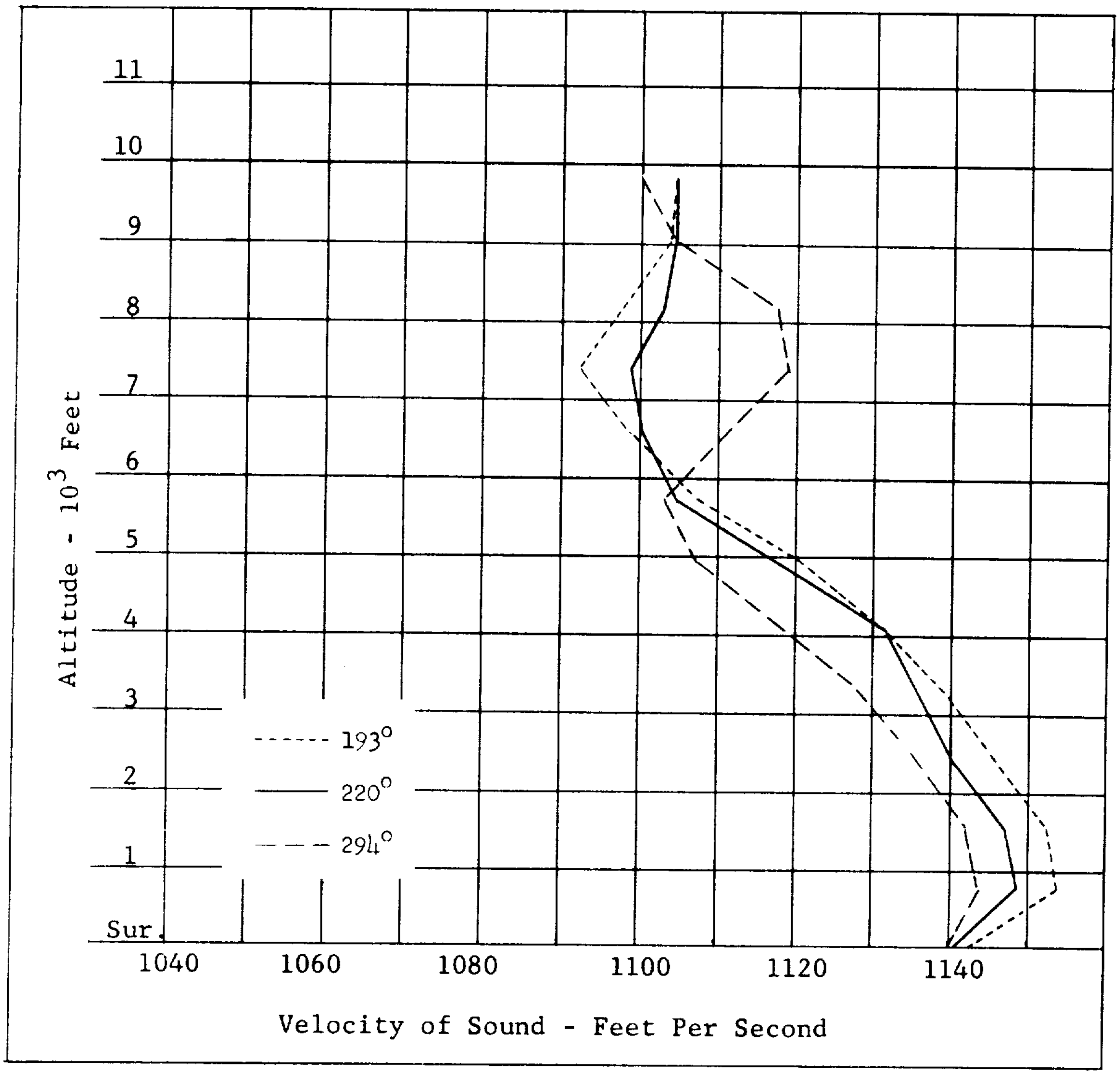

FIGURE 12. VELOCITY OF SOUND PROFILES, CAPE CANAVERAL, FLORIDA OCTOBER 24, 1961, 2000 CST.

APPROVAL MTP-TEST-62-3

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

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