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Louis Bourget

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16. ABSTRACT

Summary

A commentary relating motor vehicle noise to reasonable measurement. Maximum noise limits are suggested for three class groupings of motor vehicles. These limits are believed to be entirely feasible. A graph is also presented that permits the highway planner to predict future truck noise peaks at various distances, over exposed terrain, from three basic highway designs: Flat Sections -- Elevated Sections -- Depressed Sections.

Introduction

Sound does not actually emanate or radiate from highways except in the geographical sense. We hold that vehicles make the noise and, without them, highways are strangely silent. This distinction is offered for an important technical reason. A virtual axiom in acoustics is that noise control should be imposed to the greatest possible degree at the noise source, for once noise has escaped, it becomes much more difficult and expensive to control.

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51

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS



SOUND EMANATION FROM HIGHWAYS

By

Louis Bourget
Associate Electronics Engineer

63-19
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Presented at the Fifteenth Annual California
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Flat Sections --Elevated Sections -- Depressed Sections.

INTRODUCTION

Sound does not actually emanate or radiate from highways except in the geographical sense. We hold that vehicles make the noise and, without them, highways are strangely silent. This distinction is offered for an important technical reason. A virtual axiom in acoustics is that noise control should be imposed to the greatest possible degree at the noise source, for once noise has escaped, it becomes much more difficult and expensive to control.

HUMAN HEARING RESPONSE

Let us look at Figure 1 for a little background information. These are the free-field equal-loudness contours, for pure tones, determined by Robinson and Dadson at the National Physical Laboratory, Teddington, England. They are an up-to-date version of the famous Fletcher-Munson equal-loudness contours that were developed at Bell Telephone Laboratories in the early thirties.

These curves show how much more or less sound you require than a reference level at 1000 cycles per second (cps), so that the apparent loudness stays uniform across the acoustical spectrum. Obviously, our hearing is far from flat. It might make more sense to you if we say that turning these curves upside down, one by one at 1000 cps, will portray your response to various tones at constant intensity levels. Now the curves will all droop toward the lower frequencies just as our perception does in this region and the queer bump at the higher frequencies will rise wherever you respond better and fall wherever your response falls.

*Associate Electronics Engineer, Materials and Research Department, California Division of Highways, Sacramento, California.

SOUND LEVEL METERS

Figure 2 shows the response of an ASA approved Sound Level Meter when the A, B or C weighting-networks are employed. The C scale is reasonably flat.

The B scale has a moderate bass roll-off similar to human hearing at fairly high intensity levels. The A scale has a much faster bass roll-off similar to human hearing at the 40 phon level on the equal-loudness contour chart.

The A-weighting network, when used at all intensity levels, gives a reasonable subjective rank order for evaluating noise from trucks and automobiles. Therefore, the International Standard Organization (ISO), in cooperation with the American Standards Organization, supports the use of dbA for judging the noise from motor vehicles.

SUGGESTED NOISE LIMITS FOR MOTOR VEHICLES

The ISO recommended distance for measurement of motor vehicle noise is 7.5 meters from the center of the traveled lane. This is 24.6 feet. We suggest 25 feet as the nearest practical equivalent distance. This is the same as 19 feet from the edge of the pavement on our standard 12 foot wide lane. We only mention this because measurement from the edge of the outer lane is safer to accomplish under actual field conditions. At this distance I believe the following noise limits to be feasible:

1. Passenger vehicles other than motorcycles, gasoline powered trucks of less than 10,000 pounds gross vehicle weight, and gasoline powered busses of 15 or less passenger capacity:

80 dbA

+ 2 dbA tolerance

Excessive noise over 82 dbA

(Figure 3 offers some supporting data that was obtained at a 4 foot greater distance than the ISO recommends. Therefore 2 dbA should be added to all noise levels shown).

2. Gasoline powered trucks of over 10,000 pounds gross vehicle weight and gasoline powered busses of over 15 passenger capacity:

85 dbA

+ 2 dbA

Excessive noise over 87 dbA

3. Diesel powered trucks of over 10,000 pounds gross vehicle weight, diesel powered busses, and all motorcycles:

90 dbA

+ 2 dbA tolerance

Excessive noise over 92 dbA

(Figure 4 offers some supporting data that was obtained at a 4 foot greater distance than the ISO recommends. Therefore 2 dbA should be added to all noise levels shown. About 50% of the diesel trucks had inadequate mufflers. None had acoustical materials under the hood to reduce engine compartment noise radiation.)

If you are puzzled by the 5 dbA steps between passenger cars, gasoline powered trucks and diesel trucks, please understand that these figures are based on the measured amount of noise remaining after good mufflers are installed on typical vehicles in each group. Under these same relative conditions, gasoline powered trucks are 5 dbA quieter, and passenger cars 10 dbA quieter, than diesel trucks.

Another desirable requirement for all vehicles of over 10,000 pounds gross weight should be the installation of acoustical lining material on all possible under-surfaces of the hood including the hood side-panels. The acoustical material so employed should have an absorption coefficient of not less than .65 between 500 and 4,000 cycles per second. This is important because the radiation of excessive engine compartment noise has often been used as an excuse to avoid employment of high performance mufflers. Such arguments should be discouraged.

All of the above suggested limits can be applied to vehicles in motion along the highway and not restricted to an ISO type of acceleration test, involving measurements in both directions. If noise limits are applied to vehicles in actual operation along the highway, our law enforcement agencies will have a much wider field of application in carrying out the responsibility of motor vehicle noise control.

PREDICTING TRUCK NOISE VERSUS DISTANCE FROM THREE BASIC FREEWAY DESIGNS

The problem of estimating future peak truck noise levels that may result at various distances from proposed highways, is frequently of interest in the planning stage. This is particularly true where alternative designs or routes are possible.

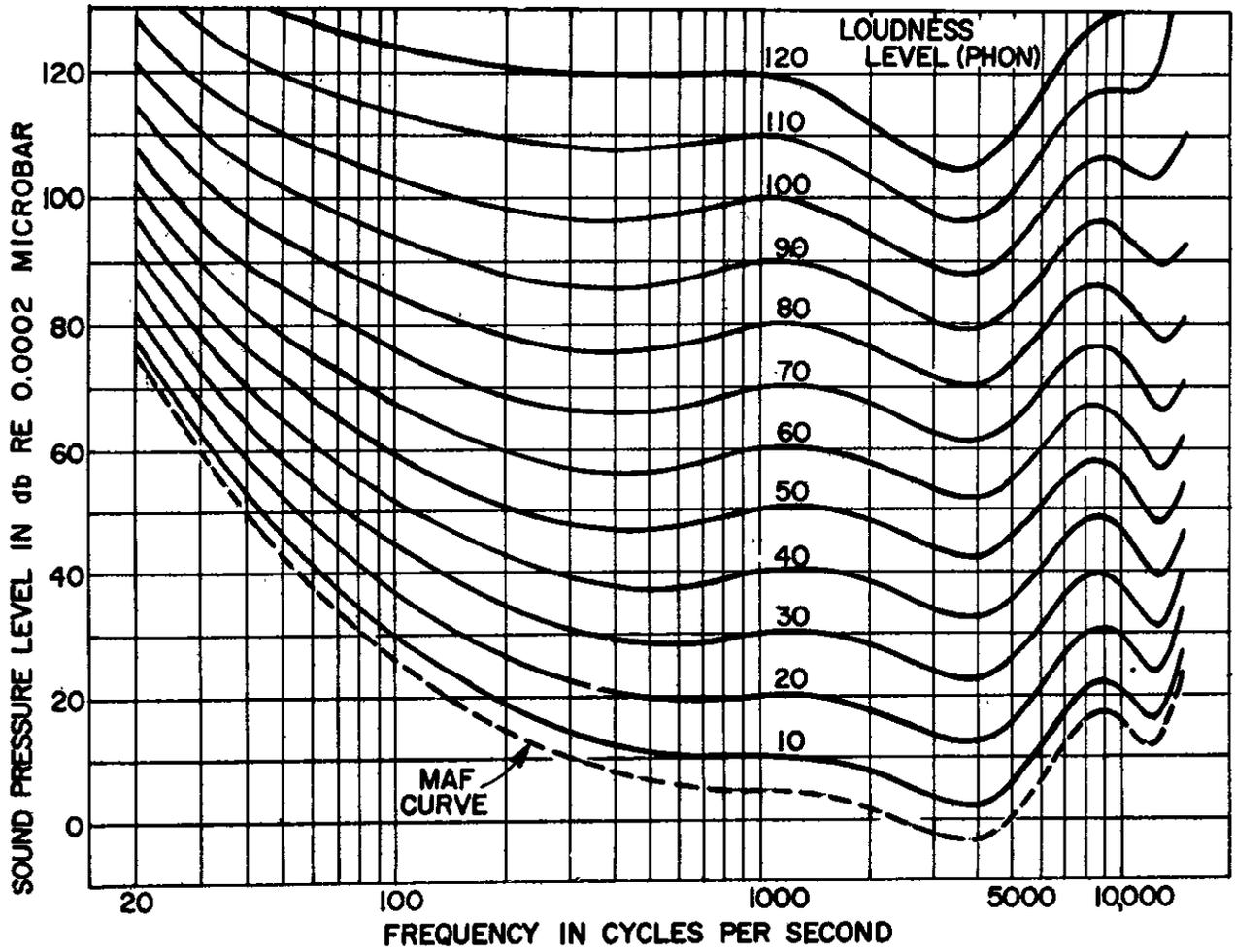
We do not pretend that a reasonably good prognosis will eliminate noise problems, but it may help you to recognize the least of several possible evils.

Figure 5 shows the basic method employed to derive the data from numerous field tests.

Figure 6 illustrates the amount of diesel truck noise in dbA that you may encounter at various distances from flat sections, elevated sections or depressed sections.

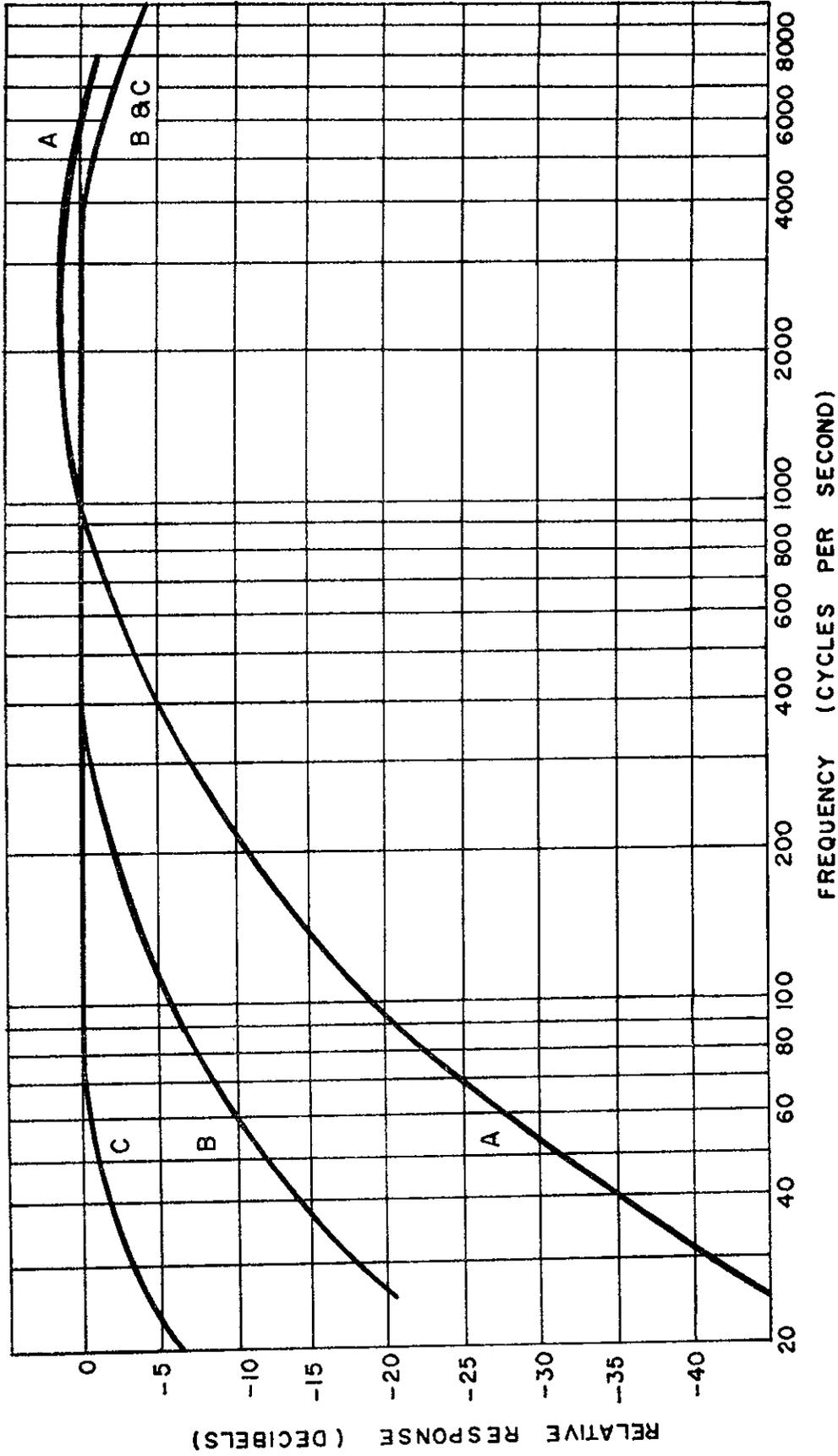
All dbA values are based on a reference noise level of 92 dbA at 25 feet from the exhaust stack, which is the primary source of noise at any reasonable distance beyond the right of way. Three overlapping bands of background noise are shown at the bottom of the chart which should help in relating truck noise to normal local levels. The greater the projection of truck noise above local background levels, the more possibility of complaint. The greatest number of complaints usually come from residents in close proximity to well traveled truck routes. Therefore industrial or semi-industrial routes, within a city, have certain advantages providing they are available and meet the other engineering considerations required.

FIG. 1



A ₀	B ₀	C ₁	D ₁	E ₁	F ₁	G ₁	A ₁	B ₁	C ₂	D ₂	E ₂	F ₂	G ₂	A ₂	B ₂	C ₃	D ₃	E ₃	F ₃	G ₃	A ₃	B ₃	C ₄	D ₄	E ₄	F ₄	G ₄	A ₄	B ₄	C ₅	D ₅	E ₅	F ₅	G ₅	A ₅	B ₅	C ₆	D ₆	E ₆	F ₆	G ₆	A ₆	B ₆	C ₇	D ₇	E ₇	F ₇	G ₇	A ₇	B ₇	C ₈																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
27.50	30.87	32.70	34.71	36.85	39.00	41.20	43.55	46.00	48.50	51.00	53.50	56.00	58.50	61.00	63.50	66.00	68.50	71.00	73.50	76.00	78.50	81.00	83.50	86.00	88.50	91.00	93.50	96.00	98.50	101.00	103.50	106.00	108.50	111.00	113.50	116.00	118.50	121.00	123.50	126.00	128.50	131.00	133.50	136.00	138.50	141.00	143.50	146.00	148.50	151.00	153.50	156.00	158.50	161.00	163.50	166.00	168.50	171.00	173.50	176.00	178.50	181.00	183.50	186.00	188.50	191.00	193.50	196.00	198.50	201.00	203.50	206.00	208.50	211.00	213.50	216.00	218.50	221.00	223.50	226.00	228.50	231.00	233.50	236.00	238.50	241.00	243.50	246.00	248.50	251.00	253.50	256.00	258.50	261.00	263.50	266.00	268.50	271.00	273.50	276.00	278.50	281.00	283.50	286.00	288.50	291.00	293.50	296.00	298.50	301.00	303.50	306.00	308.50	311.00	313.50	316.00	318.50	321.00	323.50	326.00	328.50	331.00	333.50	336.00	338.50	341.00	343.50	346.00	348.50	351.00	353.50	356.00	358.50	361.00	363.50	366.00	368.50	371.00	373.50	376.00	378.50	381.00	383.50	386.00	388.50	391.00	393.50	396.00	398.50	401.00	403.50	406.00	408.50	411.00	413.50	416.00	418.50	421.00	423.50	426.00	428.50	431.00	433.50	436.00	438.50	441.00	443.50	446.00	448.50	451.00	453.50	456.00	458.50	461.00	463.50	466.00	468.50	471.00	473.50	476.00	478.50	481.00	483.50	486.00	488.50	491.00	493.50	496.00	498.50	501.00	503.50	506.00	508.50	511.00	513.50	516.00	518.50	521.00	523.50	526.00	528.50	531.00	533.50	536.00	538.50	541.00	543.50	546.00	548.50	551.00	553.50	556.00	558.50	561.00	563.50	566.00	568.50	571.00	573.50	576.00	578.50	581.00	583.50	586.00	588.50	591.00	593.50	596.00	598.50	601.00	603.50	606.00	608.50	611.00	613.50	616.00	618.50	621.00	623.50	626.00	628.50	631.00	633.50	636.00	638.50	641.00	643.50	646.00	648.50	651.00	653.50	656.00	658.50	661.00	663.50	666.00	668.50	671.00	673.50	676.00	678.50	681.00	683.50	686.00	688.50	691.00	693.50	696.00	698.50	701.00	703.50	706.00	708.50	711.00	713.50	716.00	718.50	721.00	723.50	726.00	728.50	731.00	733.50	736.00	738.50	741.00	743.50	746.00	748.50	751.00	753.50	756.00	758.50	761.00	763.50	766.00	768.50	771.00	773.50	776.00	778.50	781.00	783.50	786.00	788.50	791.00	793.50	796.00	798.50	801.00	803.50	806.00	808.50	811.00	813.50	816.00	818.50	821.00	823.50	826.00	828.50	831.00	833.50	836.00	838.50	841.00	843.50	846.00	848.50	851.00	853.50	856.00	858.50	861.00	863.50	866.00	868.50	871.00	873.50	876.00	878.50	881.00	883.50	886.00	888.50	891.00	893.50	896.00	898.50	901.00	903.50	906.00	908.50	911.00	913.50	916.00	918.50	921.00	923.50	926.00	928.50	931.00	933.50	936.00	938.50	941.00	943.50	946.00	948.50	951.00	953.50	956.00	958.50	961.00	963.50	966.00	968.50	971.00	973.50	976.00	978.50	981.00	983.50	986.00	988.50	991.00	993.50	996.00	998.50	1001.00	1003.50	1006.00	1008.50	1011.00	1013.50	1016.00	1018.50	1021.00	1023.50	1026.00	1028.50	1031.00	1033.50	1036.00	1038.50	1041.00	1043.50	1046.00	1048.50	1051.00	1053.50	1056.00	1058.50	1061.00	1063.50	1066.00	1068.50	1071.00	1073.50	1076.00	1078.50	1081.00	1083.50	1086.00	1088.50	1091.00	1093.50	1096.00	1098.50	1101.00	1103.50	1106.00	1108.50	1111.00	1113.50	1116.00	1118.50	1121.00	1123.50	1126.00	1128.50	1131.00	1133.50	1136.00	1138.50	1141.00	1143.50	1146.00	1148.50	1151.00	1153.50	1156.00	1158.50	1161.00	1163.50	1166.00	1168.50	1171.00	1173.50	1176.00	1178.50	1181.00	1183.50	1186.00	1188.50	1191.00	1193.50	1196.00	1198.50	1201.00	1203.50	1206.00	1208.50	1211.00	1213.50	1216.00	1218.50	1221.00	1223.50	1226.00	1228.50	1231.00	1233.50	1236.00	1238.50	1241.00	1243.50	1246.00	1248.50	1251.00	1253.50	1256.00	1258.50	1261.00	1263.50	1266.00	1268.50	1271.00	1273.50	1276.00	1278.50	1281.00	1283.50	1286.00	1288.50	1291.00	1293.50	1296.00	1298.50	1301.00	1303.50	1306.00	1308.50	1311.00	1313.50	1316.00	1318.50	1321.00	1323.50	1326.00	1328.50	1331.00	1333.50	1336.00	1338.50	1341.00	1343.50	1346.00	1348.50	1351.00	1353.50	1356.00	1358.50	1361.00	1363.50	1366.00	1368.50	1371.00	1373.50	1376.00	1378.50	1381.00	1383.50	1386.00	1388.50	1391.00	1393.50	1396.00	1398.50	1401.00	1403.50	1406.00	1408.50	1411.00	1413.50	1416.00	1418.50	1421.00	1423.50	1426.00	1428.50	1431.00	1433.50	1436.00	1438.50	1441.00	1443.50	1446.00	1448.50	1451.00	1453.50	1456.00	1458.50	1461.00	1463.50	1466.00	1468.50	1471.00	1473.50	1476.00	1478.50	1481.00	1483.50	1486.00	1488.50	1491.00	1493.50	1496.00	1498.50	1501.00	1503.50	1506.00	1508.50	1511.00	1513.50	1516.00	1518.50	1521.00	1523.50	1526.00	1528.50	1531.00	1533.50	1536.00	1538.50	1541.00	1543.50	1546.00	1548.50	1551.00	1553.50	1556.00	1558.50	1561.00	1563.50	1566.00	1568.50	1571.00	1573.50	1576.00	1578.50	1581.00	1583.50	1586.00	1588.50	1591.00	1593.50	1596.00	1598.50	1601.00	1603.50	1606.00	1608.50	1611.00	1613.50	1616.00	1618.50	1621.00	1623.50	1626.00	1628.50	1631.00	1633.50	1636.00	1638.50	1641.00	1643.50	1646.00	1648.50	1651.00	1653.50	1656.00	1658.50	1661.00	1663.50	1666.00	1668.50	1671.00	1673.50	1676.00	1678.50	1681.00	1683.50	1686.00	1688.50	1691.00	1693.50	1696.00	1698.50	1701.00	1703.50	1706.00	1708.50	1711.00	1713.50	1716.00	1718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FIG. 2



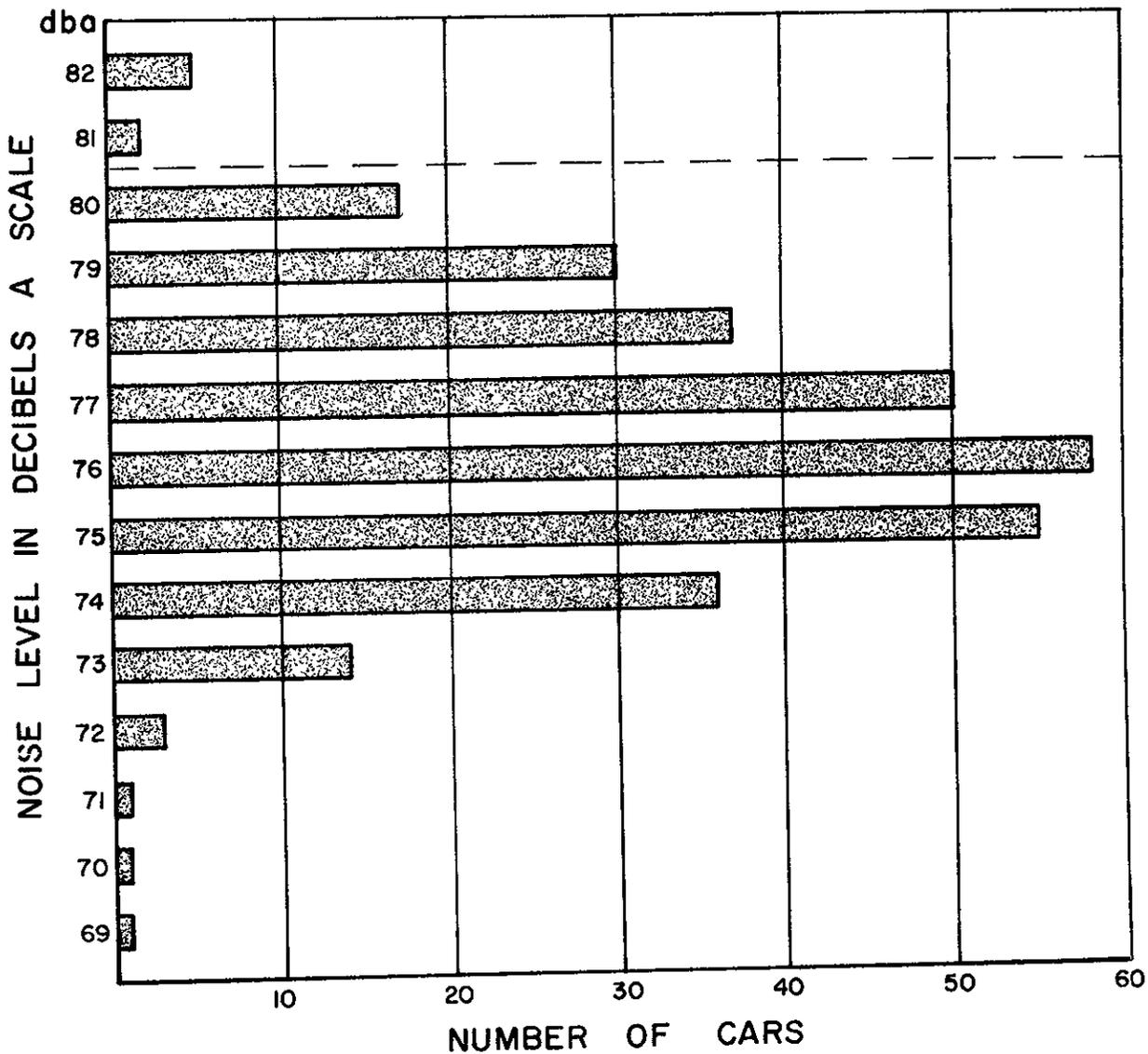
Random-Incidence Response
Of Sound Level Meter
For Different Networks

ASA S1.4-1961

Fig. 3

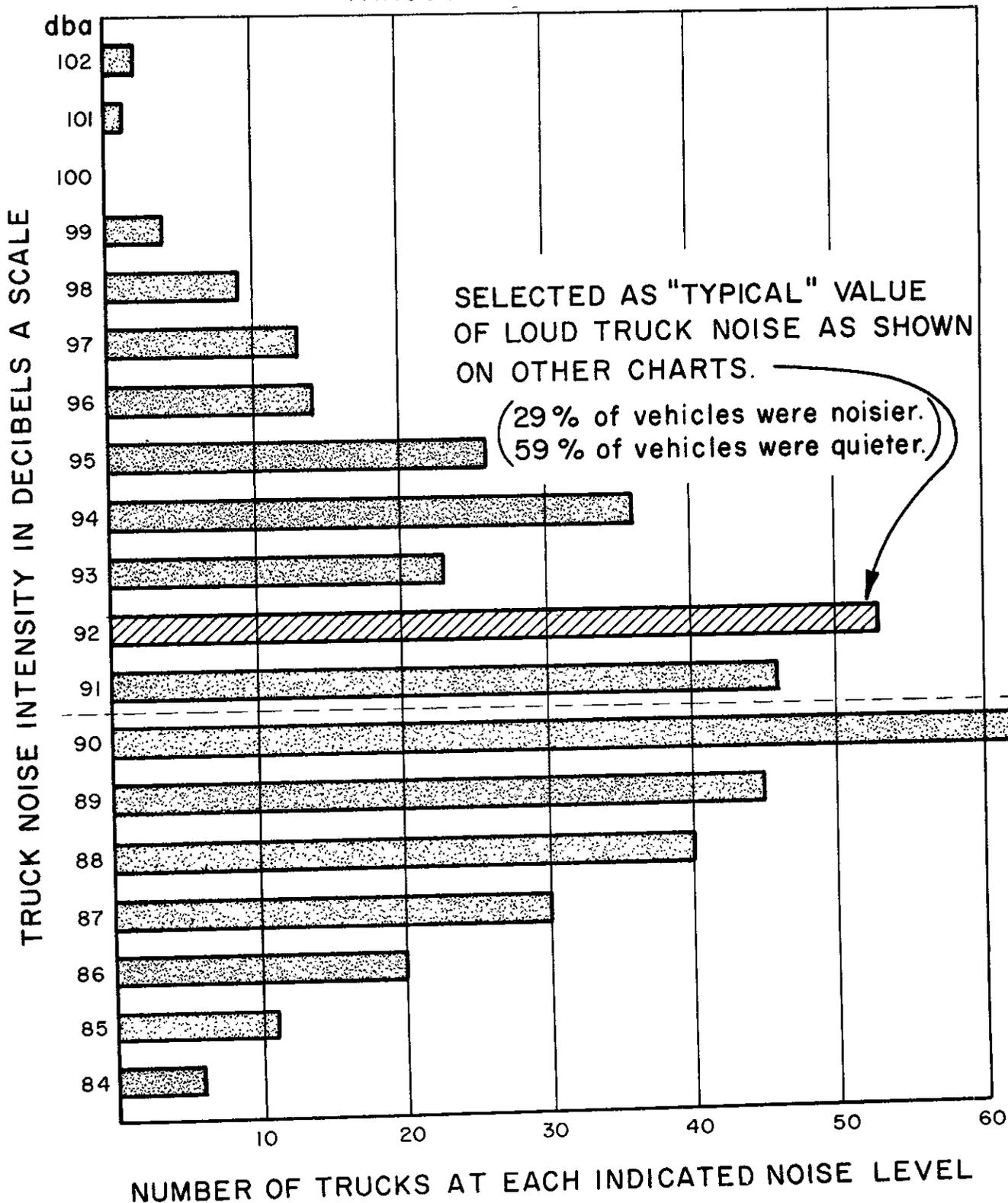
PASSENGER CAR NOISE DISTRIBUTION AT 23' FROM EDGE OF OUTER LANE

PICK-UP TRUCKS AND LIGHT DELIVERY VANS ARE INCLUDED



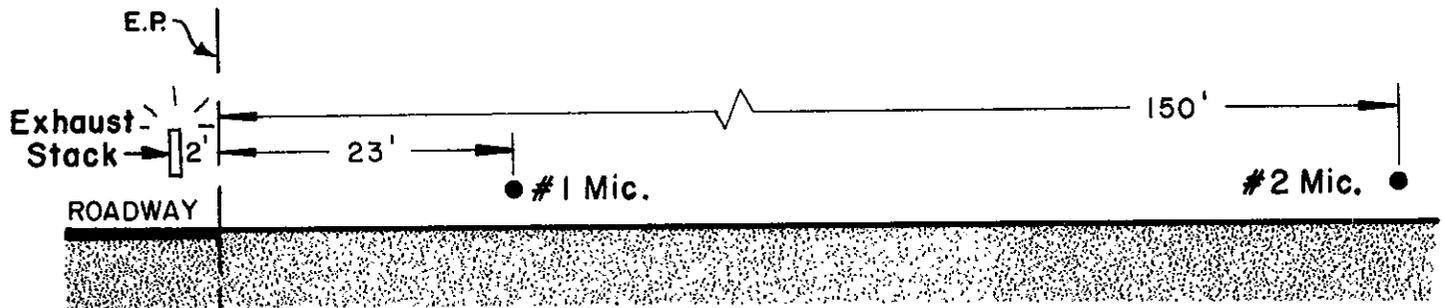
TRUCK NOISE DISTRIBUTION AT 25' FROM THE EXHAUST STACK

A COMPOSITE OF THE 441 VEHICLES INDEXED ON
THE NOISE CHART RECORDINGS AT 17 LOCATIONS
THROUGHOUT CALIFORNIA

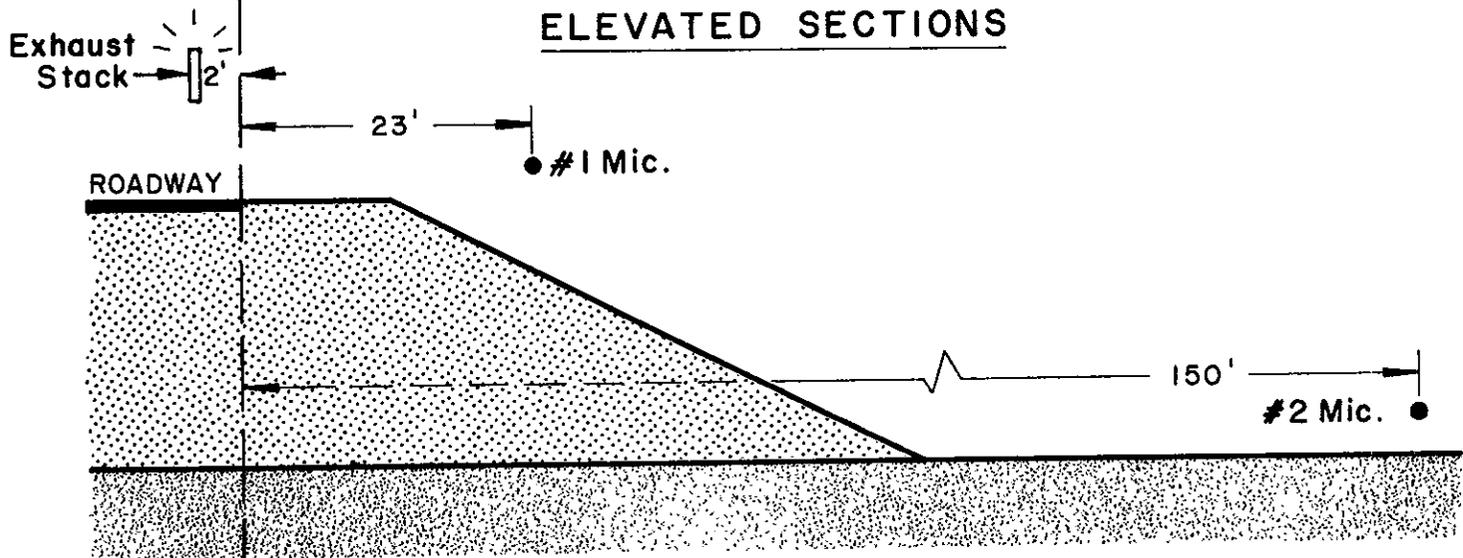


TYPICAL TEST METHOD FOR DETERMINATION OF NOISE ATTENUATION WITH DISTANCE

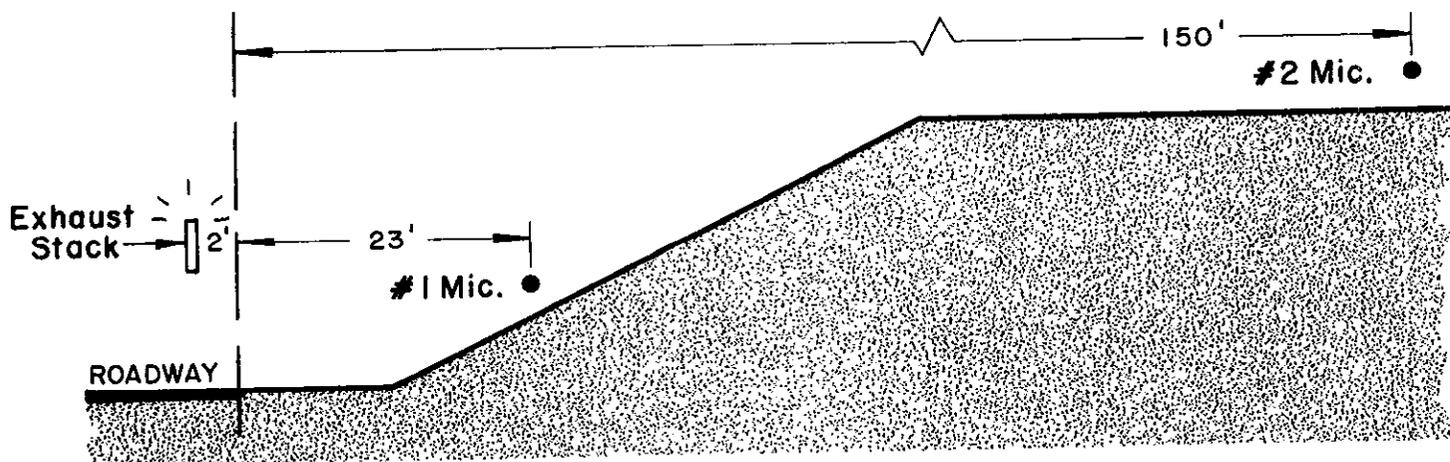
FLAT SECTIONS



ELEVATED SECTIONS



DEPRESSED SECTIONS



STATE OF CALIFORNIA - DIVISION OF HIGHWAYS - MATERIALS AND RESEARCH DEPT.

"TYPICAL" TRUCK NOISE VERSUS DISTANCE FROM 3 BASIC FREEWAY DESIGNS

NOISE = 92 dba AT 25' FROM SOURCE

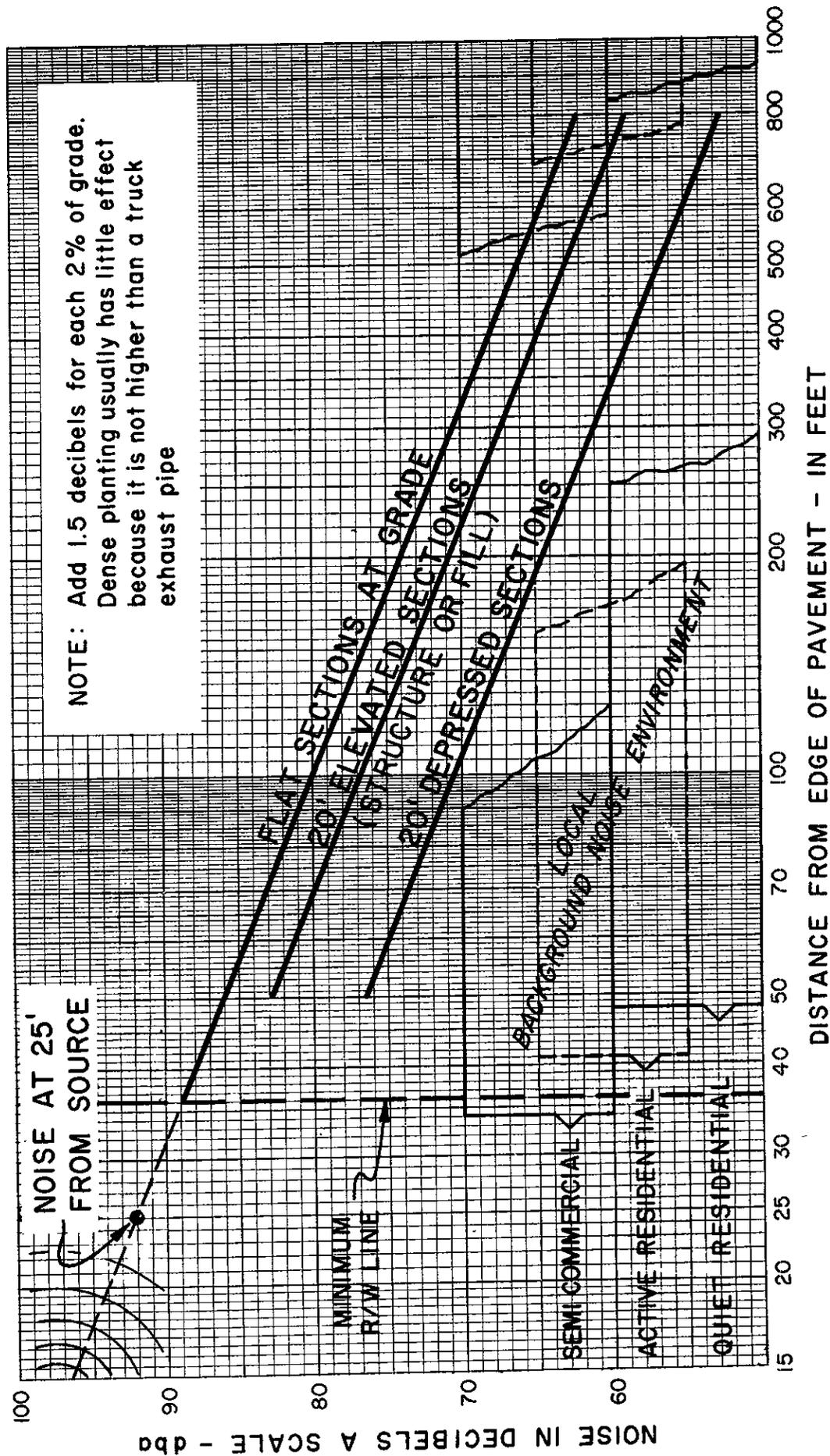


FIG. 6

DISTANCE FROM EDGE OF PAVEMENT - IN FEET