VEHICLE NOISE STUDY -- FINAL REPORT

PREPARED FOR

WASHINGTON STATE HIGHWAY COMMISSION

DEPARTMENT OF HIGHWAYS

UNDER GRANT AGREEMENT Y-1460

BY

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ABSTRACT

This study was made to obtain information on the noise levels being emitted by vehicles currently using the highways of the State of Washington. The Washington State Highway Commission requested this study for guidance in proposing vehicle noise control legislation. The main controversy in states with existing comprehensive vehicle noise legislation has concerned trucks traveling on roads with posted speeds above 35 mph. The main thrust of our study is therefore concerned with this particular area, although data were also taken on automobiles and on roads posted at less than 35 mph. This study is unique in that the noise level and the speed of all vehicles were measured. In addition, all trucks over 10,000 lb were weighed. Our large body of data has been graphed in numerous ways to illustrate various aspects--including how the noise factor varies with speed, weight, and percentage of full load, etc. Some photographs of the trucks together with their noise data are also included.

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SUMMARY

The purpose of this study was to obtain factual information on the noise levels being emitted by vehicles currently using the highways of the State of Washington. This study was requested by the Washington State Highway Commission to help it make rational and meaningful recommendations to the Legislature for enactment of vehicle noise control legislation. Its desire is to set noise limits as low as possible without placing an unreasonable or technically impossible standard on vehicles in this State.

The most comprehensive legislation on this subject has been enacted by the State of California. (Excerpts from their legislation are given in Appendix F.) The California controls which have generated the most controversy are for trucks operating on freeways and other roadways with posted speeds above 35 mph. The main thrust of our study is therefore concerned with this particular area, although data were also taken on automobiles and on roadways posted at less than 35 mph.

Cumulative frequency curves of truck traffic on highways have been made before in other states, e.g., California. However, these studies have not been sufficiently comprehensive to give specific information on how trucks as noise sources contributed to these data. Thus it has not been possible to predict the effect of a stated number of decibels (dB)* in a proposed piece of legislation on any particular segment of the trucking industry.

In our study the trucks were recorded on audio/video tape so that data could be checked and rechecked in the laboratory. A large amount of data was taken on each of the 1,433 trucks in the survey. This included the noise level of the truck on the dBA and dBB scales (see Appendix H for definitions of dB terms), the actual speed as measured on a Doppler-shift radar, the class of the truck, licensed maximum gross weight, measured gross weight, the grade of the roadway on which the vehicle was traveling, and other criteria. The measurements were made at four different sites.

This large body of data has been graphed in various ways in order to illustrate various aspects--including how the noise factor varies with the speed, weight, and percentage of full load. Some photographs of the trucks together with the noise data are also included.

One statement often made by the trucking industry in regard to proposed noise levels derived from cumulative distribution curves is that the trucks on the quiet end of the curve are the small ones or those traveling at low speeds, whereas the other end of the curve contains all the big heavy trucks which are going at full legal speed. Thus, they

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*As defined in Appendix H.

fear that noise legislation would wipe out the heavy truck transport industry because it would be technologically impossible to quiet these trucks sufficiently. This report sheds some light on this problem. For example, one of the curves presented is a cumulative distribution curve limited entirely to vehicles which had measured weights over 30,000 lb and which were traveling at more than 50 mph. There were 344 trucks in this category, making a good statistical sample. This curve, Fig. 37, shows that 50% of the trucks in this category were quieter than the present California limit of 90 dBA. It also shows that 2%, or about seven trucks, were actually quieter than 84 dBA. From this information it is obvious that it is technologically possible for heavy, full-speed trucks to be fairly quiet (84 dBA or less).

In general, the data show that the noise level does increase with truck weight and speed. However, the range of variability is great, showing that other factors have a strong influence on the noise output. The plot of noise versus percentage of full load shows almost no correlation. In other words, it is the total weight of the vehicle and not the percentage of the load that counts. The data also show that many trucks would still be very noisy even if all of their low-frequency noise were removed by improved mufflers. Putting an adequate muffler on a truck is not necessarily going to solve that vehicle's noise-emitting problem.

Included in the report are cumulative noise curves for automobiles as well as curves of automobile noise versus speed. Also included are the results of our survey of existing noise legislation (1971) for the U.S. and the Canadian provinces, and a survey of muffler manufacturers and their catalog literature.

SURVEY TECHNIQUE

Figure 1 is a block diagram of the system used for gathering the data in the field. Basically, the information was recorded on a tape recorder having one video and two audio channels. The General Radio microphone and 20 dB preamplifier were located 50 ft from the center line of the curb lane of the highway under test. The sound information from this was brought back via cable to a van truck in which the recorder and instrumentation were situated. A control box in the van contained an adjustable attenuator so that the dynamic range of the recorder could be placed optimally with respect to the expected noise levels to be measured. This box also contained a carefully calibrated and amplitude-stabilized 1 kHz oscillator. This oscillator was switched on frequently (when there was no truck or automobile of interest on the road) to allow an independent calibration of the system; this signal injected a voltage equivalent to a 90 dB sound signal. In addition, several times during any one tape a General Radio type 1562A sound level calibrator was slipped over the measuring microphone to form a 1 kHz calibration throughout the entire system. Each time the sound calibrator was used it was first coupled to the microphone and then turned on. This allowed the recording to include the warmup period of the acoustic calibrator; whereas when the stabilized oscillator was turned on momentarily for the calibration, no warmup was involved. From the presence or absence of the characteristic warmup signal it was obvious which type of calibration was taking place.

The audio/video tape recorded data for slightly over one hour. Full acoustic calibration was carried out three times during this period with the local stabilized oscillator calibration taking place with even greater frequency. This information was recorded on audio channel "A" of the tape recorder. A voice microphone was connected to audio channel "B" and was used for giving a running commentary on the traffic passing by at the time the measurements were being taken. This included comments on the type, make, class, and size of truck, as well as lettering, color, size, etc., so the vehicle could be positively identified when it stopped at the weighing station and had other measurements made. This information was complementary to the video channel data which was directly recorded.

The video camera had a view of the roadway immediately in front of the measuring microphone so that in later analysis one could ascertain which vehicle was being measured, and that the accuracy of the data was not clouded in any way by the presence of other vehicles in other lanes. By listening to the recorded sound while watching the vido tape, one could tell that the truck driver had not, for example, suddenly let up on his throttle at the moment of recording. Also in the field-of-view of the video camera were a 24-hr clock, a sign with the date, and a radar speedometer. The speedometer read from 0 to 100 mph full-scale. Having all of these audio and video data in "raw" form on the tape is very important when looking for extrema such as very loud or very quiet trucks. Some errors are bound to creep in when handling large quantities of data, but having it all on tape provided a check on the data points which were of the greatest interest.

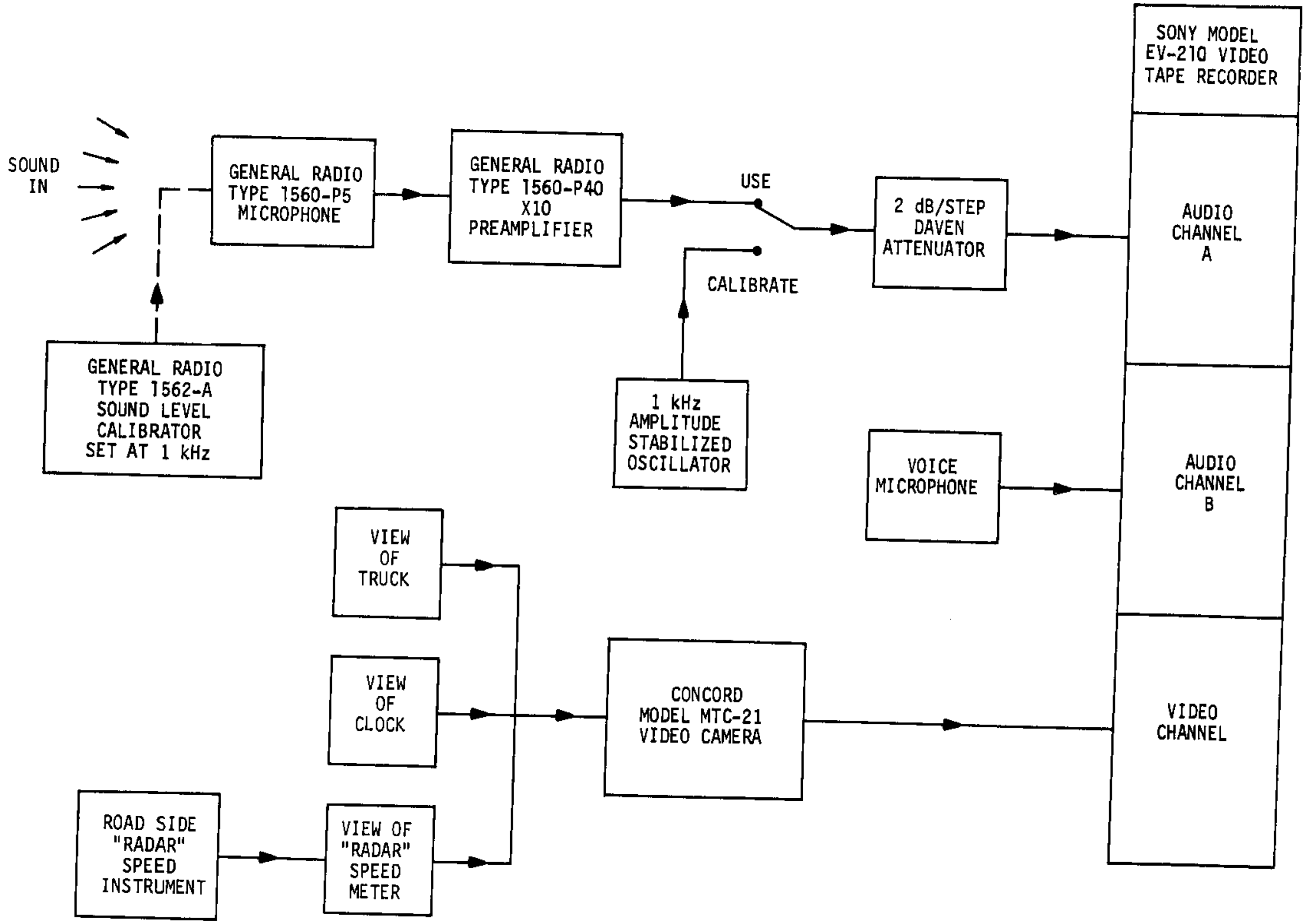


FIGURE 1. BLOCK DIAGRAM OF FIELD DATA GATHERING.

After passing the video and acoustic recording site, the trucks stopped at a Washington State Patrol weighing station. At the weighing station the license number and licensed gross wieght were recorded along with the measured weight. A verbal description of the vehicle was recorded as an aid in identifying the vehicle with the information already on the recorder in the van.

Figure 2 is a block diagram indicating in a general way the method of reducing the data. The noise from channel "A" was passed through an A-weighting filter and a B-weighting filter (see Appendix H). Each of these outputs fed a wide dynamic range detector and peak-holding circuit, and each output was finally displayed on two meters 10 dB apart in range so as to give a wide dynamic range on one visual reading without frequent scale-changing. This permitted the personnel to view these meters quickly and to then record manually the dBA and dBB levels. In addition, the noise from channel "A" was fed into an amplifier and loudspeaker so the people reducing the data could monitor the noise from each truck for possible abnormalities such as gear-shifting or sudden changes in power level. At the same time, audio channel "B" was amplified and put on a loudspeaker for identification of the vehicle with the data that was recorded at the weighing station. Simultaneously, the video channel was viewed and the time-of-day and speed of the particular vehicle on the picture were recorded. The results of these data as recorded from the audio/video tape and the weighing stations were then punched on computer cards. A computer was then used to do the sorting and correlating, and, finally, the results were plotted on a Calcomp digital plotter.

Figure 3 is a view of the microphone location at the Everett site during the December measurements. The microphone with its preamplifier is in the center of the picture. We are looking at the northbound lane, and we see one truck coming into view on the curb lane. This field-of-view is more or less south down the road. The southbound lane is not visible in this picture because it is separated from the northbound lane by a wide, tree-covered median. This was a very desirable site for the measurements as there was no acoustic interference from the southbound lane of traffic.

Figure 4 shows the radar speedometer equipment in position at the side of the highway. This, again, was at the Everett site in December. A large truck can be seen in the curb lane.

Figure 5 is a view of the highway from the instrument van at the Everett site. A truck is in the curb lane approaching the microphone location, the video camera is on the left, and the radar speedometer readout shows the truck's speed as 59 mph. Also shown are the date (December 30, 1971) and time (10:37) the truck passed by.

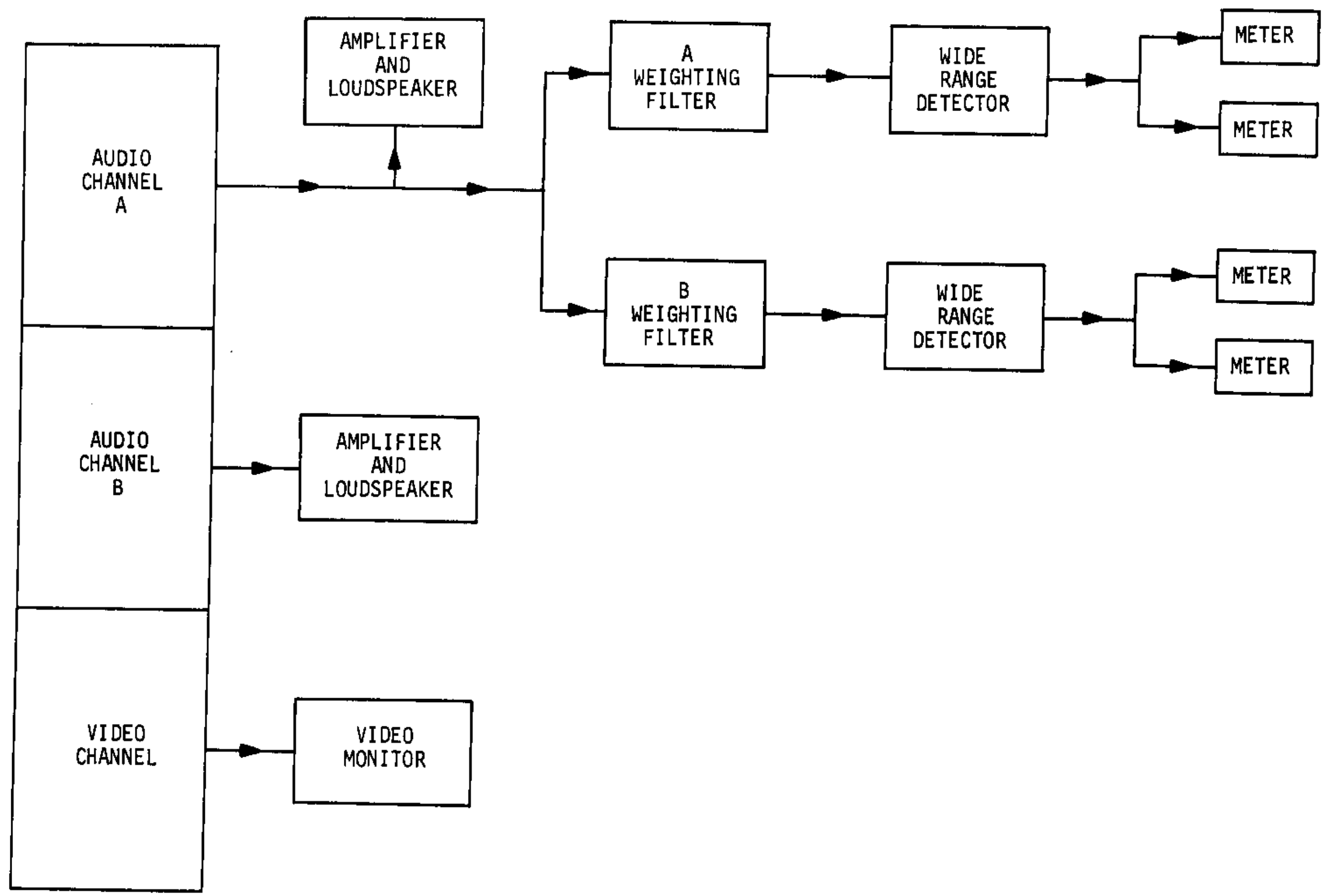


FIGURE 2. BLOCK DIAGRAM OF FIRST STEP IN DATA REDUCTION.

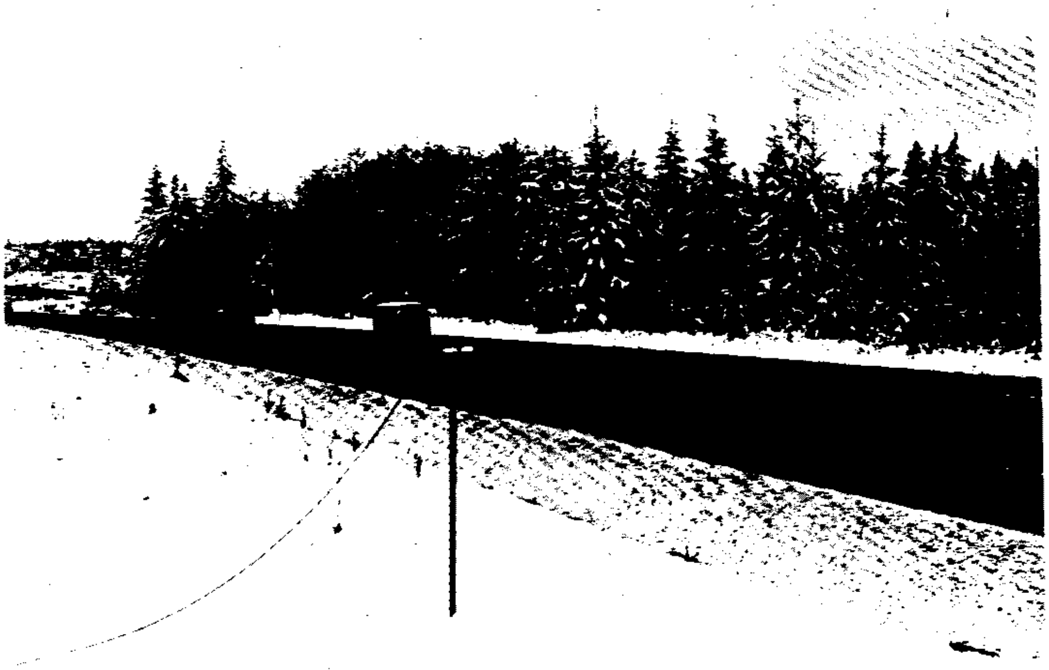


FIGURE 3. VIEW OF THE MICROPHONE LOCATION AT THE EVERETT SITE.

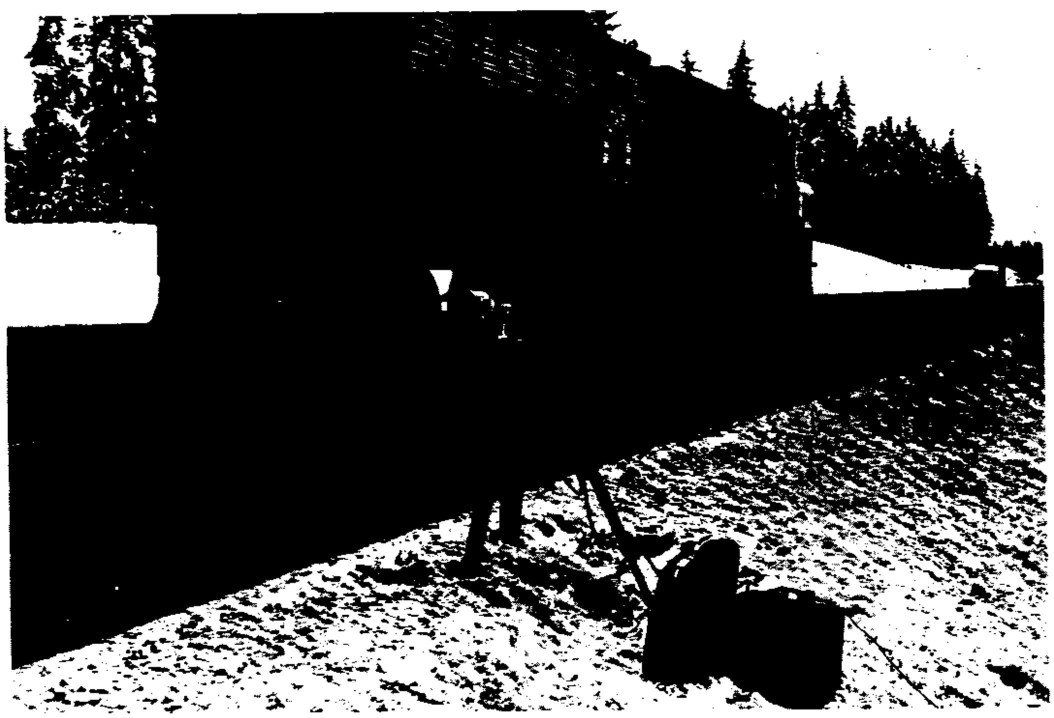


FIGURE 4. VIEW OF THE RADAR LOCATION AT THE EVERETT SITE.

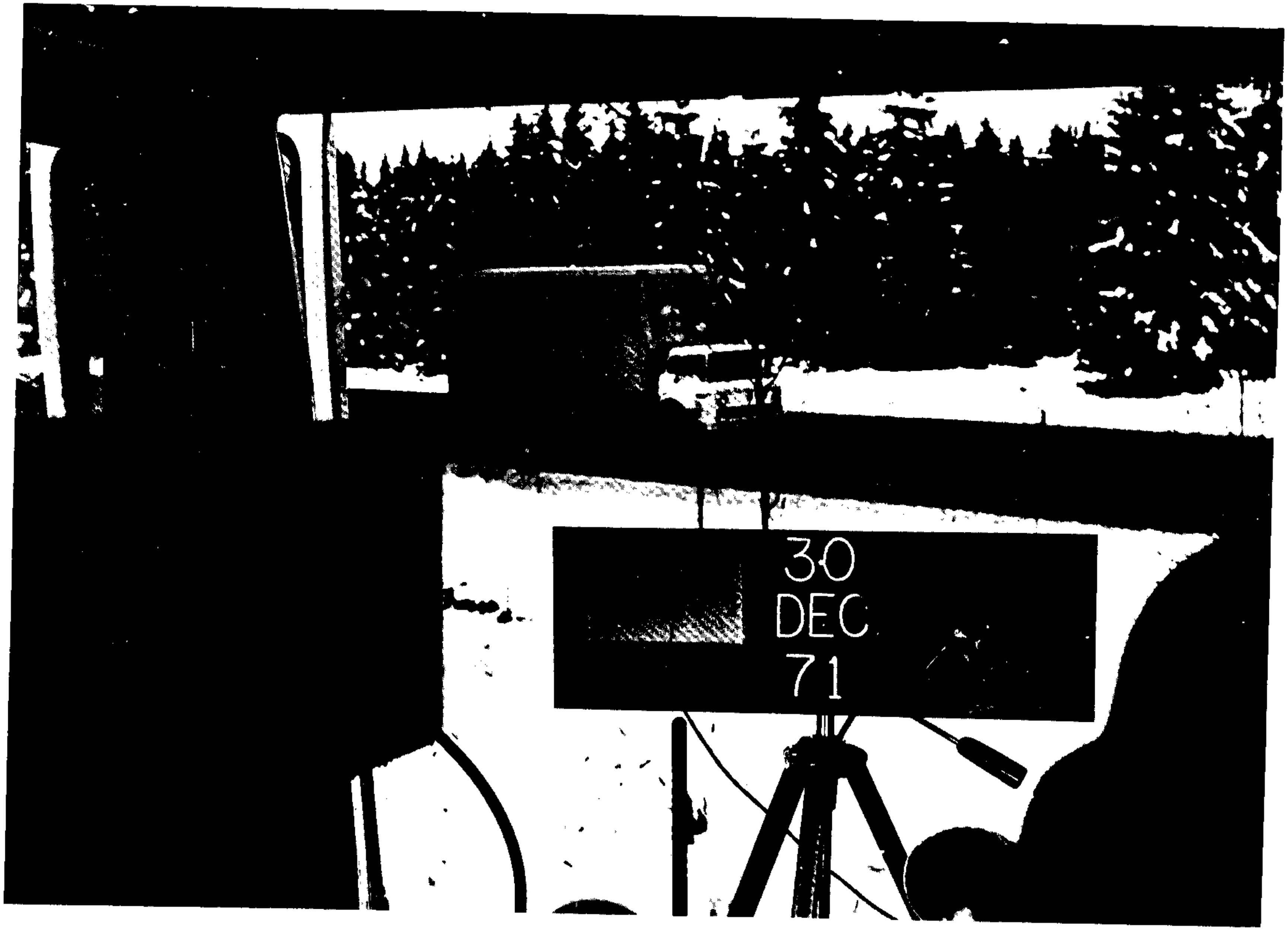


FIGURE 5. VIEW FROM INSIDE THE VAN AT THE EVERETT SITE.

Figure 6 is a view looking back from the highway toward the instrument van. Figure 7 was taken inside the weighing station and shows the recording of the weights as the truck passed over the scales, one axle or group of axles at a time. The weights were summed to get the total weight of each truck. The State's weight controllers in each of the stations were most helpful in calling out the weights and identifying the classes of trucks to our personnel.

Figure 8 shows Laboratory personnel obtaining mileage and other relevant information from a truck driver and measuring the tire tread depth, etc. Early in the program an attempt was made to correlate tire data with noise level. For this effort we recorded the tire type (with reference to a tire-type chart) and measured the tread depth as well. Figure 9 shows tire tread depth being measured. As can be seen in this picture, the two tires on the same axle are different, and it turns out that most trucks have a very "mixed bag" of tires. The steering tires are generally of the ribbed type, such as is shown with the depth indicator. The traction tires are generally of the lug type, such as the tire immediately next to the ribbed tire on the same axle. The remaining tires on the trailer can be almost anything. Apparently, as the tractor tires become worn they are moved to the trailer randomly; often the generalization about the steering and traction tires does not hold. All sorts of combinations of tire types were found--to such an extent that any correlation of noise with tire type is impractical from our data. Studies correlating tire noise with tire types will have to be made by controlling the tires on the truck at the time of noise measurements.

Figure 10 is a view of the highway location for the Fife measurements. The van is in the left center, and the northbound highway is beyond the microphone which is just showing in the center of the picture.

As shown in Fig. 12, five different sites were used in the noise study. Three of the sites (Everett, Fife, and Cle Elum) were on highways which had State Patrol weighing stations; one site (Nisqually) was on a section of U.S. Interstate 5 where there was no weighing station; and the fifth location was on a well-traveled street in a 35 mph zone in an industrial area of Seattle where again there was no weighing station. Except for the measurements at this latter site, the microphone was placed 50 ft from the center line of the curb lane and data were taken only on vehicles in this lane. Having the data on video tape makes it quite easy to verify that the vehicle being measured was in the appropriate lane and that the noise data were not being distorted by vehicles in other lanes. In each case traffic was traveling up the indicated grades.

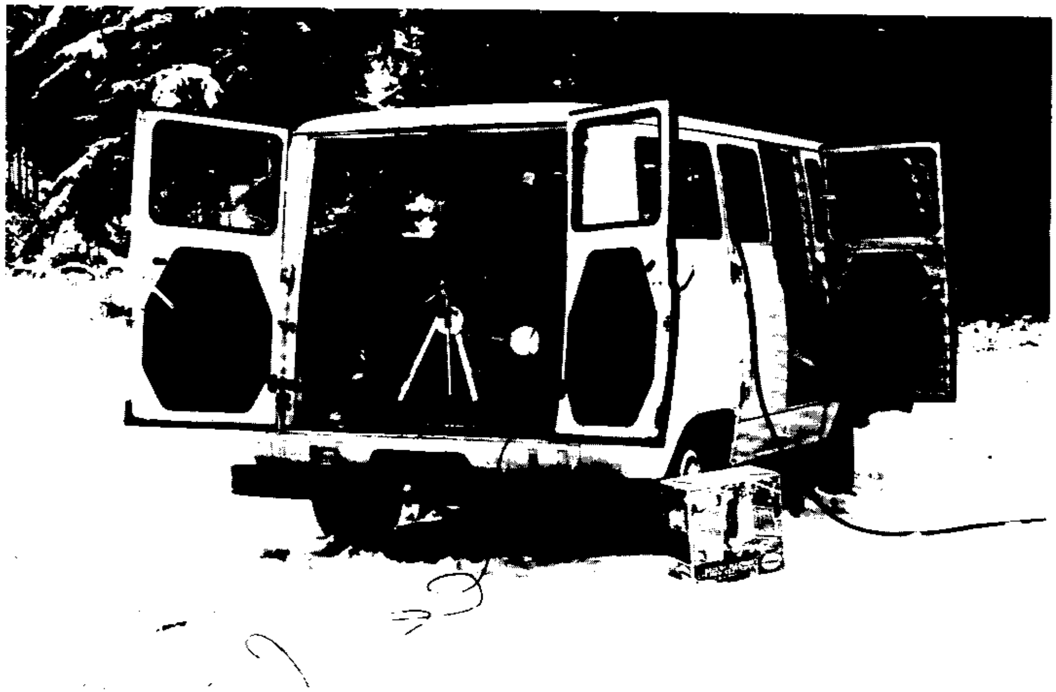


FIGURE 6. VIEW OF THE VAN SET UP AT THE EVERETT SITE.

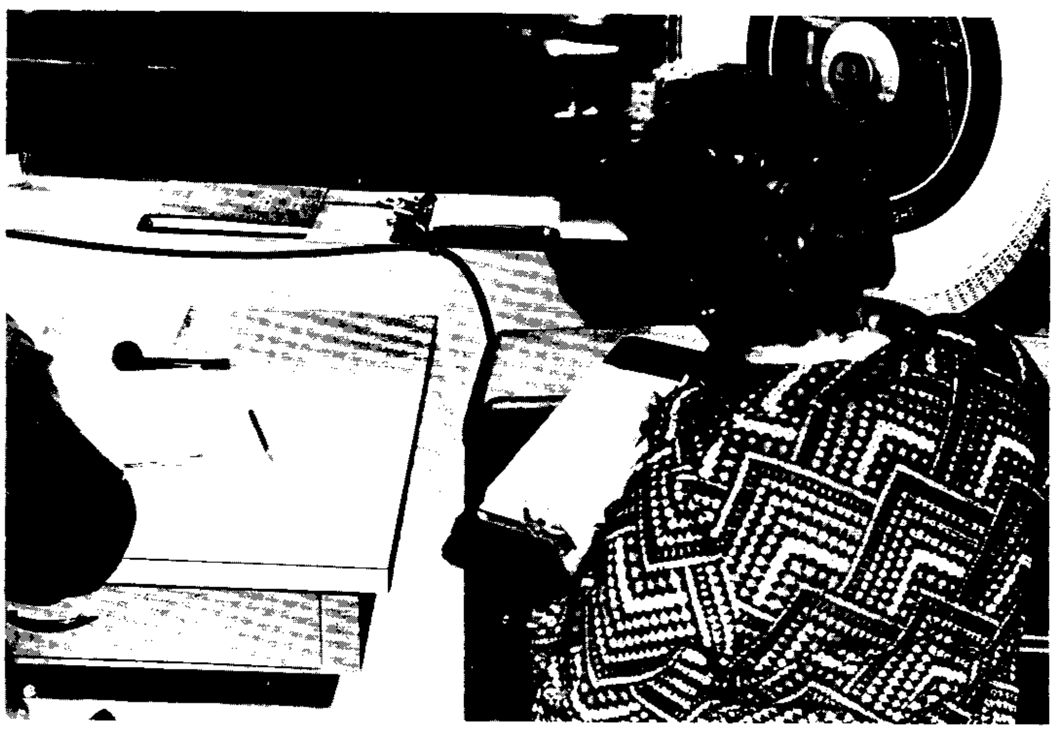


FIGURE 7. VIEW OF THE RECORDING OF TRUCK WEIGHTS AT THE EVERETT WEIGH STATION.

FIGURE 8. VIEW OF TRUCK DRIVER BEING INTERVIEWED AT THE EVERETT WEIGH STATION.

FIGURE 9. VIEW OF TIRE TREAD DEPTH MEASUREMENT AT THE EVERETT WEIGH STATION.

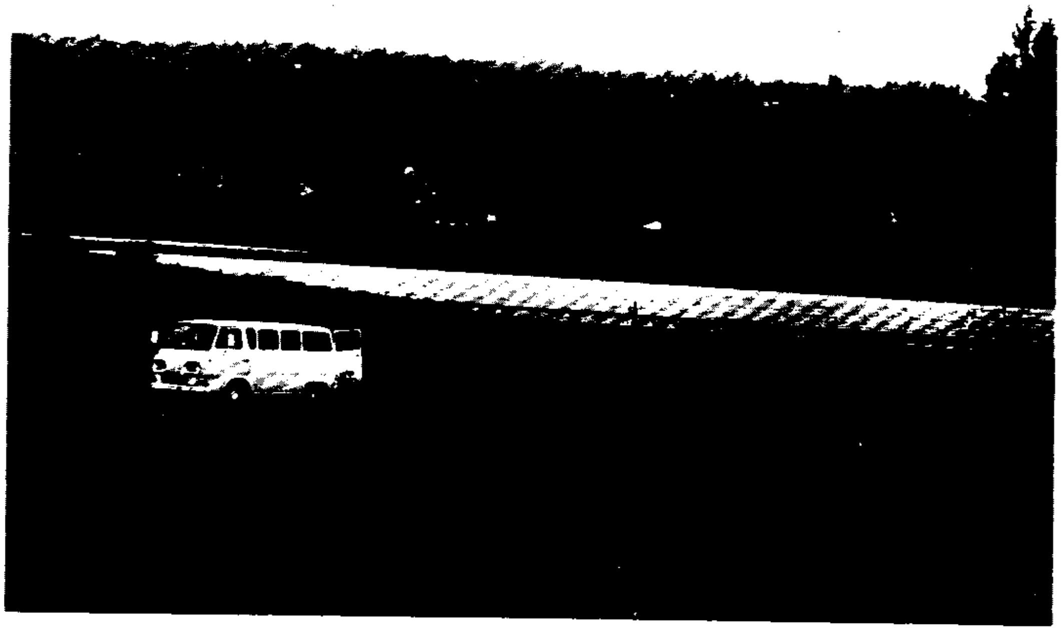


FIGURE 10. VIEW OF THE VAN LOCATION AT THE FIFE SITE.

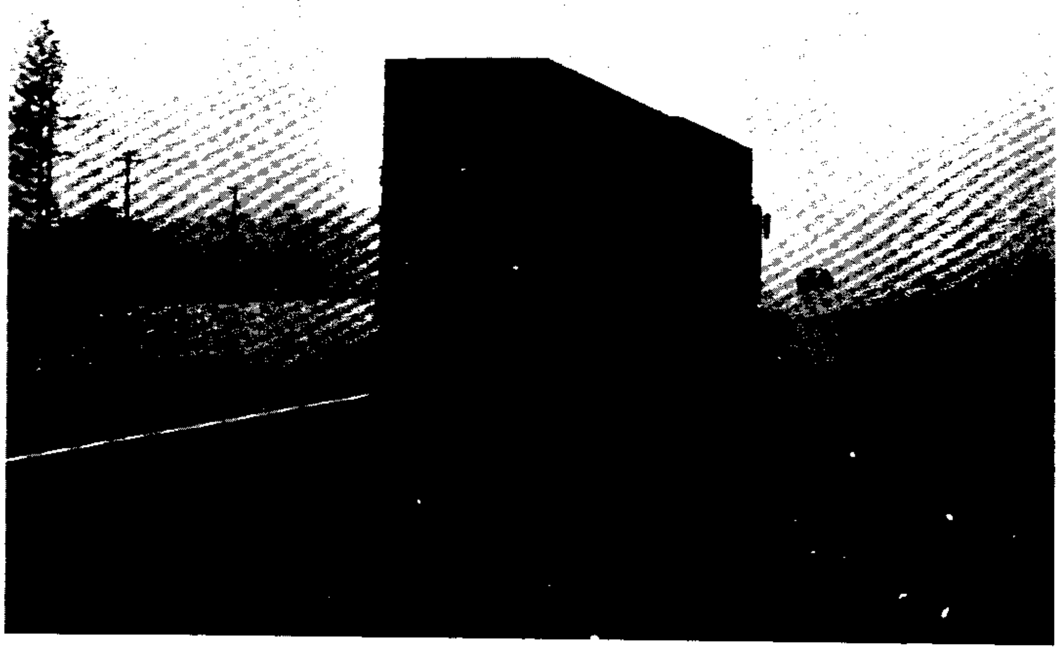


FIGURE 11. VIEW OF A TRUCK ON I-5 DURING A HEAVY RAIN AT THE FIFE SITE.

Location	Highway Grade	Microphone Location
Everett	0.3%	The microphone was placed 50 ft from the center of the outside northbound lane of U.S. Interstate 5 directly west of Peters Place near the southern city limits of Everett. The area is approximately 3/4 mile south of Scale 38 which is just south of Everett, Washington.
Cle Elum	flat	The microphone was placed 50 ft from the center of the outside westbound lane of U.S. Interstate 90, 200 ft west of the overpass going to Roslyn on State Highway 903. The area is approximately 1/2 mile east of Scale 53, 3-1/2 miles east of Cle Elum, Washington.
Fife	2.8%	The microphone was placed 50 ft from the center of the outside northbound lane of U.S. Interstate 5, approximately 200 ft north of the 70th Ave. E. overpass to Fife, Washington. The area is approximately 1/2 mile south of Scale 26.
Nisqually	3.13%	The microphone was placed 50 ft from the center of the outside southbound lane of U.S. Interstate 5, approximately 200 ft south of the North Meridian Road overpass near Nisqually, Washington.
Sixth & Hanford, Seattle	flat	The microphone was placed 50 ft from the center of either the inside or outside southbound lane of 6th Ave. S. across from the entrance of Hanford St.

FIGURE 12.

For large, noisy trucks, the data were considered valid even if a car or two were nearby, provided the truck was in the curb lane. For automobiles or trucks with low noise levels, we did not consider the data valid unless the vehicle in question was in the curb lane and there were no other vehicles in other lanes at that particular time.

The traffic was so heavy at the Fife location that it was practically impossible to get any automobile data meeting the above criteria. Whenever there was a car in the curb lane there was nearly always a second car in another lane to invalidate the reading. It was possible to get more automobile data at the Everett site since the traffic was not as heavy and was better spaced, and occasionally there was a single car proceeding in the curb lane. It should be pointed out that the faster cars seldom use the curb lane, so our automobile measurements at this site were primarily of slower cars. Since the trucks were turning into the weighing station three-fourths of a mile up the road, they were, for the most part, in the curb lane and thus could be measured validly.

The best high-speed automobile data were taken at the Cle Elum site since the traffic load was very light and most of the cars, fast and slow, were in the curb lane. The Nisqually site, on the long up-grade hill on U.S. Interstate 5 northeast of Olympia, did not have a weighing station. This location was chosen in order to get measurements of noise levels produced on a relatively steep grade. This grade measures 3.13%, not much steeper than the Fife site where the grade was 2.8%; however, the Nisqually grade is longer, and measurements were made at a position about two-thirds to the top. At this site the data show a great number of trucks with considerably slower speeds, the speeds probably being limited by engine power.

DATA

Figure 13 is a histogram of all the trucks measured; the sample size is 1,433. As can be seen, this histogram peaks at about 85 and 89 dBA. There were 170 trucks out of this sample which read 85 to 86 dBA and five trucks which fell between 95 and 96 dBA.

Figure 14 is the cumulative frequency plot of the same data shown on Fig. 13. Note that 90% of the trucks were noisier than 82.5 dBA, half were noisier than 86 dBA, and 10% were noisier than 91 dBA.

Figure 15 shows both the cumulative frequency plot of Fig. 12 and a plot of data taken by the California Highway Department on that state's roads. (The California study has data only for this type of plot, i.e., there are no data on speeds, weights, classes, etc. on trucks.) This plot shows that the trucks in this Washington State study are a little noisier than the trucks in the California study; however, the difference is so small as to be insignificant and could well be a happenstance of the sample taken. At the 50% cumulative point there is only 0.5 dBA difference--this close agreement strengthens the validity of both studies.

Figure 16 is a cumulative frequency plot showing each of the test sites plotted separately. As expected, the Nisqually site is the noisiest but not by a great deal; these data do not differ much from the springtime data taken at the Everett site. An examination of the noise versus speed curve for the two sites (see Appendices D and E, pages D7 and E3) shows that the trucks at the Everett site were moving substantially at full speed, whereas there is a very wide variation in speed, with many slow trucks, at the Nisqually site. The speed of many of the trucks on the Nisqually grade was engine-limited and the trucks slowed down sufficiently so that their noise levels were not much greater than those at the Everett site.

The quietest sites were Cle Elum and Fife. There were several reasons why Cle Elum was quieter; the terrain was flat, and during the time of measurement (10:00 a.m. - 3:00 p.m.) there were many apparently empty loads heading west, thus reducing the total weight. At the Fife site the noise level was low despite the grade. There was rain and fog during most of the one-day's work at this site, and perhaps this caused the trucks to proceed at a slower pace. In addition, the only suitable acoustic site was somewhat closer to the turn-off for the weighing station than had been the case at the other sites, and thus most of the trucks were slowing down in preparation for the exit. Although we had hoped to determine whether the noise levels would be significantly affected by the rain, this was not possible because of the reduced speeds and the effects of other parameters. However, it appears that rain does not have a significant effect on radiated noise. (Rain may have a greater relative effect on slow traffic (below 35 mph) noise, but we do not have data to substantiate this surmise.)

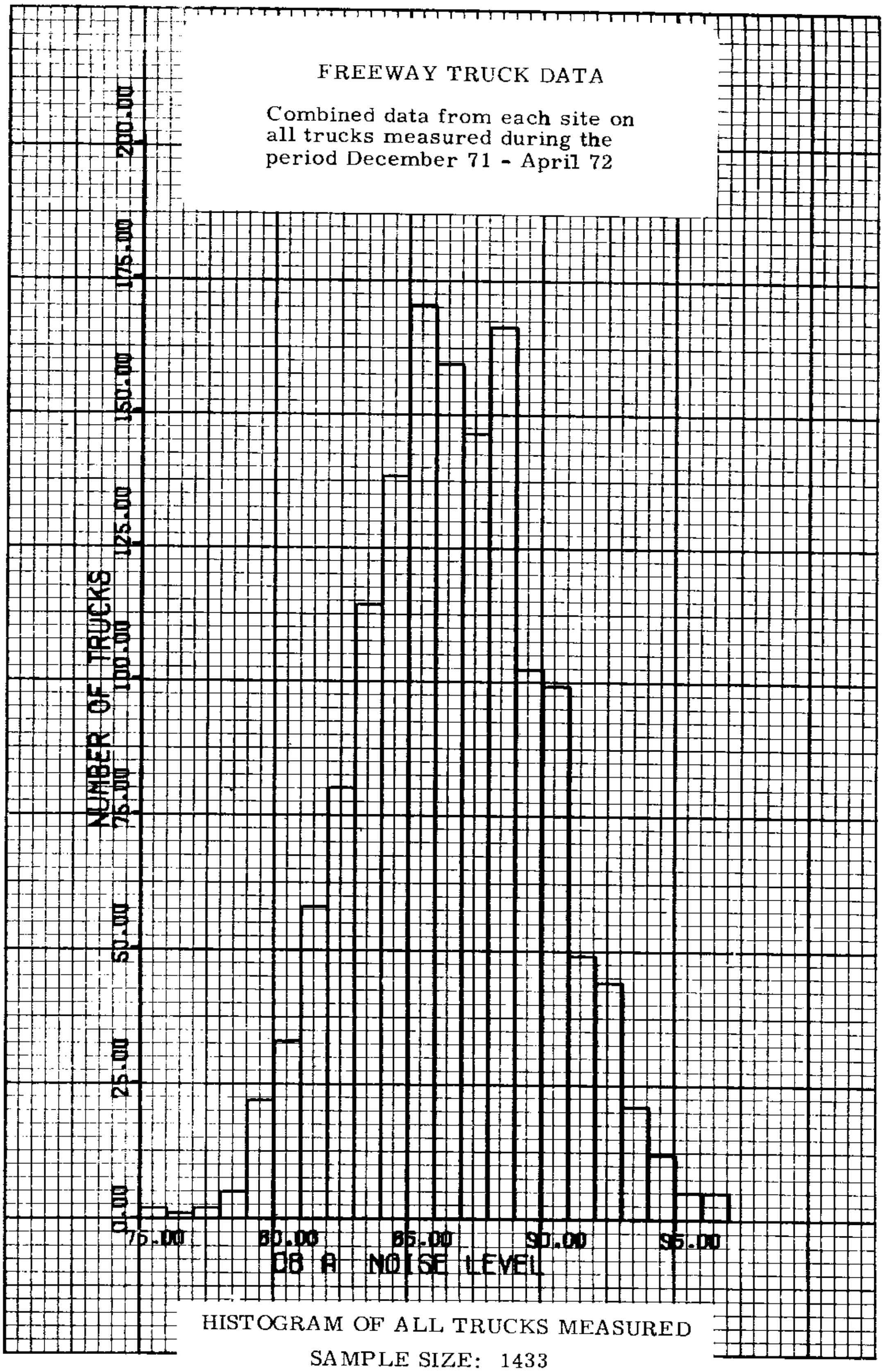

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72
NUMBER OF TRUCKS
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
75.00
80.00
85.00
90.00
95.00
DB A NOISE LEVEL
HISTOGRAM OF ALL TRUCKS MEASURED
SAMPLE SIZE: 1433

FIGURE 13.

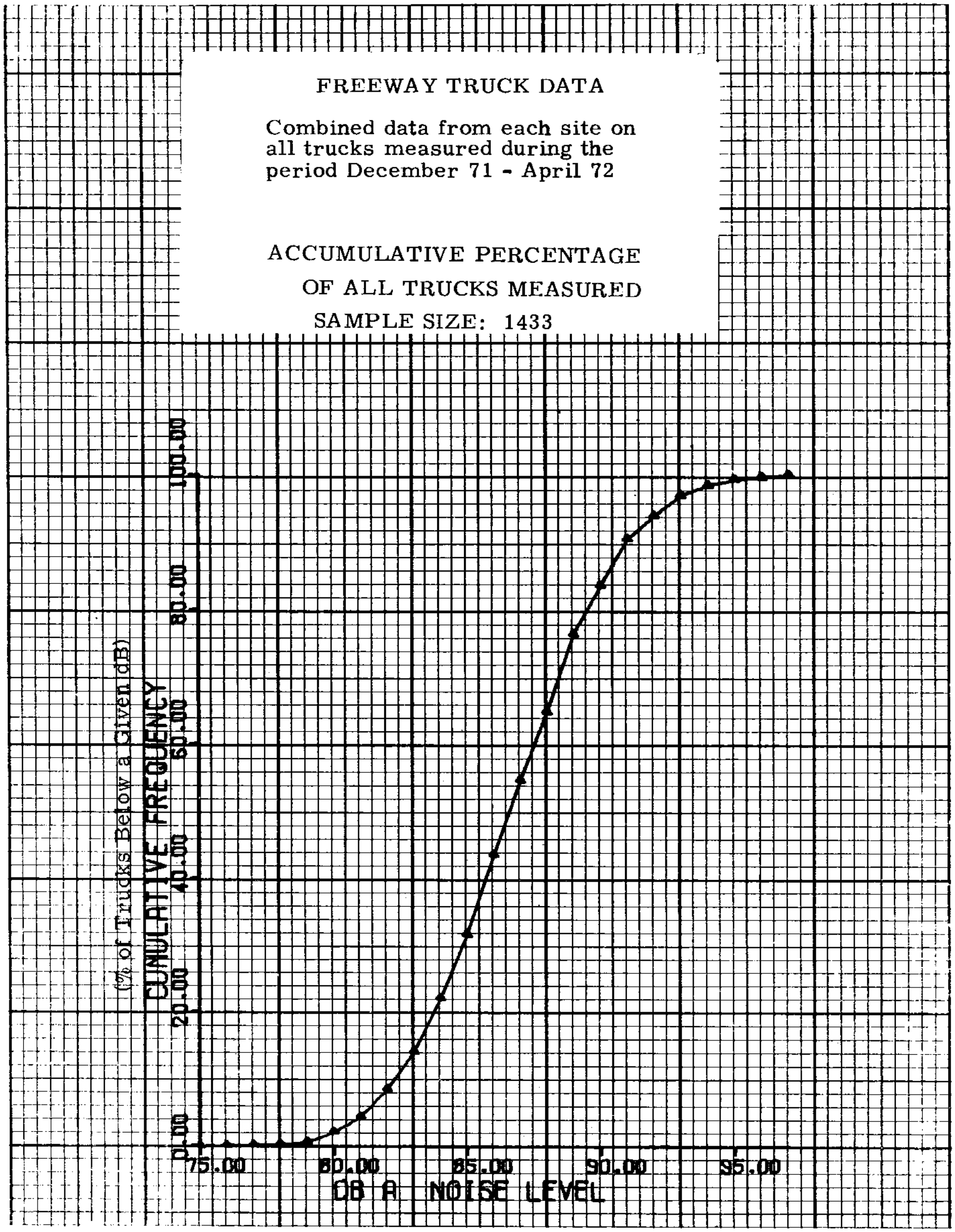

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72
ACCUMULATIVE PERCENTAGE OF ALL TRUCKS MEASURED
SAMPLE SIZE: 1433
(% of Trucks Below a Given dB)
CUMULATIVE FREQUENCY
0.00
20.00
40.00
60.00
80.00
100.00
75.00
80.00
85.00
90.00
95.00
DB A NOISE LEVEL

FIGURE 14.

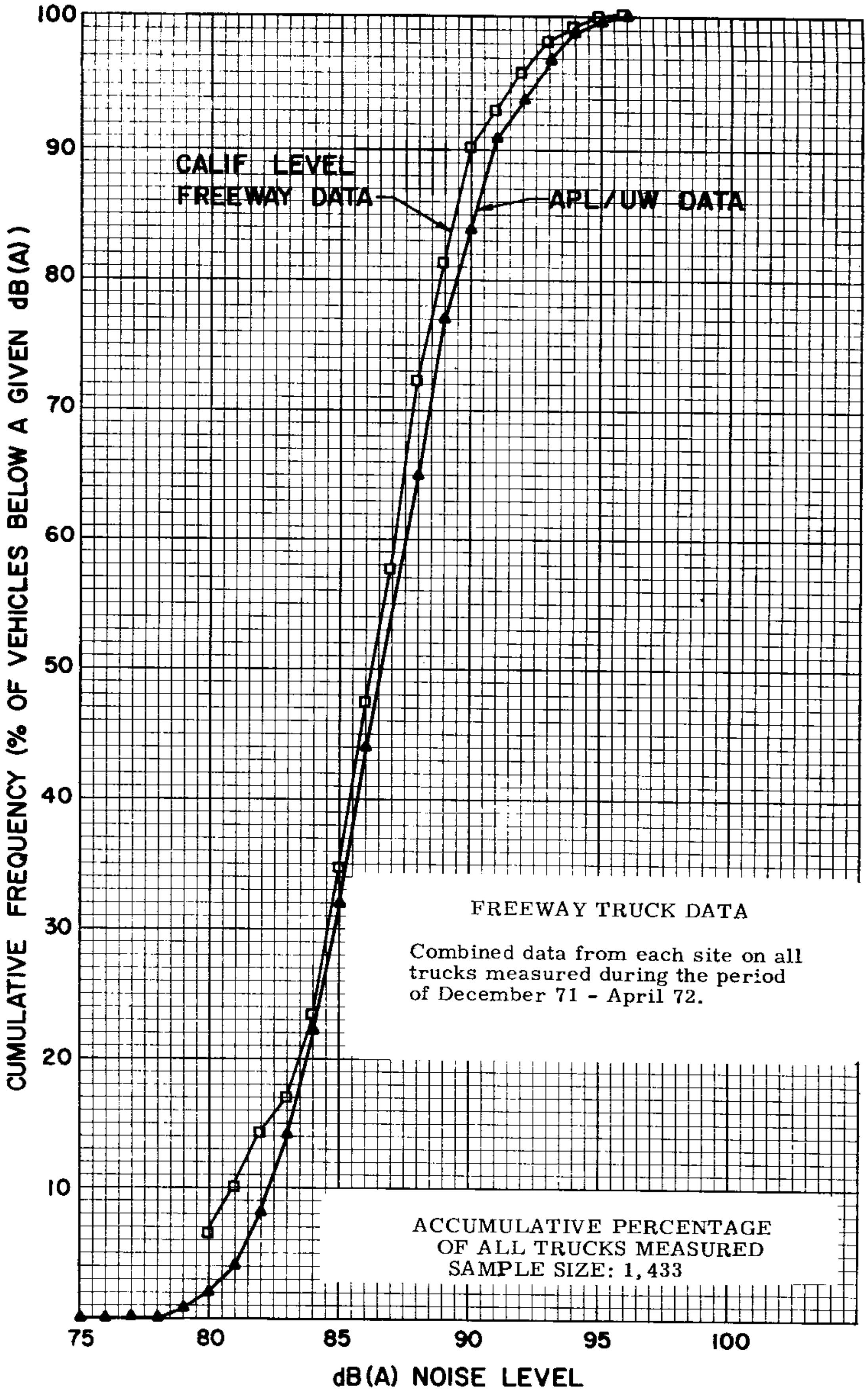
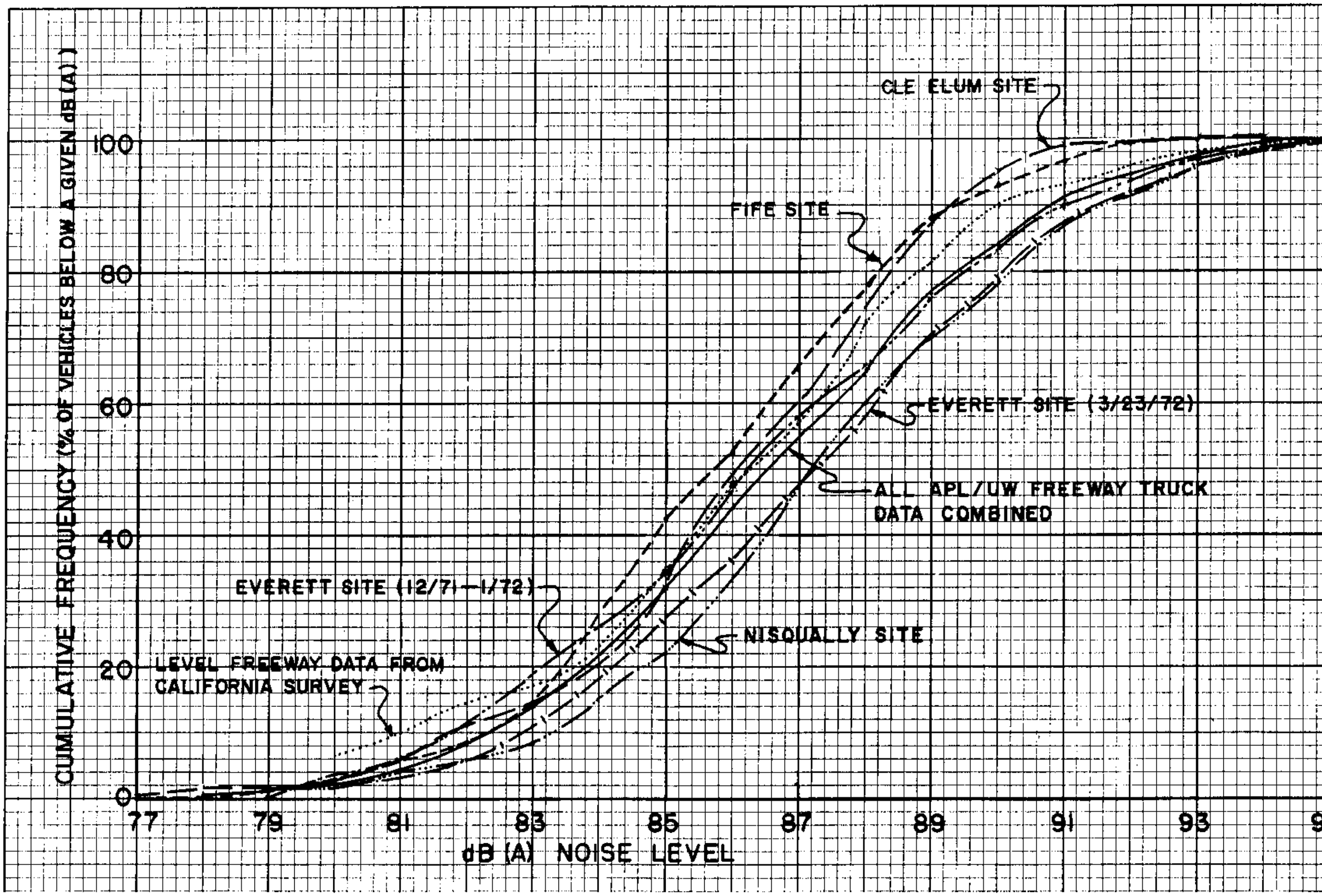

CALIF LEVEL FREEWAY DATA
APL/UW DATA
FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period of December 71 - April 72.
ACCUMULATIVE PERCENTAGE OF ALL TRUCKS MEASURED
SAMPLE SIZE: 1,433
CUMULATIVE FREQUENCY (% OF VEHICLES BELOW A GIVEN dB(A))
dB(A) NOISE LEVEL
100
90
80
70
60
50
40
30
20
10
75
80
85
90
95
100

FIGURE 15.



EVERETT SITE (DEC 71-JAN 72)	0.3% UPGRADE - WINTER, ROAD BARE, SNOW ON SIDES
FIFE SITE (9 MARCH 72)	2.8% UPGRADE - DARK, DRIZZLY, RAINY, FOGGY DAY; ROAD WET
CLE ELUM SITE (21 MARCH 72)	FLAT - WARM DAY BUT WITH WINTER SNOW PACK STILL ON SIDES, LIGHT TRAFFIC
EVERETT SITE (23 MARCH 72)	0.3% UPGRADE - NICE SPRING DAY
NISQUALLY SITE (11 APRIL 72)	3.13% UPGRADE - MOSTLY NICE DAY, SPRINKLE RAIN NEAR END OF DATA SESSION

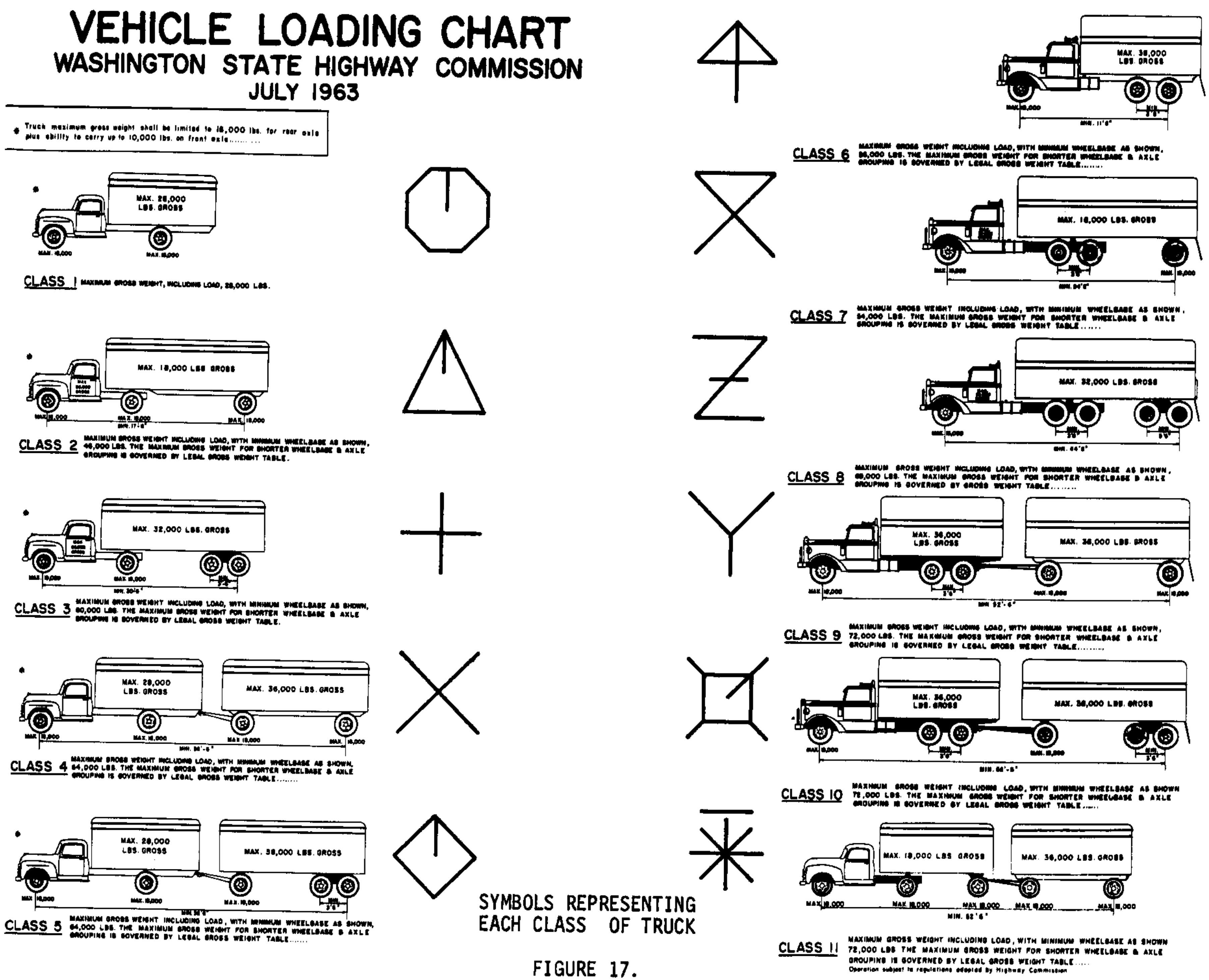
FIGURE 16.

The plot of the data taken at the Everett site in mid-winter shows only a slightly less noisy cumulative percentage curve than the springtime data; the difference at the 50% cumulative point is only 0.3 dBA, which is insignificant. However, it is possible that the colder tires were somewhat less noisy and/or the particular sample of trucks had slightly different statistics. Note that the total spread of the data at the 50% point for all the sites is only about 1.5 dBA, which is very small. The average person could barely detect a 1.5 dBA change even if he heard one level right after the other. The California data are plotted also and appear more or less in the middle of the data from all of the sites.

Figure 17 shows the various classes of trucks as categorized by the vehicle loading chart of the Washington State Highway Department, dated July 1963. Also shown on this chart are eleven different symbols, one for each truck class. These symbols are used extensively in many of the graphs presented here; e.g., the letter Z represents a Class 8 truck, the configuration of which is shown in Fig. 17.

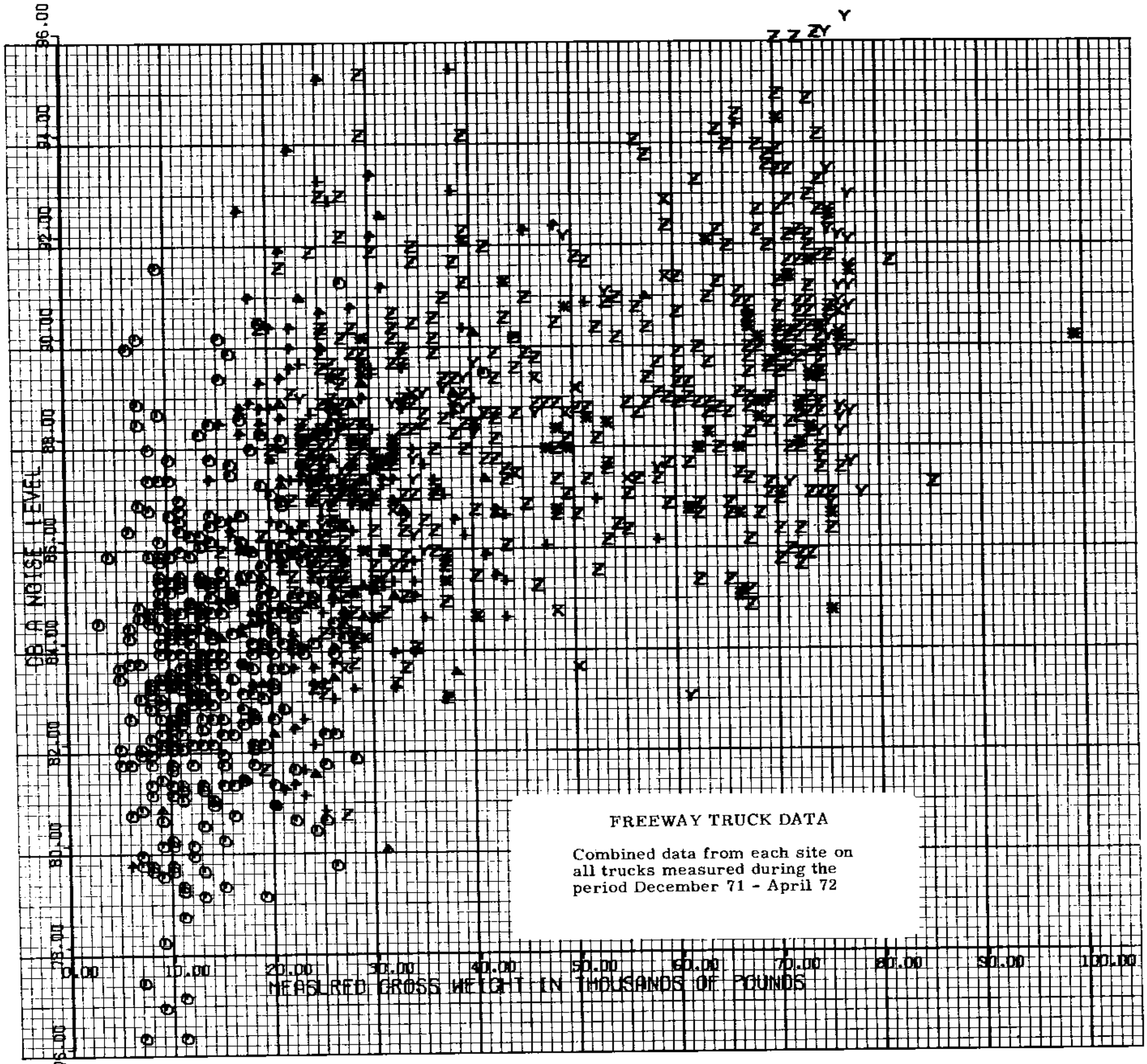
Figure 18 is a plot of noise level in dBA versus measured gross weight in thousands of pounds. Each data point symbol corresponds to a class of truck, as explained in the preceding paragraph. Note that there is a general trend for the vehicle to radiate more noise as its gross weight increases. There is, however, a wide spread in noise levels at any given weight. For example, at the 75,000 lb level there is one truck below 85 dBA and another in excess of 96 dBA; also, at the 10,000 lb level there are trucks below 77 dBA and at least one above 91 dBA. This clearly shows that the big, heavy trucks are not the sole offenders, and that there are, indeed, some large heavy trucks which are quiet. The plot of Fig. 18 includes trucks at all speeds and indicates that the quieter ones are the low-speed trucks.

Figure 19 is similar to Fig. 18 except that all the trucks with speeds below 50 mph have been eliminated, leaving trucks which are all going at about the same speed (the speed limit is 60 mph). (It will be seen in later data that there are trucks which exceed this limit.) Once again, it can be seen that there are trucks weighing more than 65,000 lb (as measured at the weighing station) which are below 85 dBA. There are also trucks in this same weight bracket above 96 dBA. Similarly, in the region of 10,000 lb gross weight, there is one truck as low as 77 dBA and another one above 91 dBA. The trend, then, is to greater noise as the vehicle gets heavier, but there is a very wide spread in the truck noise levels. This clearly shows that if all trucks were as quiet as the low 10%, the noise level would be down considerably. Note on this figure that the heavier trucks in this study tend to be predominantly Class 8's. There are also a number of Class 11 trucks among the heaviest weights; at the lighter end of the scale the Class 1's predominate (octagonal symbols).



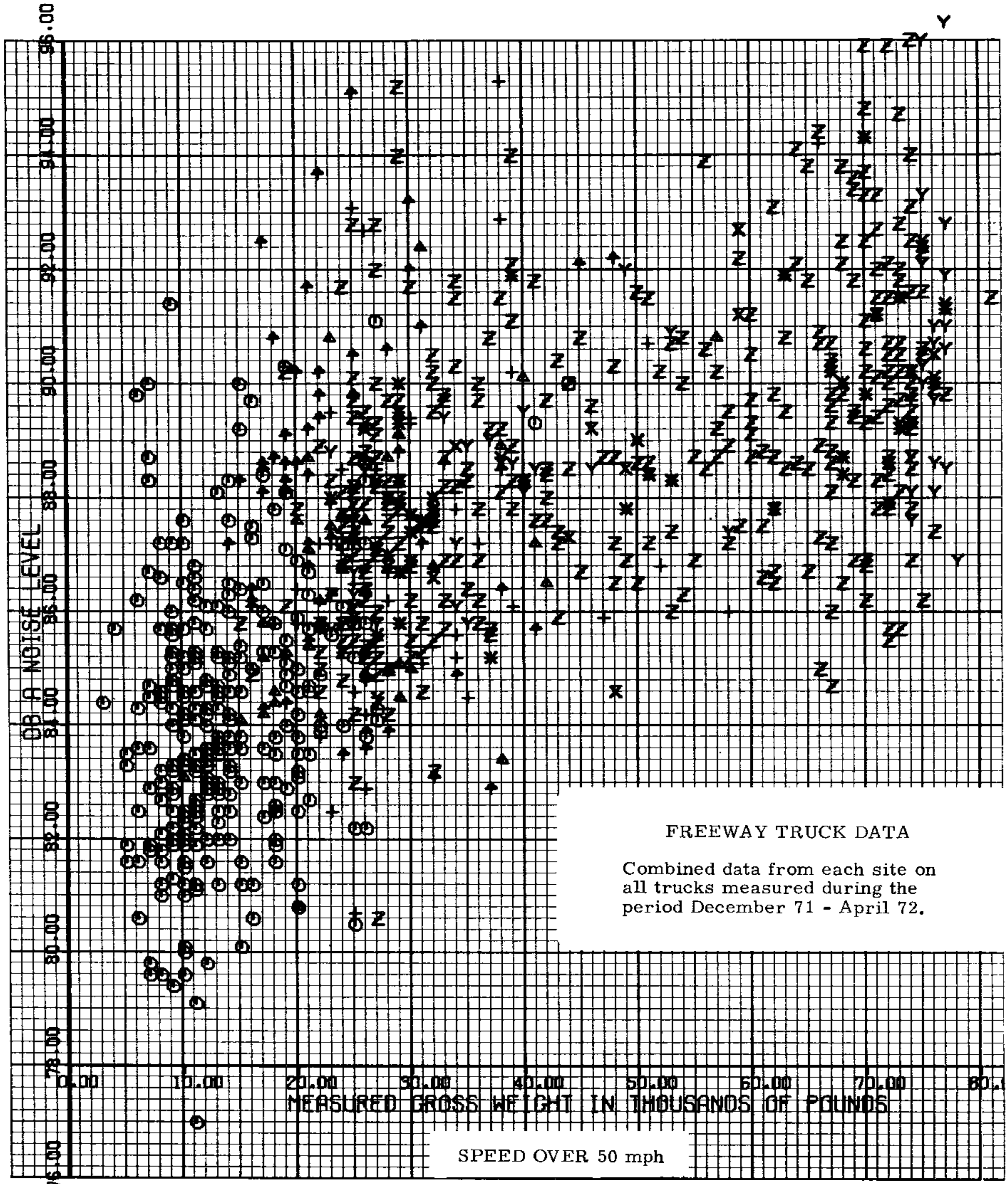
SYMBOLS REPRESENTING
EACH CLASS OF TRUCK

FIGURE 17.



DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72

FIGURE 18.



96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
DB A NOISE LEVEL
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72.
SPEED OVER 50 mph

FIGURE 19.

Figure 20 is a plot of all the trucks measured, showing their noise levels versus speeds. A Doppler-shift radar unit was used to measure the speed. The noise level shows the trend of increasing noise with speed, but a very wide spread is observed.

In an attempt to eliminate the weight variable from the speed plots, Figs. 21-27 show the trucks in various weight categories, and within each of these categories the dBA versus the speed has been plotted. In Fig. 21 the noise level increases with speed in the under-10,000 lb vehicles, but, again, there is a very wide scatter. As we proceed through these charts, notice the median level of noise increases a little bit with each higher weight category. In practically all of these categories an increase of noise with increase of speed is shown although the scatter in the data is very wide. Several variables, other than weight and speed, contribute to the scatter. These include the adequacy of the muffling system, tires, amount of noise emanating from the supercharger or compressor of the motor, gear noise, etc. None of these are necessarily correlative with either speed or weight.

The question arises as to how much of this noise level could be corrected with adequate mufflers, with no other changes being made to the trucks now on the highways. This question cannot be answered directly and unequivocally from this study. However, the information plotted in Fig. 28 can give a definite clue. At the time the data were reduced, sound levels were recorded not only for the standard A-weighting filter but also for a B-weighting filter. A B-weighting filter is a standard noise measurement frequency response which allows more low-frequency information to be measured; in other words, if a sound has a lot of low-frequency components, it will measure louder on an indicating meter set to the B-scale than it will on one set to the A-scale. It is probably fair to say that the major source of excessive low-frequency sound from trucks is the engine exhaust. Therefore, a poorly muffled vehicle would have a dBB reading which is significantly higher than a dBA reading; there would not be much difference in the dBA and dBB readings from a truck that is adequately muffled. In Fig. 28 the numerical value for the dBA reading for a truck has been subtracted from the numerical value of the dBB reading and the differences have been plotted against the measured gross weight of the truck. Under the foregoing assumptions, those vehicles with large differences can be presumed to be poorly muffled, whereas those with differences between 0 and 1 dB can be presumed to be adequately muffled. It should be pointed out that on this particular chart a truck which is poorly muffled <u>and</u> extremely noisy otherwise would have a relatively low dBB and dBA difference. Another truck might show a large difference, even though its muffler is in good condition, if its tires, engine, gear train, etc. were exceptionally quiet. In general, though, it is probably still valid to consider those vehicles which show more than 2 or 3 dB difference on this plot as being in need of better mufflers.

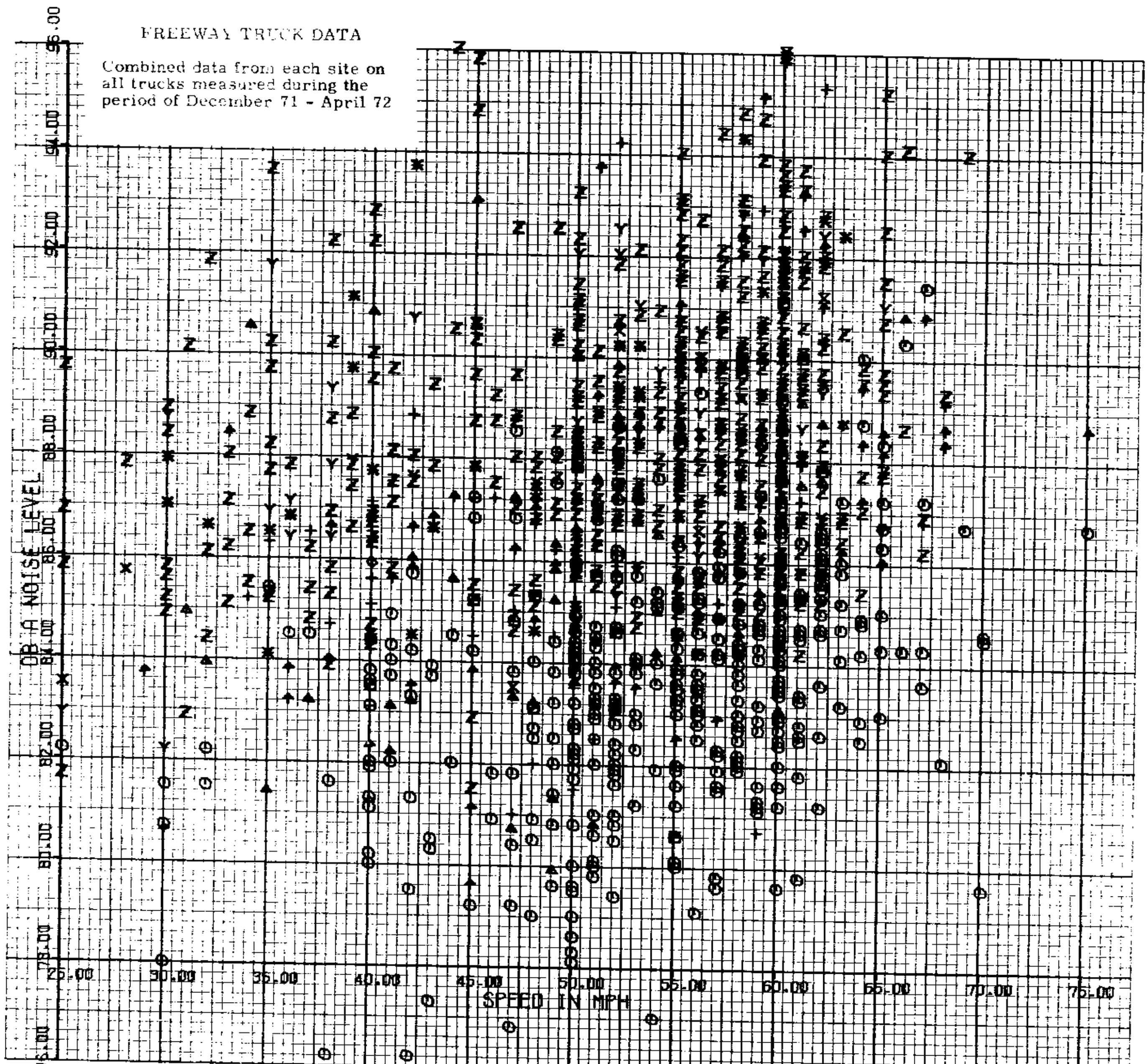

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period of December 71 - April 72
DB A NOISE LEVEL
SPEED IN MPH
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00

FIGURE 20.

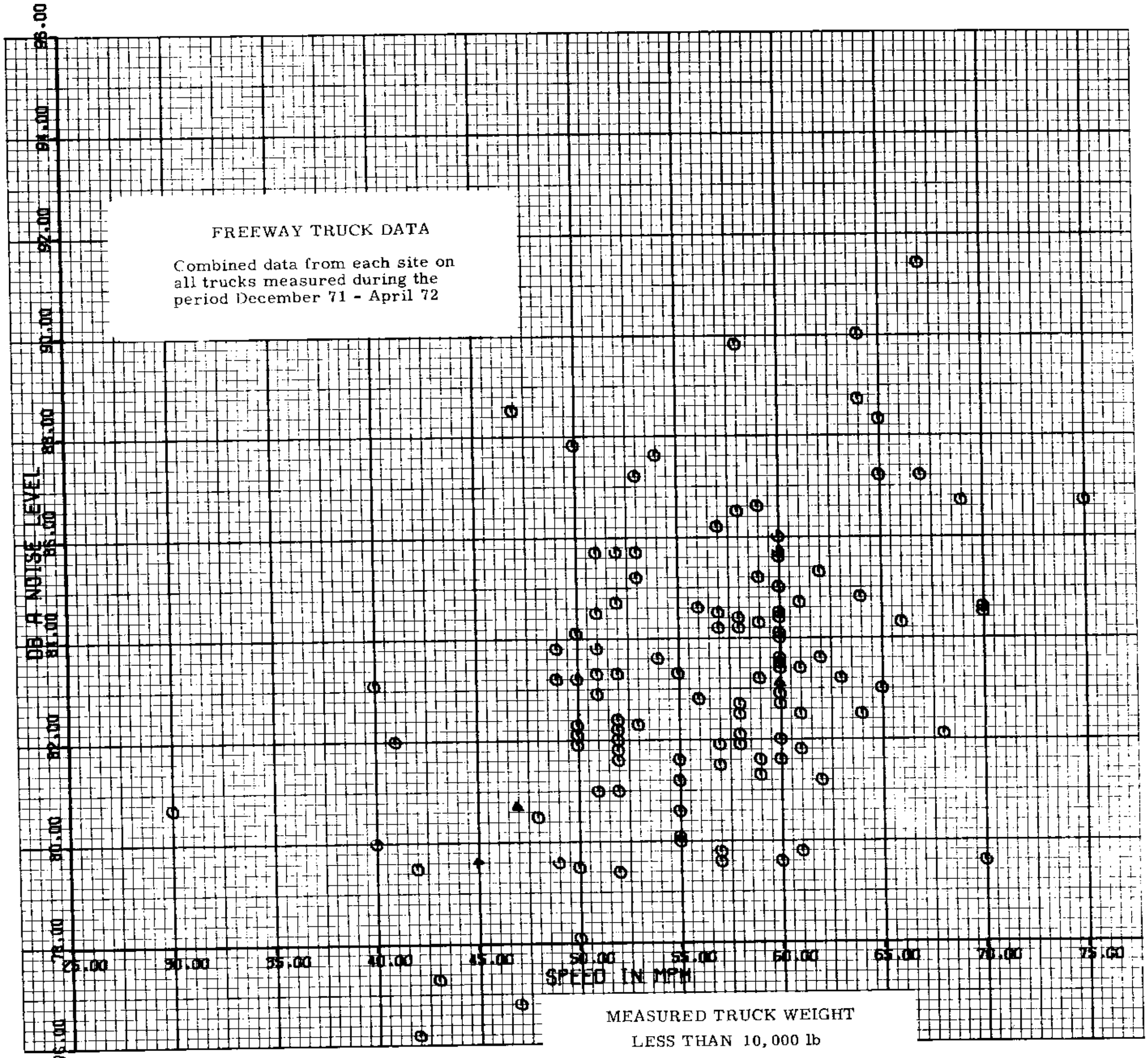
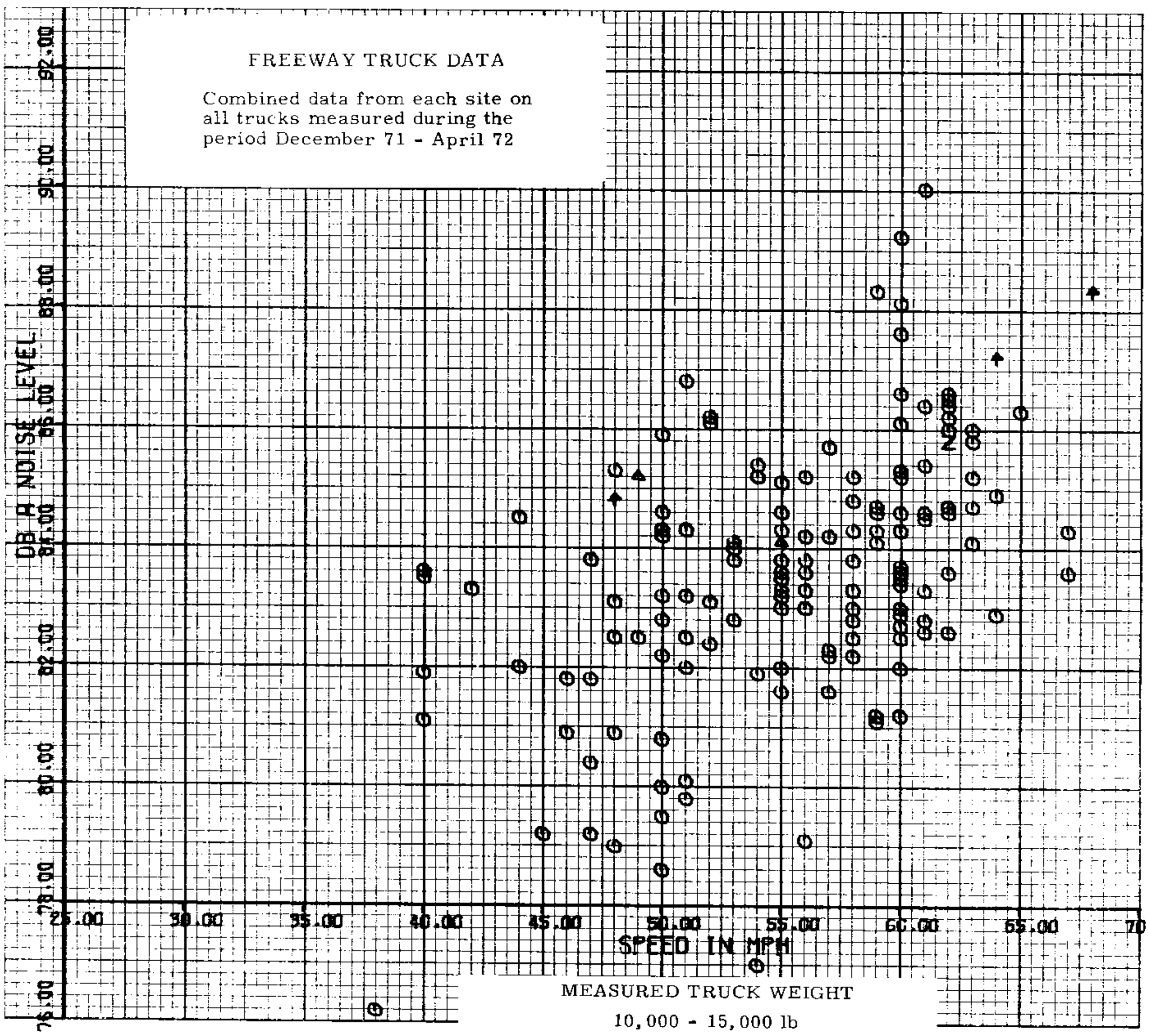
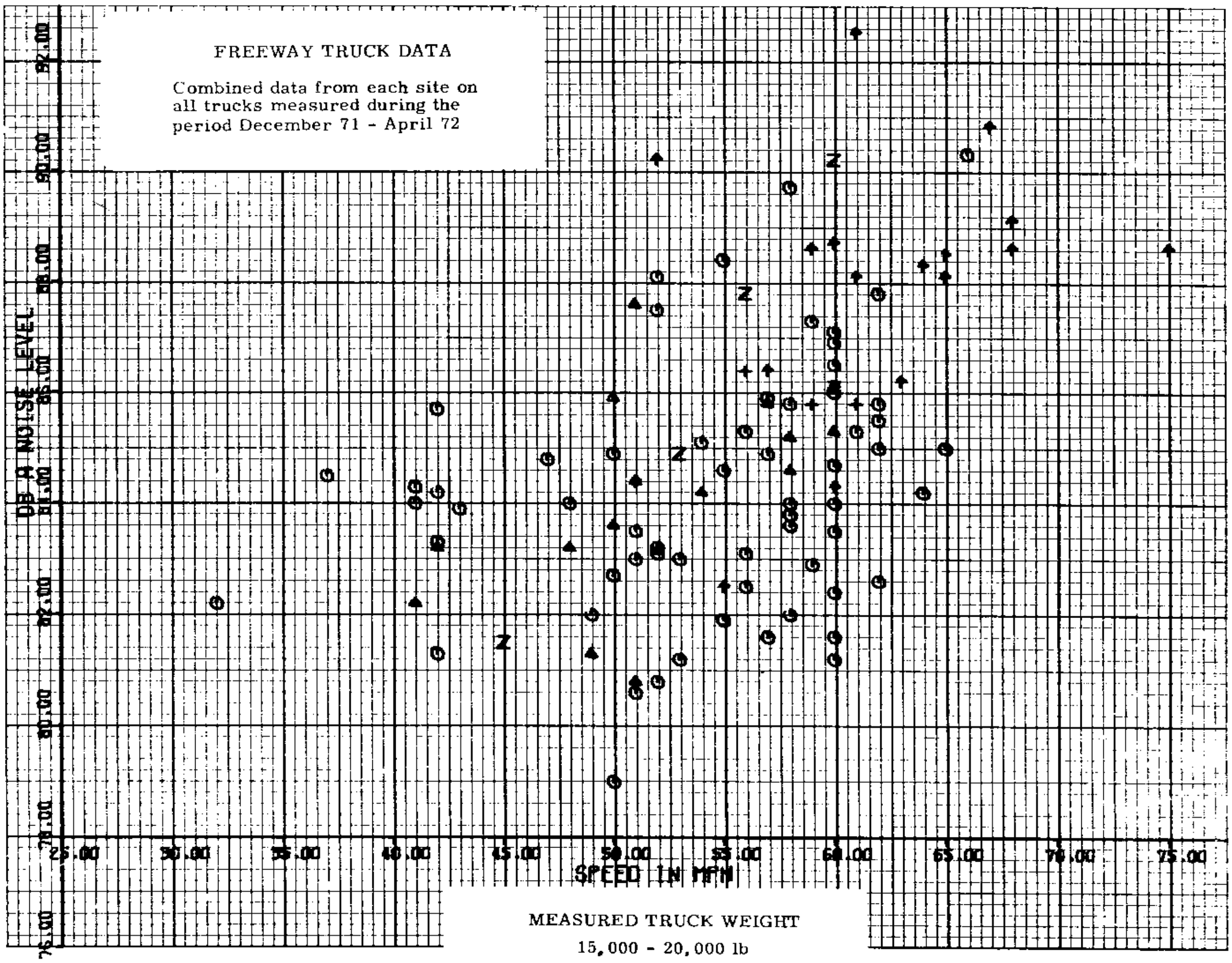

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72
DB A NOISE LEVEL
SPEED IN MPH
MEASURED TRUCK WEIGHT LESS THAN 10,000 lb

FIGURE 21.



FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72
DB A NOISE LEVEL
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70
SPEED IN MPH
MEASURED TRUCK WEIGHT
10,000 - 15,000 lb

FIGURE 22.



FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72
DB A NOISE LEVEL
SPEED IN MPH
MEASURED TRUCK WEIGHT
15,000 - 20,000 lb

FIGURE 23.

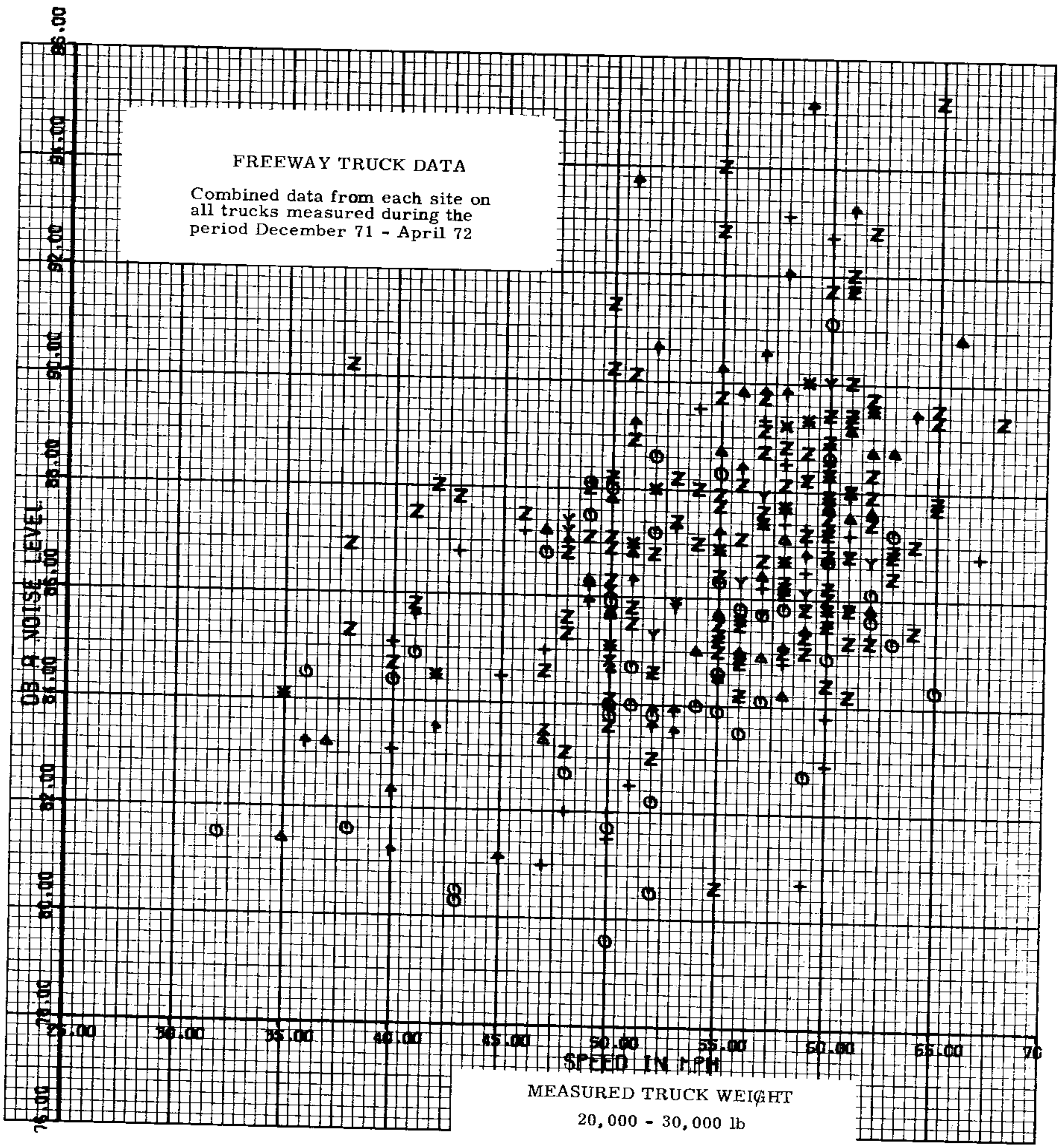

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72
DB A NOISE LEVEL
SPEED IN MPH
MEASURED TRUCK WEIGHT
20,000 - 30,000 lb

FIGURE 24.

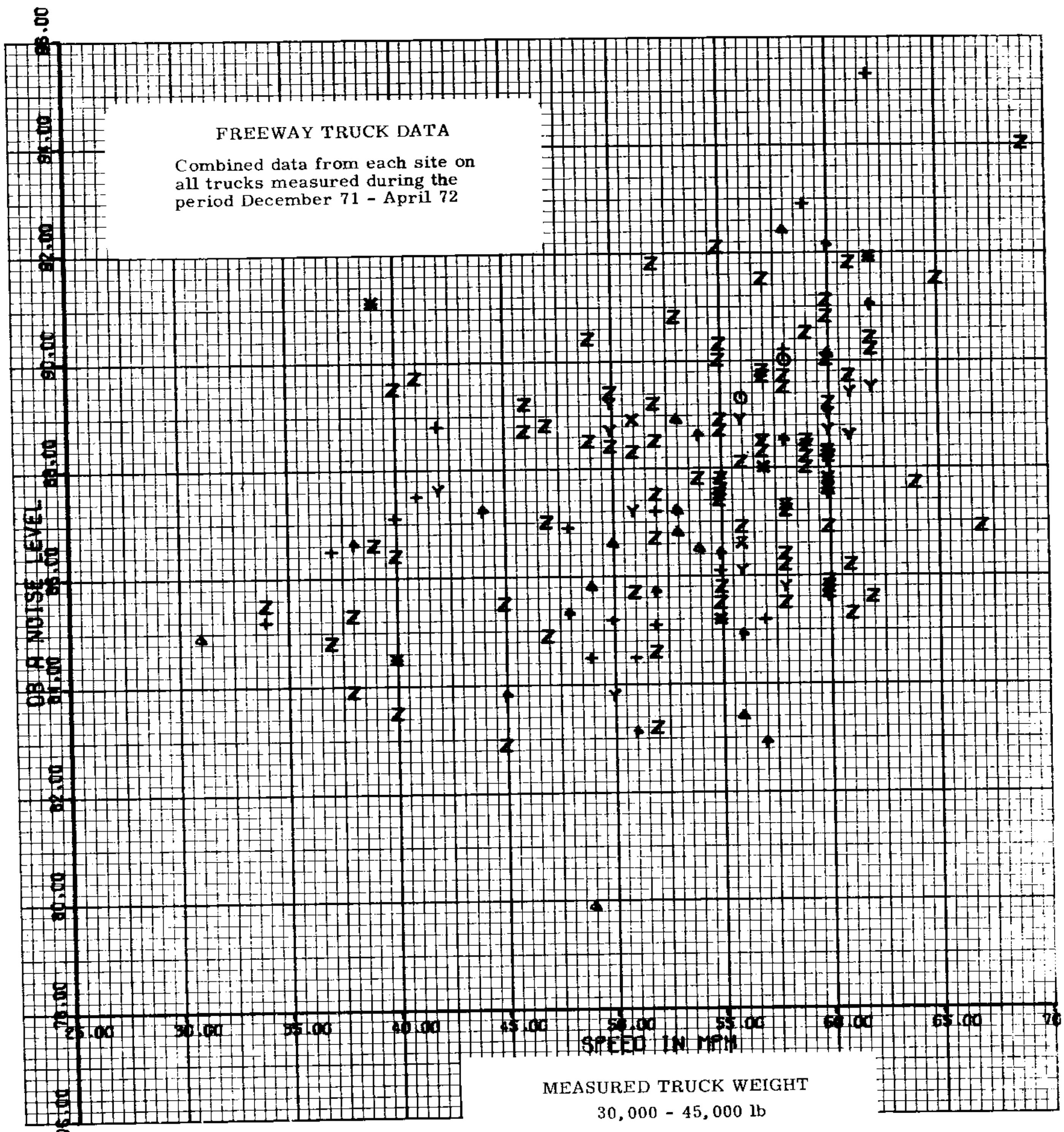

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72
DB A NOISE LEVEL
SPEED IN MPH
MEASURED TRUCK WEIGHT
30,000 - 45,000 lb

FIGURE 25.

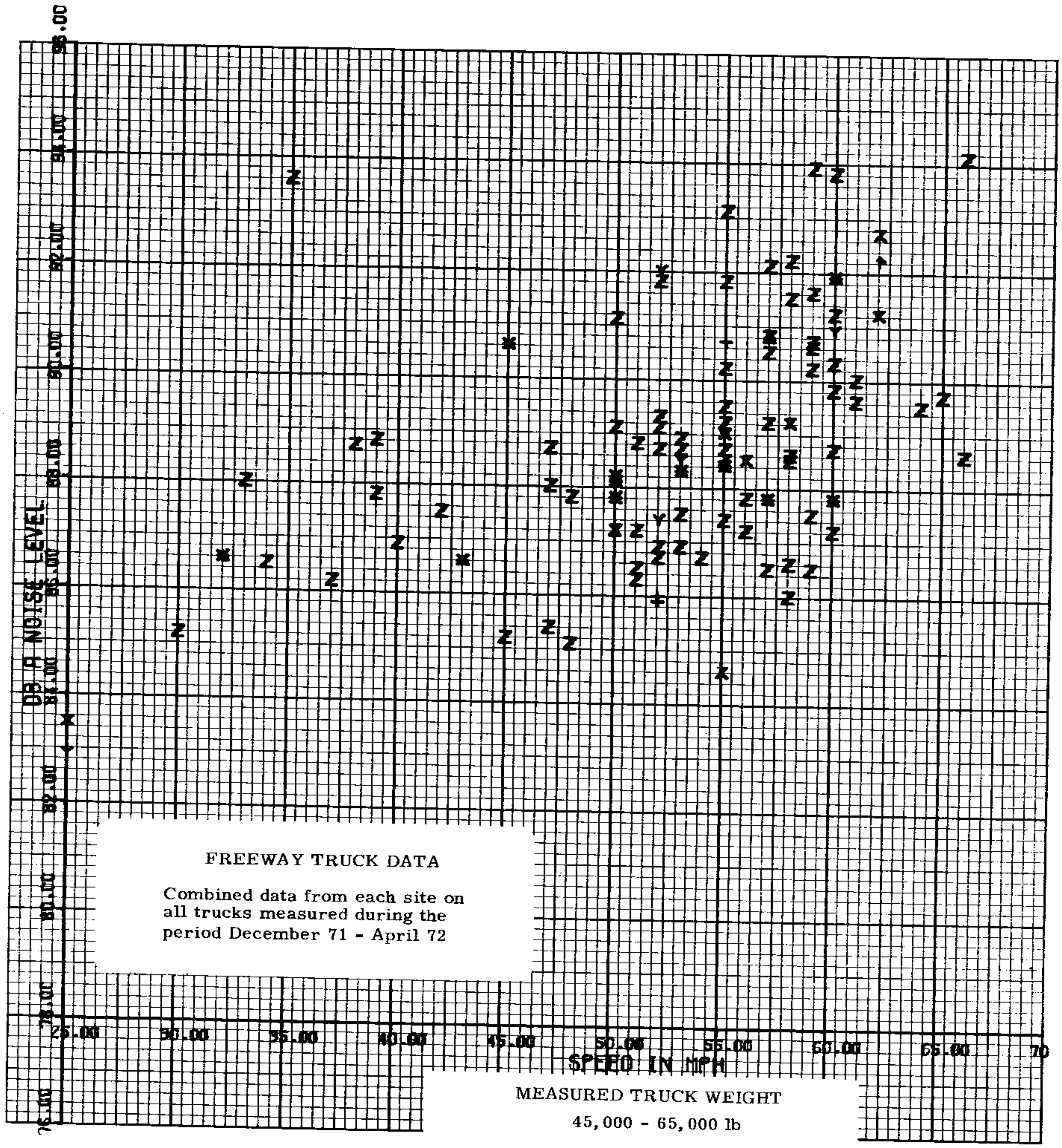

DB A NOISE LEVEL
SPEED IN MPH
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70
FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72
MEASURED TRUCK WEIGHT
45,000 - 65,000 lb

FIGURE 26.

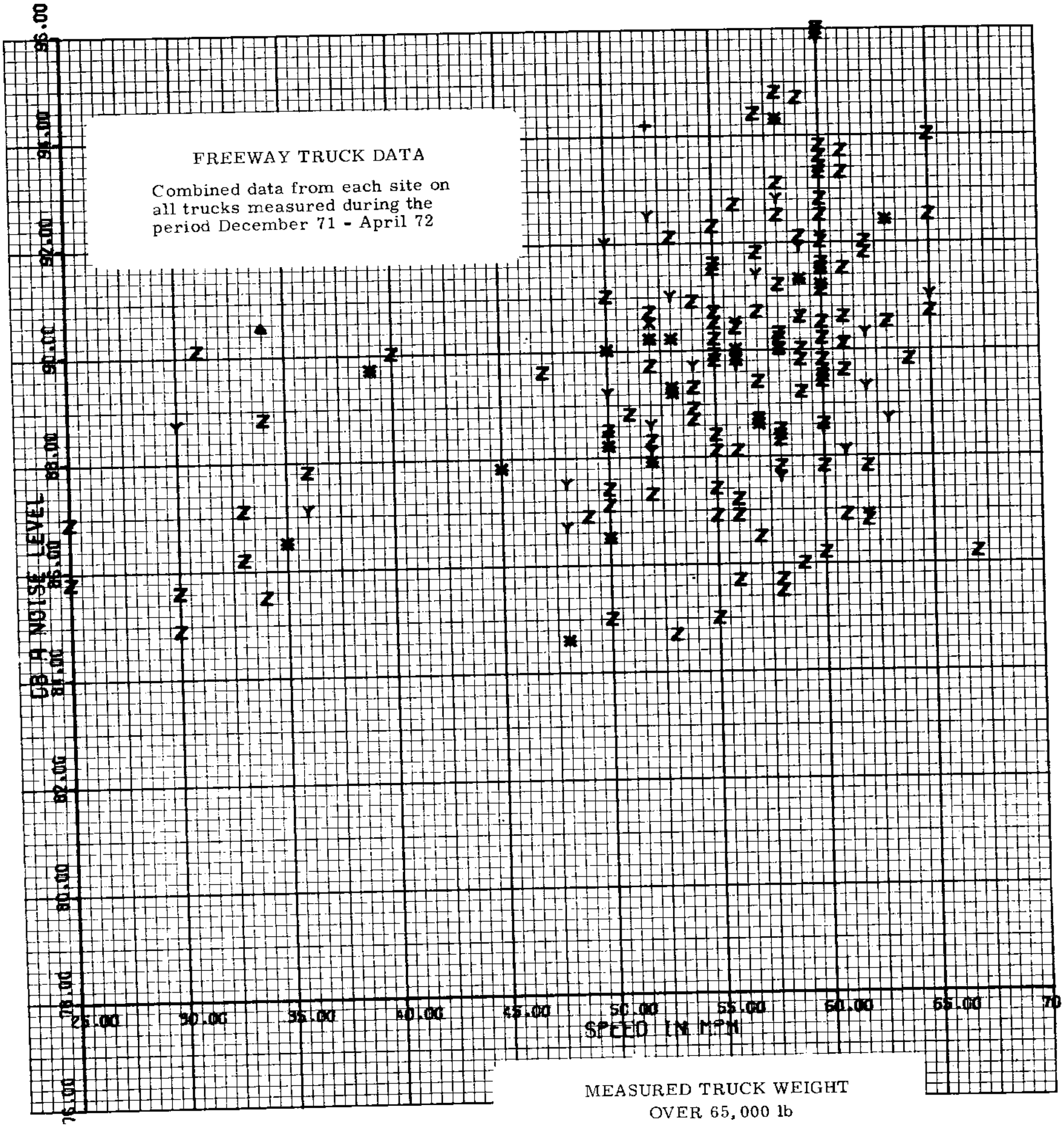

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72
MEASURED TRUCK WEIGHT OVER 65,000 lb
DB A NOISE LEVEL
SPEED IN MPH

FIGURE 27.

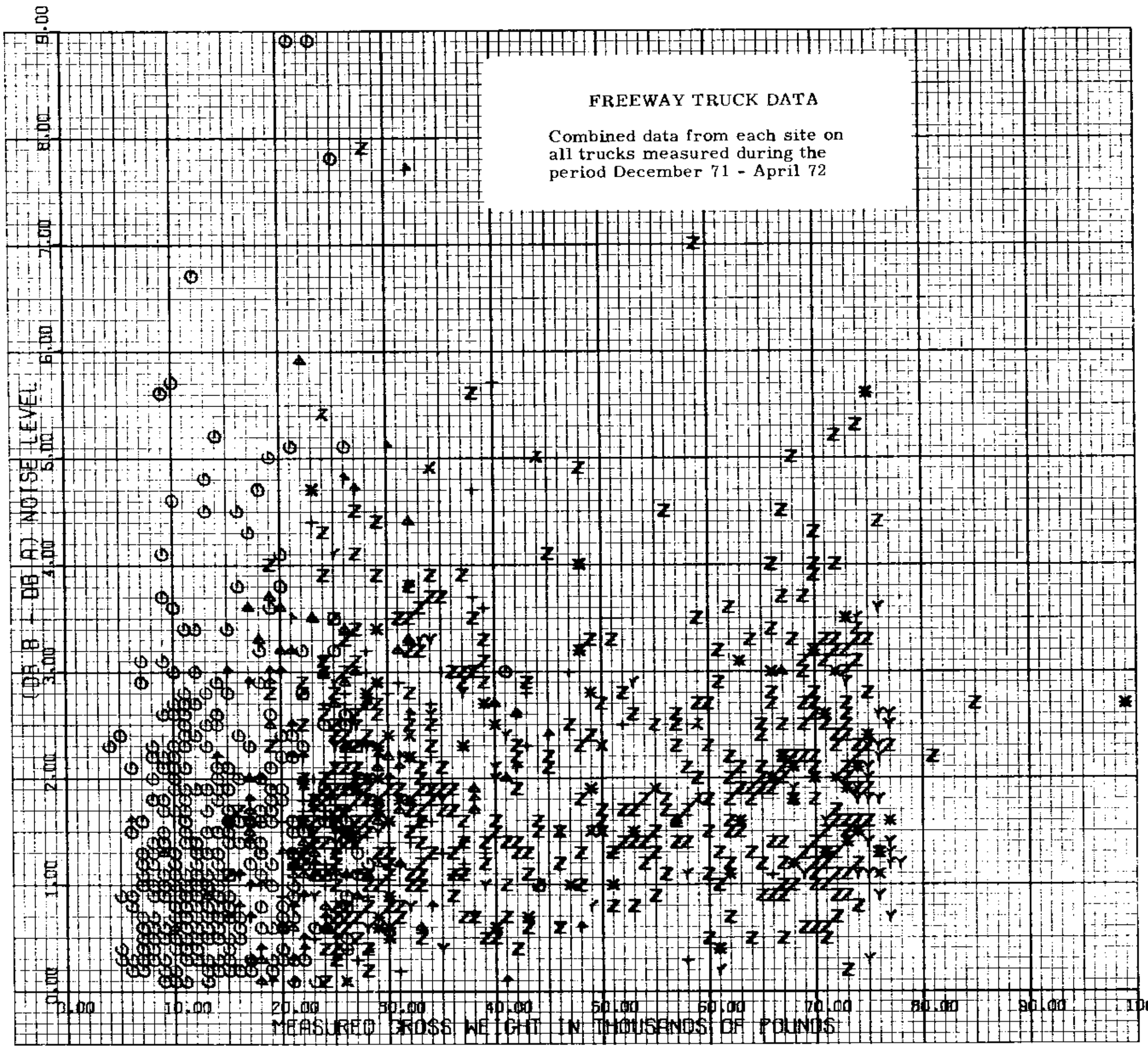

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71 - April 72
(DB B - DB A) NOISE LEVEL
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS

FIGURE 28.

Figure 29 is similar to Fig. 28 except that the dBB minus dBA differences are plotted against truck speed rather than gross weight. A further question might now arise: is it predominantly the trucks which are very noisy overall that show up poorly on Fig. 28? This is answered in Figs. 30 through 33, which are plots for several of the sites in which the dBB minus the dBA level is plotted against the noise level in dBA. If only the noisier trucks had the stronger low-frequency component, these plots would show an increasing trend in dBB minus dBA as the dBA value increases. Examination of these figures shows that this is not true. The highest levels of dBB minus dBA were obtained in the mid-range of dBA values, i.e., in the region between 84 and 88 dB. The reason the quiet trucks do not show high values of dBB minus dBA is that they are quiet because they are well muffled (in addition to other noises being low), and effective muffling reduces the low-frequency noise. On the other hand, some very noisy trucks do not show high values of dBB minus dBA because they are very noisy in other respects, and this tends to drown out the low-frequency exhaust noise.

Figure 34 contains four cumulative frequency plots; one is the cumulative frequency plot for all of the trucks and is a duplicate of Fig. 14, and the other three are plots for three different weight categories ("all trucks" divided into three categories"). One category is for a measured weight less than 15,000 lb, the second between 15,000 and 30,000 lb, and the third for over 30,000 lb. In these plots the cumulative frequency of 50%, where half of the trucks are above and half are below, for trucks of 15,000 lb or less occurs at 84 dBA. For trucks between 15,000 and 30,000 lb, the 50% cumulative frequency occurs at 86 dBA (remember, for "all trucks" it occurs at 86.5 dBA), and for trucks weighing more than 30,000 lb the reading is slightly under 89 dBA. Or, if one picks a particular noise level, one can see what percentage of the trucks in the various classes would be noisier than that level. For example, if you chose 88 dBA, the charts show only 37% of the large vehicles are quieter than that value, 66% of the whole truck sampling population is quieter than that value, 75% of all the trucks between 15,000 and 30,000 lb are quieter than that value, and 88% of all the trucks weighing less than 15,000 lb are below 88 dBA.

The data plotted in Fig. 34 include trucks of all speeds. Since the slow ones are known to be less noisy, one might ask--to what degree do the slower trucks lower the "total" noise level? This is answered in Figs. 35 through 37 where only data on heavy, full-speed vehicles are included. Figure 35 is the histogram and Fig. 36 is the cumulative plot. Figure 37 shows two cumulative frequency plots, one for all (1,433) trucks that were measured on the highways, and one for only big, heavy, fast-moving trucks, of which there were 344 as shown in Fig. 36. Specifically, these were the trucks which weighed more than 30,000 lb and were traveling faster than 50 mph. The full-speed, heavy vehicles are indeed noisier than "all trucks."

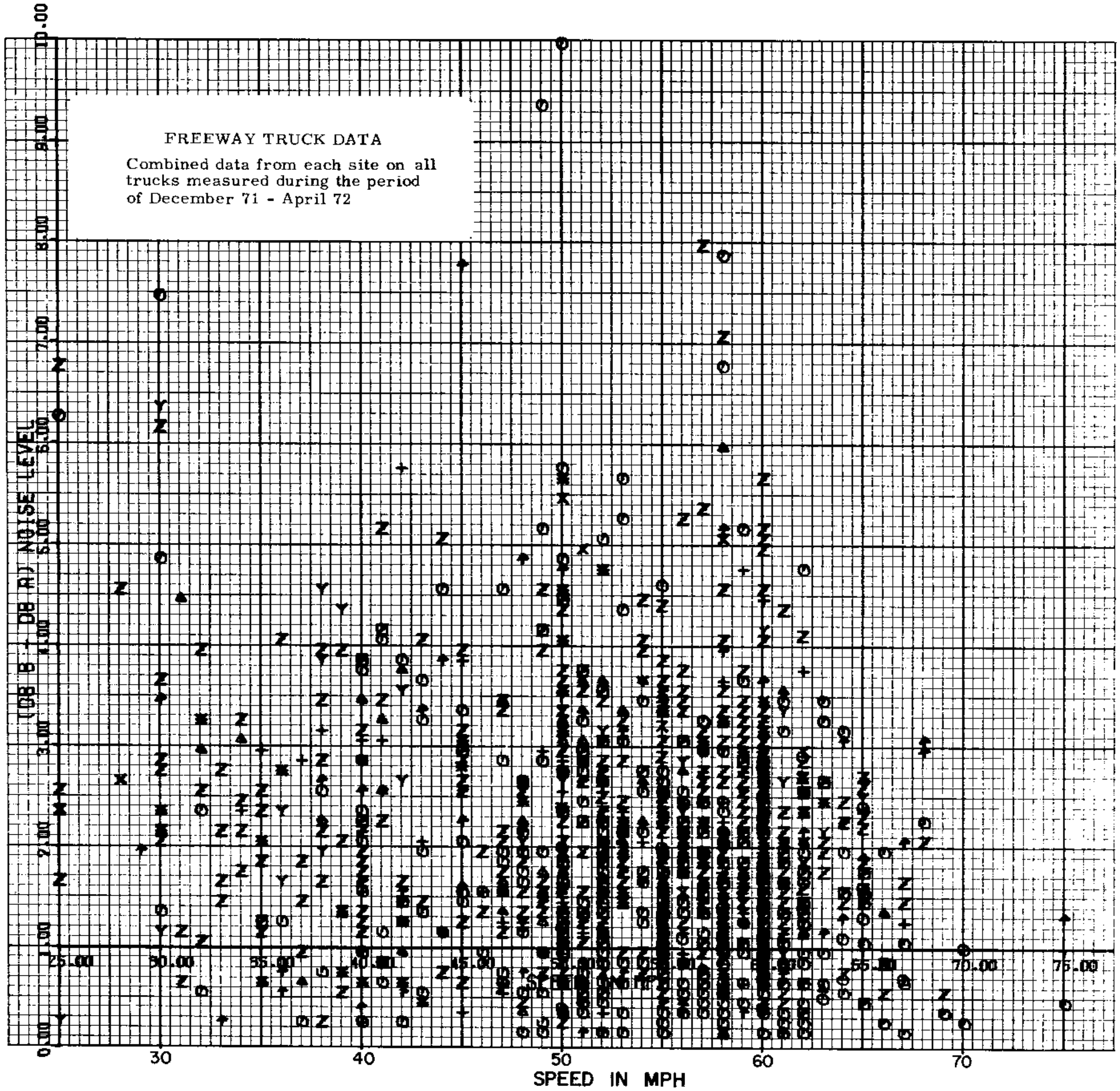

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period of December 71 - April 72
(DB B - DB A) NOISE LEVEL
SPEED IN MPH
30
40
50
60
70

FIGURE 29.

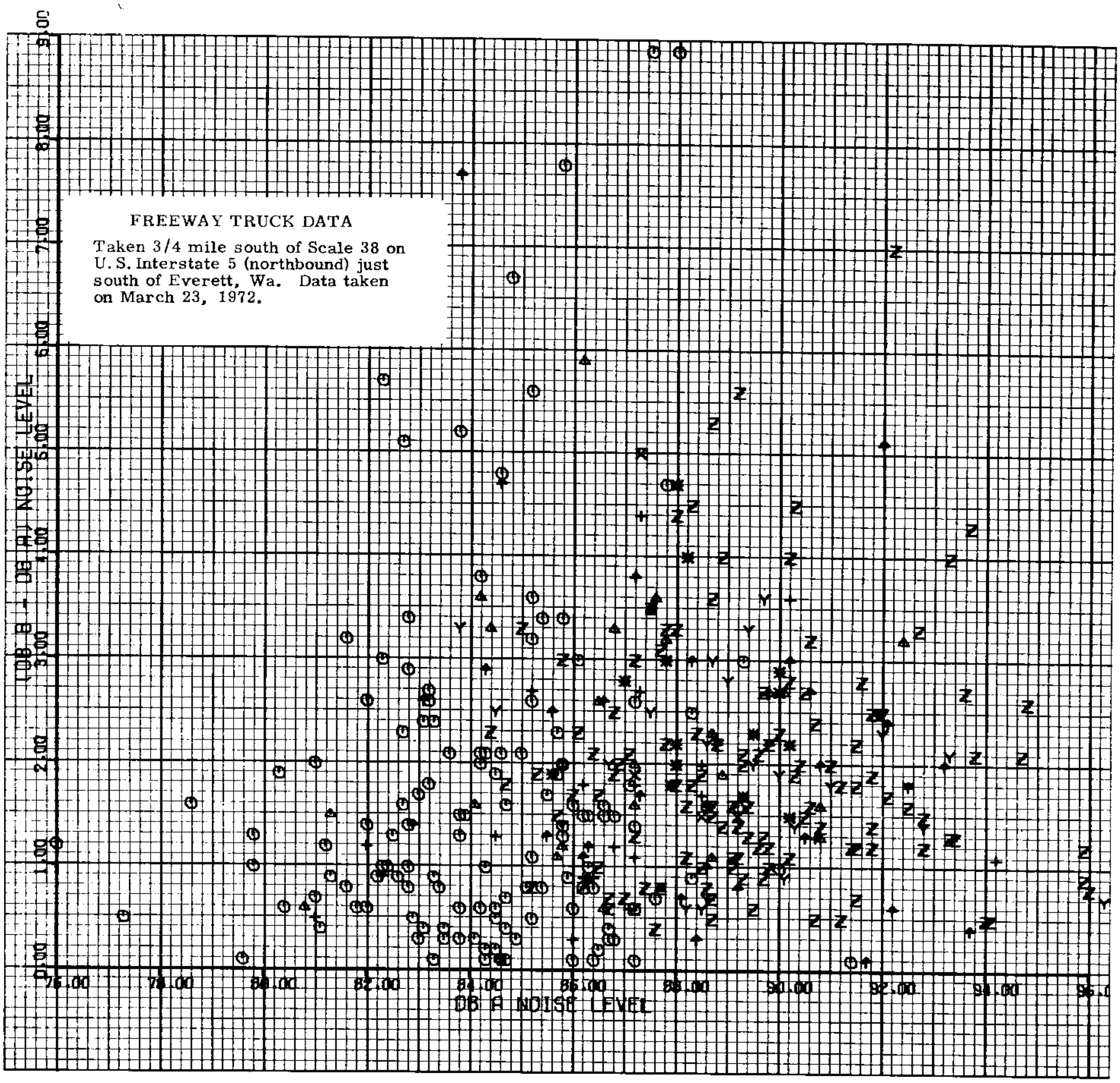

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken on March 23, 1972.
(DB B - DB A) NOISE LEVEL
DB A NOISE LEVEL
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00
94.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00

FIGURE 30.

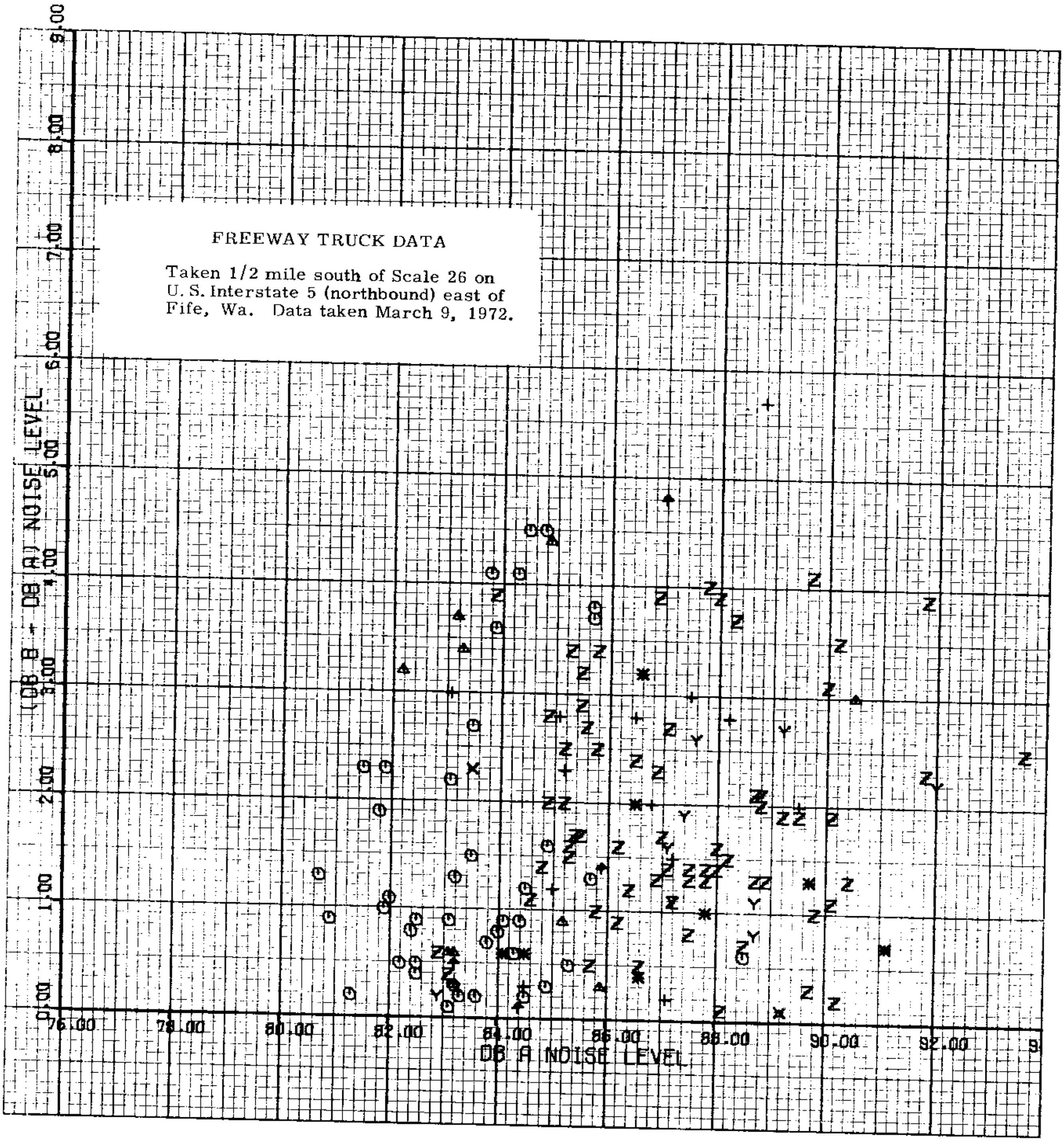

FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U.S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.
(DB B - DB A) NOISE LEVEL
DB A NOISE LEVEL
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00

FIGURE 31.

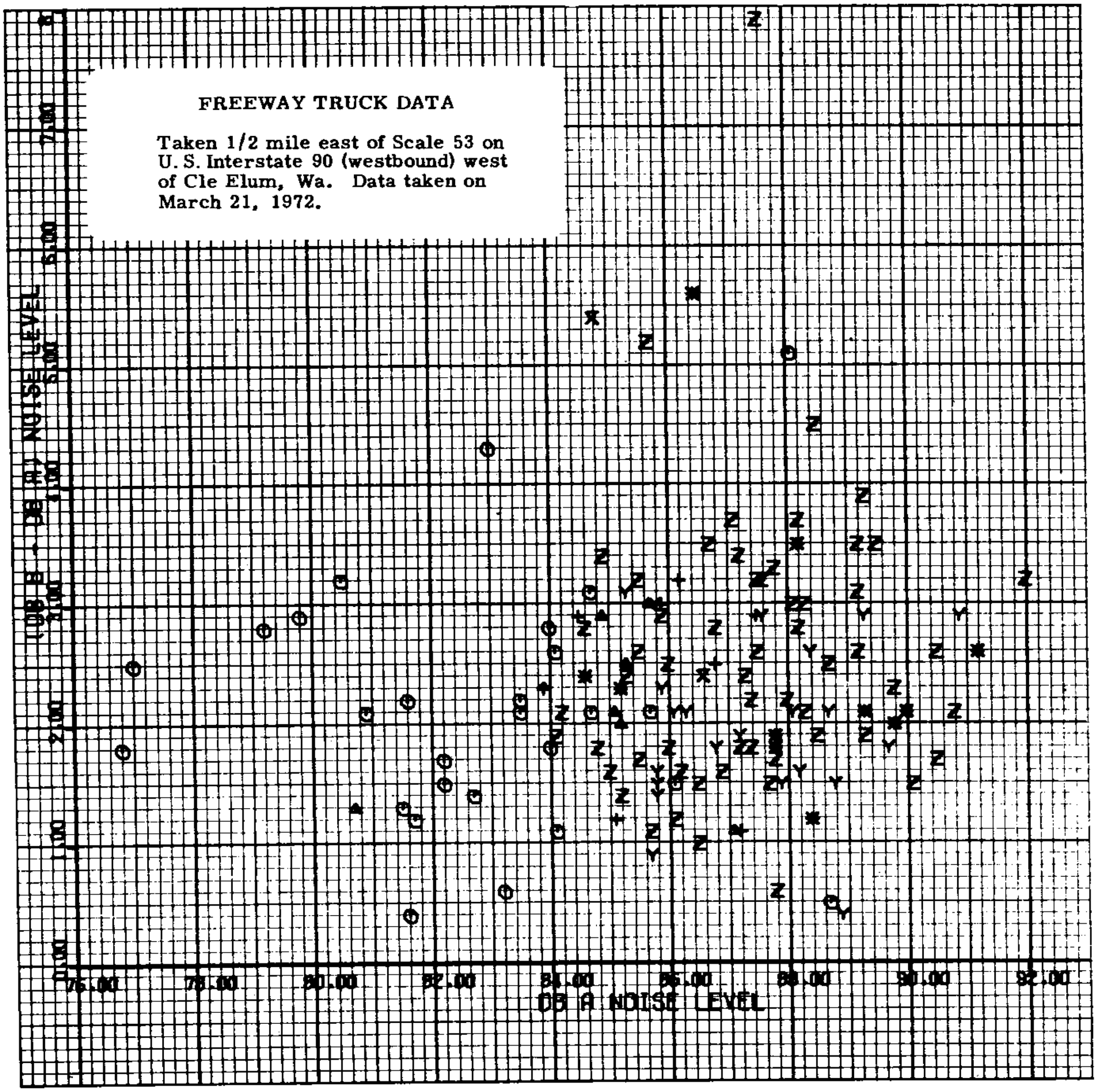

FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U. S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
(DB B - DB A) NOISE LEVEL
DB A NOISE LEVEL
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00

FIGURE 32.

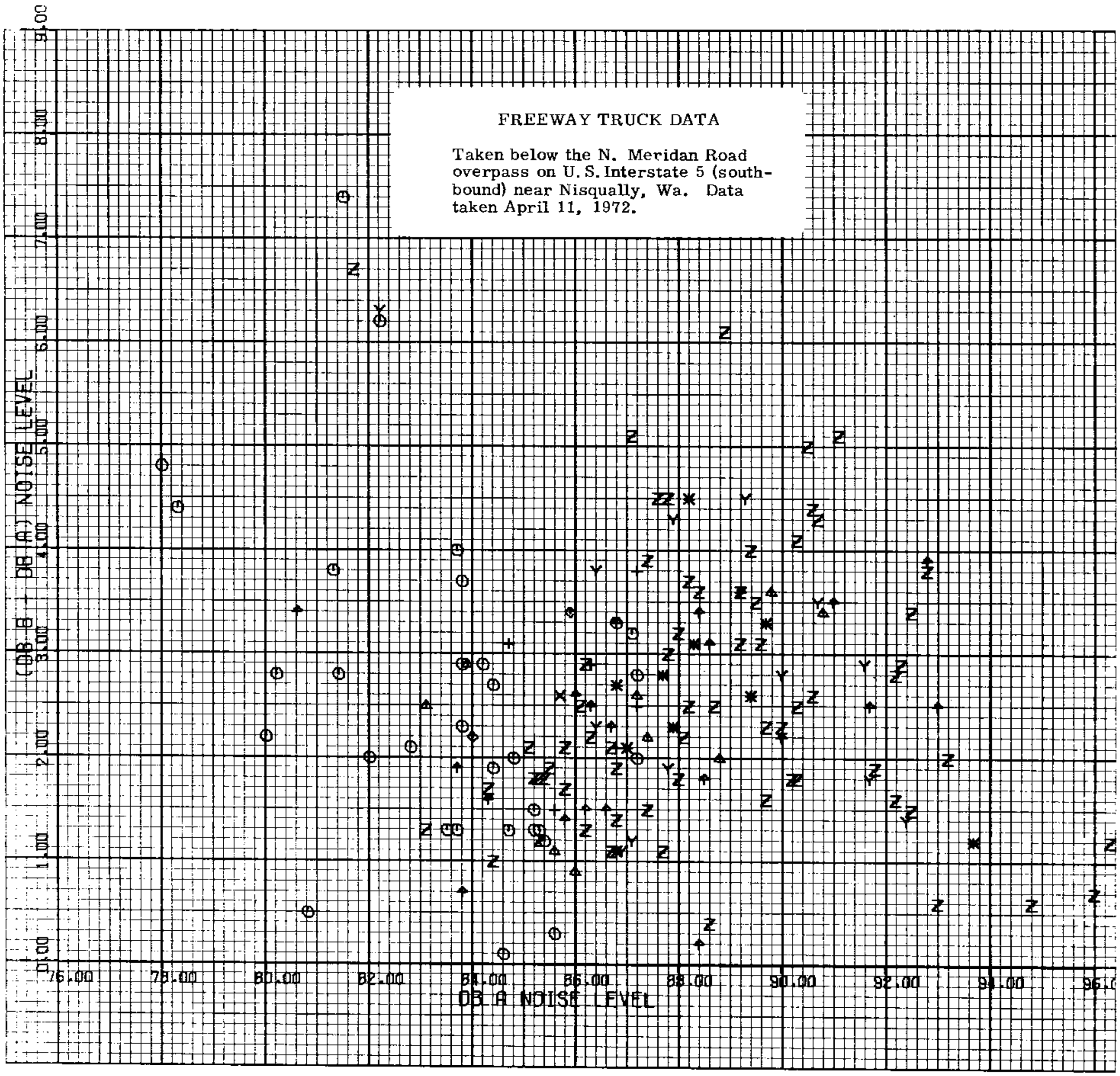
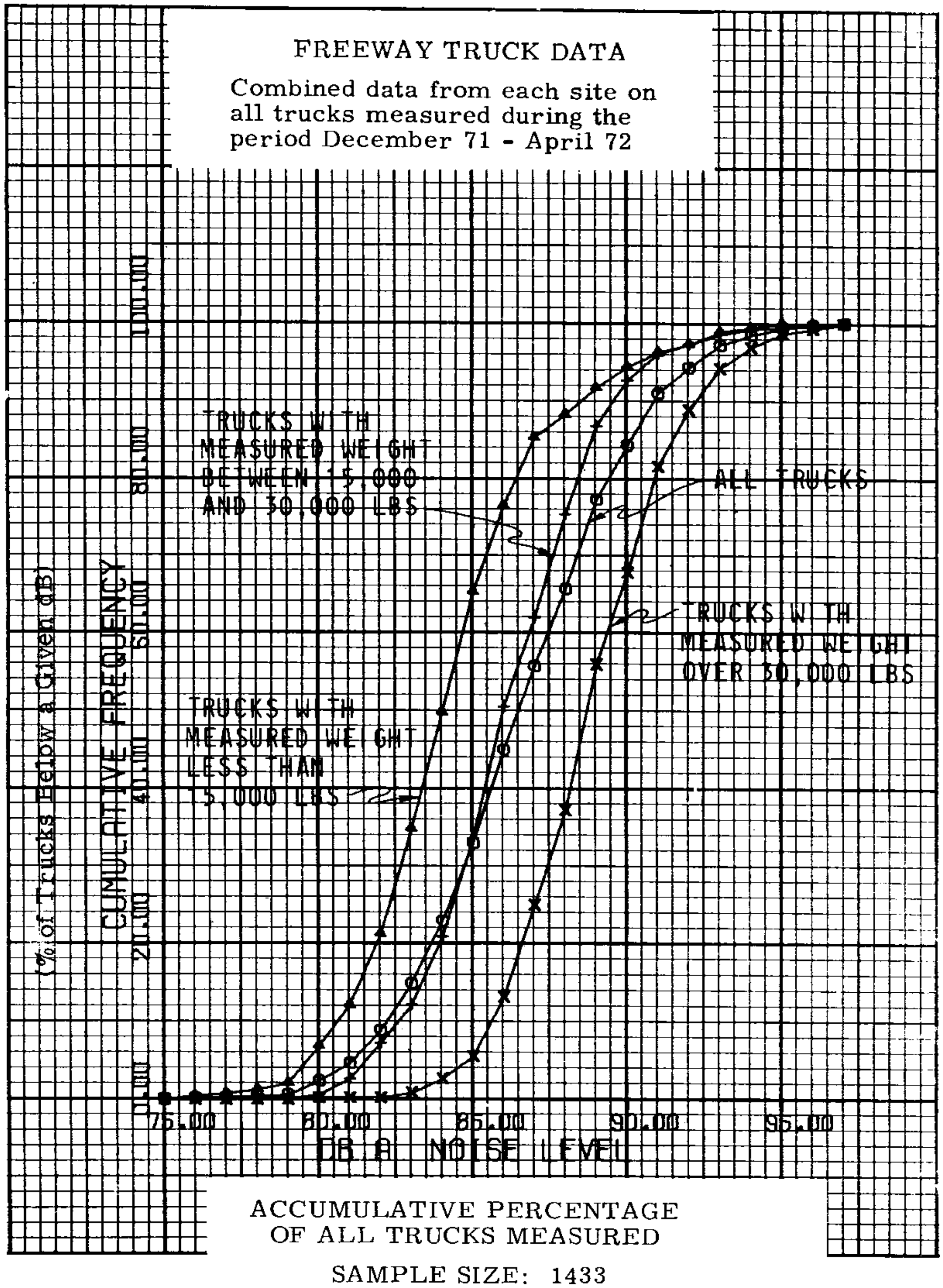

FREEWAY TRUCK DATA
Taken below the N. Meridan Road overpass on U.S. Interstate 5 (southbound) near Nisqually, Wa. Data taken April 11, 1972.
(DB B - DB A) NOISE LEVEL
DB A NOISE LEVEL
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00
94.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00

FIGURE 33.



SAMPLE SIZE: 1433

FIGURE 34.

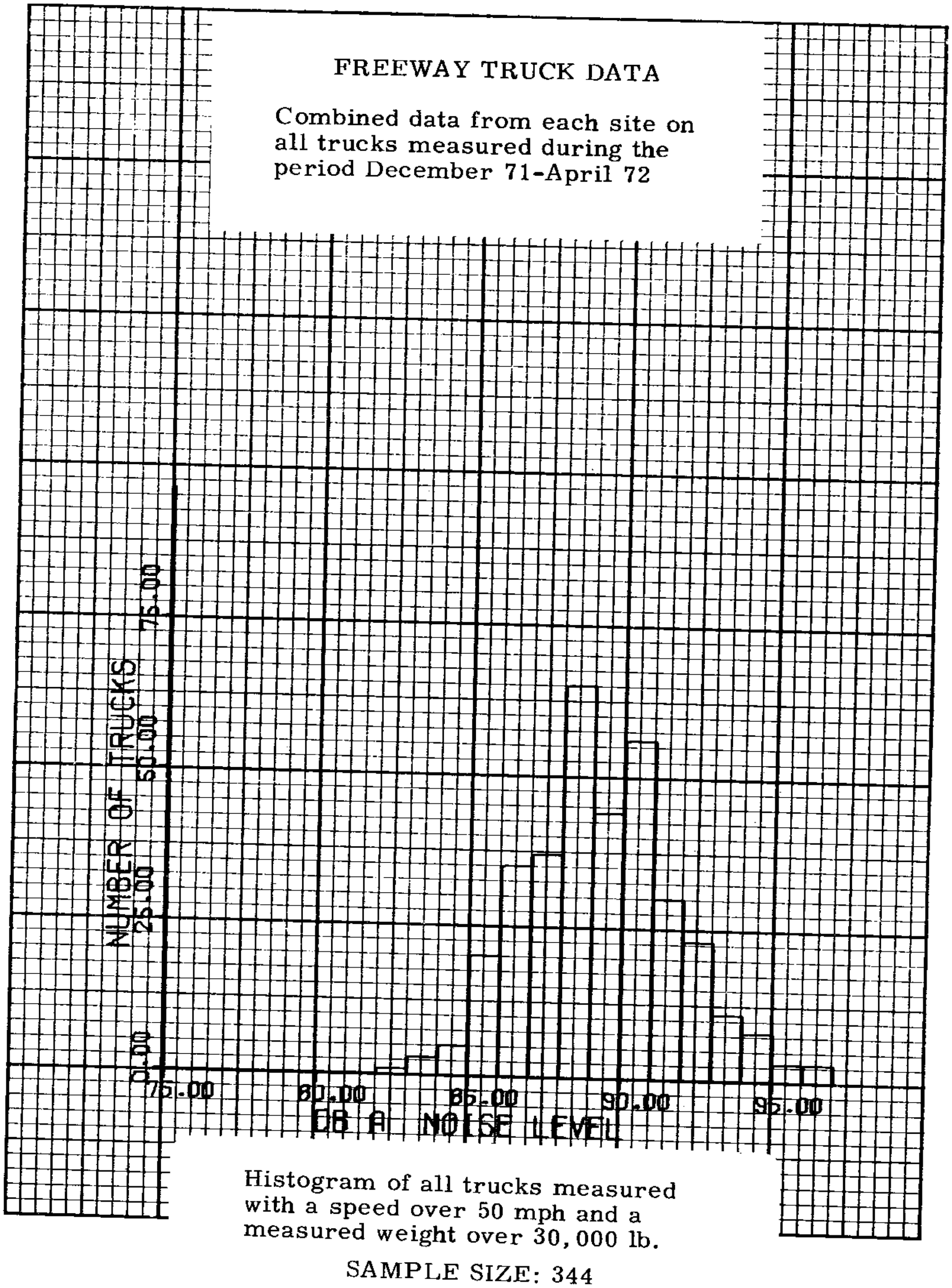

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71-April 72
NUMBER OF TRUCKS
0.00
25.00
50.00
75.00
75.00
80.00
85.00
90.00
95.00
DB A NOISE LEVEL
Histogram of all trucks measured with a speed over 50 mph and a measured weight over 30,000 lb.
SAMPLE SIZE: 344

FIGURE 35.

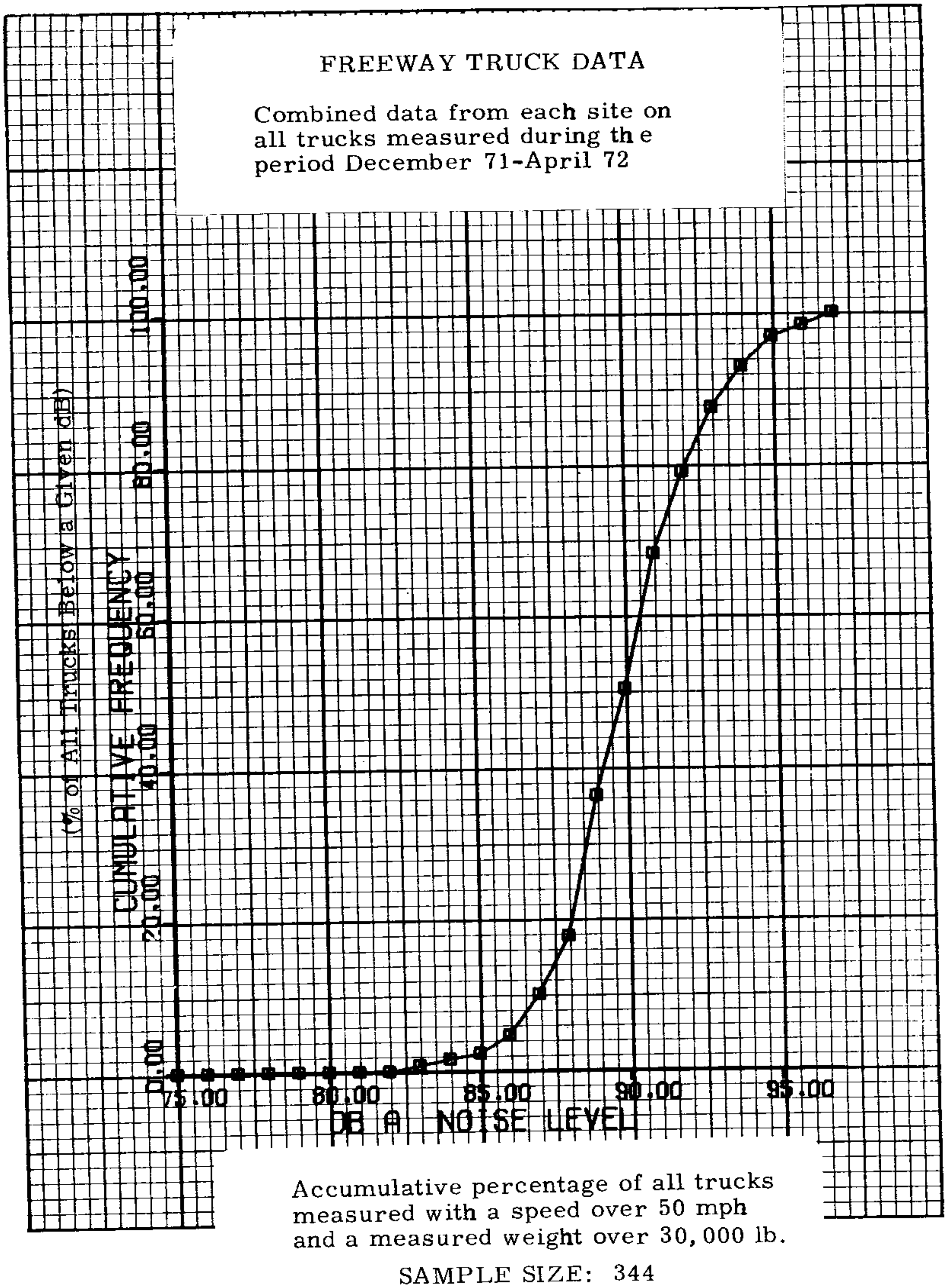

FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period December 71-April 72
CUMULATIVE FREQUENCY
(% of All Trucks Below a Given dB)
0.00
20.00
40.00
60.00
80.00
100.00
75.00
80.00
85.00
90.00
95.00
DB A NOISE LEVEL
Accumulative percentage of all trucks measured with a speed over 50 mph and a measured weight over 30,000 lb.
SAMPLE SIZE: 344

FIGURE 36.

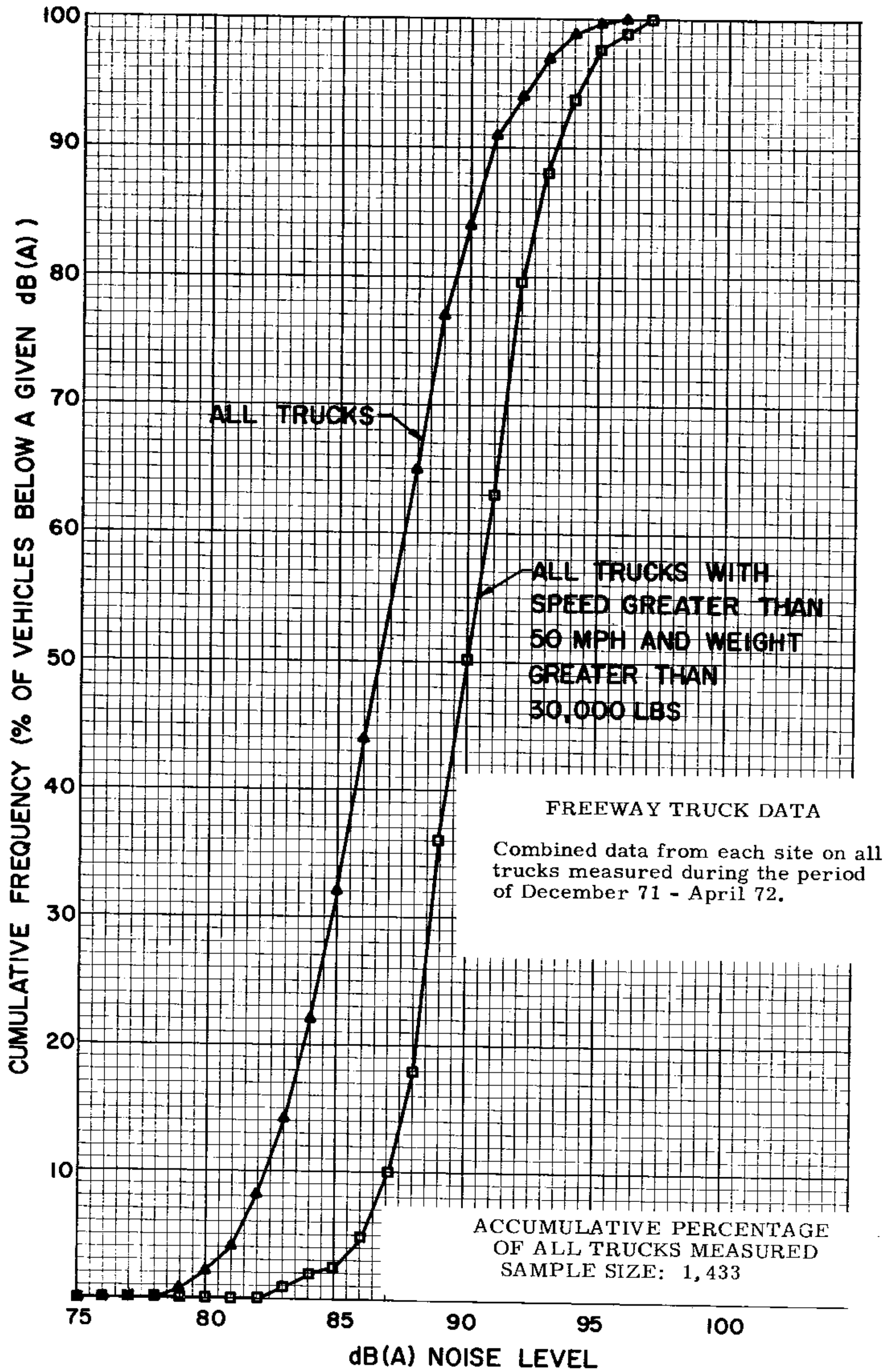

CUMULATIVE FREQUENCY (% OF VEHICLES BELOW A GIVEN dB(A))
100
90
80
70
60
50
40
30
20
10
75
80
85
90
95
100
dB(A) NOISE LEVEL
ALL TRUCKS
ALL TRUCKS WITH SPEED GREATER THAN 50 MPH AND WEIGHT GREATER THAN 30,000 LBS
FREEWAY TRUCK DATA
Combined data from each site on all trucks measured during the period of December 71 - April 72.
ACCUMULATIVE PERCENTAGE OF ALL TRUCKS MEASURED
SAMPLE SIZE: 1,433

FIGURE 37.

DISCUSSION

Table I is taken from Fig. 37 for six specific dBA noise levels. The first column in this table lists six possible maximum noise levels that could be enacted into law as the maximum dBA level at 50 ft for a truck traveling on a freeway. The second column shows the percentage of trucks now on the road which would be in compliance with such a law without needing improvements to their equipment. The third column lists the percentage of heavy, full-speed vehicles which would be in compliance with the limits given in the first column.

TABLE I.

Max. dBA of hypothetical noise control law	Percentage of vehicles now quieter than limits	Percentage of heavy, full-speed trucks now quieter than limits*
94	99	93
92	94	80
90	84	50
88	65	18
86	44	5
84	22	2

*Measured gross weight over 30,000 lb and speed greater than 50 mph

As shown in Table I, if the law allows 94 dBA, 99% of the trucks now on the highway would comply and only 1% would be in violation with excessive noise. At this maximum 94 dBA level, 93% of the heavy, full-speed trucks would be legal. Ninety-four dBA is very noisy, and, as the curve shows, enacting legislation with this limit would be virtually tantamount to no legislation at all since the overwhelming majority of trucks are already below it. If the level were set at 92 dBA, 94% of the trucks would pass and 80% of the heavy, full-speed trucks would pass. If the level were set at 90 dBA, which is the current California limit, 84% of all trucks would pass such a requirement and 50% of the big trucks going full speed would pass. If the level were set at 88 dBA, which is the next step down in the California law, 65% of all existing trucks would pass and 18% of the big, heavy, full-speed trucks would pass. If the level were set at 86 dBA, 44% of all trucks would pass and 5% of the big trucks going full speed would pass. Finally, if the level were set at 84 dBA, which is probably the lowest feasible level (considering current technology), about 22% of all existing trucks would pass this requirement and about 2% of the big, heavy, full-speed ones would pass.

A number of comments are in order concerning this Table.

1. Even at the comparatively low level of 84 dBA, there are on the roads today a small number of trucks weighing over 30,000 lb and traveling in excess of 50 mph which meet this limit. This clearly shows that this level is not only technologically feasible but that it can be achieved with commercial equipment now, here, today.

2. These data were taken on audio/video tape so that data on the very quiet or very noisy vehicles could be rechecked to make absolutely certain that there were no reading or transcribing errors involved for these extrema. We have rechecked our data, and it is correct and valid.

3. The scope of our contract is not large enough to allow us to investigate exactly what features of these trucks make them quiet. However, it seems certain that a fortuitous combination of tires, transmission, engine, mufflers, and maintenance practices enabled these trucks to show such good performance.

4. Although the data clearly show that a level of 84 dBA is actually achieved by some trucks at present, it also shows that there are few big trucks which do so--and it would probably be a considerable strain on the trucking industry to require all trucks to meet such a low level now, particularly since they would not know precisely what to do to their trucks to bring them to this level. Obviously, more research has to be done to find out what changes can be made in truck design--hopefully, in the area of alterations to existing trucks as well as in the manufacture of new trucks--to bring them down to this level. I think that the 84 dBA level will ultimately be written into the statutes; perhaps, in time, even lower levels will be reasonable.

5. At the other end of the scale, it would not seem worthwhile to pass a law which would be any less effective than the California law, which has been 90 dBA for trucks traveling over 35 mph. This level will be reduced to 88 dBA in California in the near future (see Appendix F).

We have already seen that there is some noise correlation with speed; that is, the faster the vehicles go, the noisier they become. (As a matter of fact, for automobiles, at least, the noise power is probably proportional to the cube of speed.) We have also seen that the heavier the vehicles are, the more likely they are to be noisier. An appropriate question arises--is this increase in noise with weight always associated with the total weight of the truck or does the percentage of full load enter into the picture? For example, in a fully loaded, 30,000 lb truck, is it the load that causes it to be noisy or would a large truck running empty at that same weight be equally noisy? Figure 38 sheds some light on these questions. It uses data from the Everett site and is a plot of the dBA level versus the percentage of full load. Since most trucks have a decal or lettering indicating the licensed gross weight and we were able to determine their actual weight at the weighing station, we could compute the percentage of full load. Figure 38 plots this percentage level against the noise level. Note that this plot includes data which exceed 100%; there were vehicles that were overloaded by as much as 20%. Probably the most significant feature of the chart is that there does not seem to be any real correlation between the noise of the truck and the percentage of full load. Together with the other information in the report, this clearly shows that actual total weight is important, whereas the percentage of full load is not.

As shown in Fig. 38, some vehicles were overloaded, and in the Appendices (which give more complete data on the individual sites) it is obvious that some trucks were exceeding the 60 mph speed limit. The question then arises--just how much do these trucks, which are violating one or both of these regulations, add to the overall noise curves for trucks in general?

Figure 39 addresses itself to this question. It uses Everett data taken in the wintertime. There are two plots on this figure: one is a cumulative frequency plot for all of the trucks taken at Everett during the wintertime, and the other shows the same data after those trucks exceeding 62 mph and 101% of licensed gross weight have been eliminated. Note that the cumulative noise curve is slightly reduced. The effect, however, for this particular case is not large. At the 50% cumulative frequencies there is only about 0.5 dB difference between the two curves. Therefore, 100% strict enforcement of the speed and weight regulations cannot be regarded as a method for significantly quieting vehicle noise on the highways.

One question that might be asked is what would be the effect of removing from the road all those vehicles which have a high dBB minus dBA reading, which we interpret to mean, in most cases, that they are poorly muffled vehicles? Figure 40 answers this, again using wintertime Everett data. There are four plots on this curve: one is the regular cumulative frequency curve for this site; the second plot is the same curve but with all trucks whose dBB minus dBA is in excess of 3 dB deleted; the third curve is the same but it deletes even more trucks--those in excess of 2 dB; and, finally, a curve which eliminates those with a difference in excess of 1 dB. These deletions produce a quieter cumulative frequency curve, but not by a large amount. At the 50% point, eliminating all those above the 3 dB difference reduces the curve about 0.5 dB; eliminating all those above 2 dB reduces the curve by a little over 1 dB; and eliminating all those above 1 dB reduces it by a little over 2 dB. These curves clearly show that truck noise problems are not going to be solved by better mufflers, and that there are other important sources of noise which occur at the frequencies to which the A-scale and human ears are sensitive. Adequate muffling of trucks is certainly the

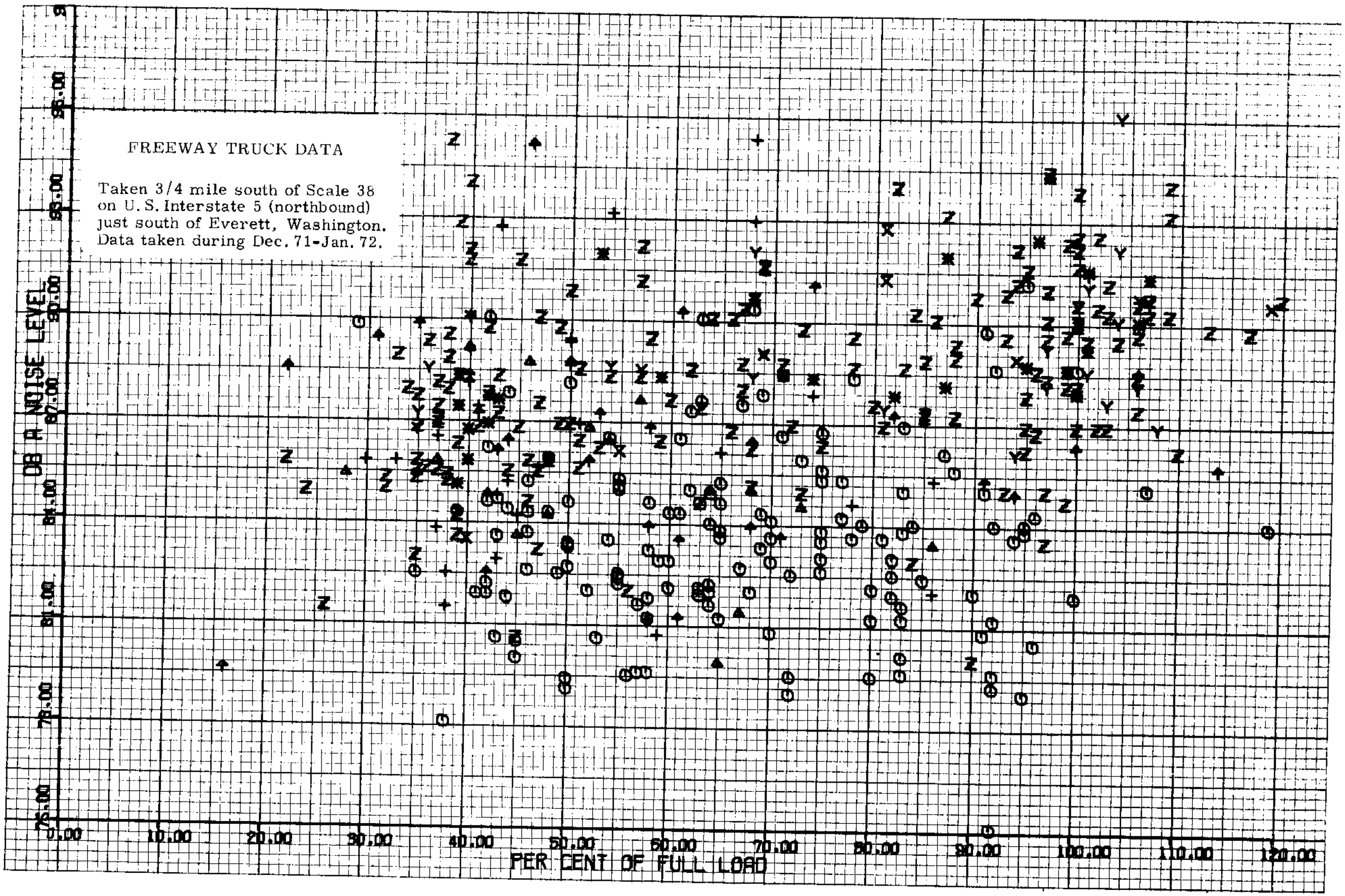

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
DB A NOISE LEVEL
75.00
78.00
81.00
84.00
87.00
90.00
93.00
96.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
PER CENT OF FULL LOAD

FIGURE 38.

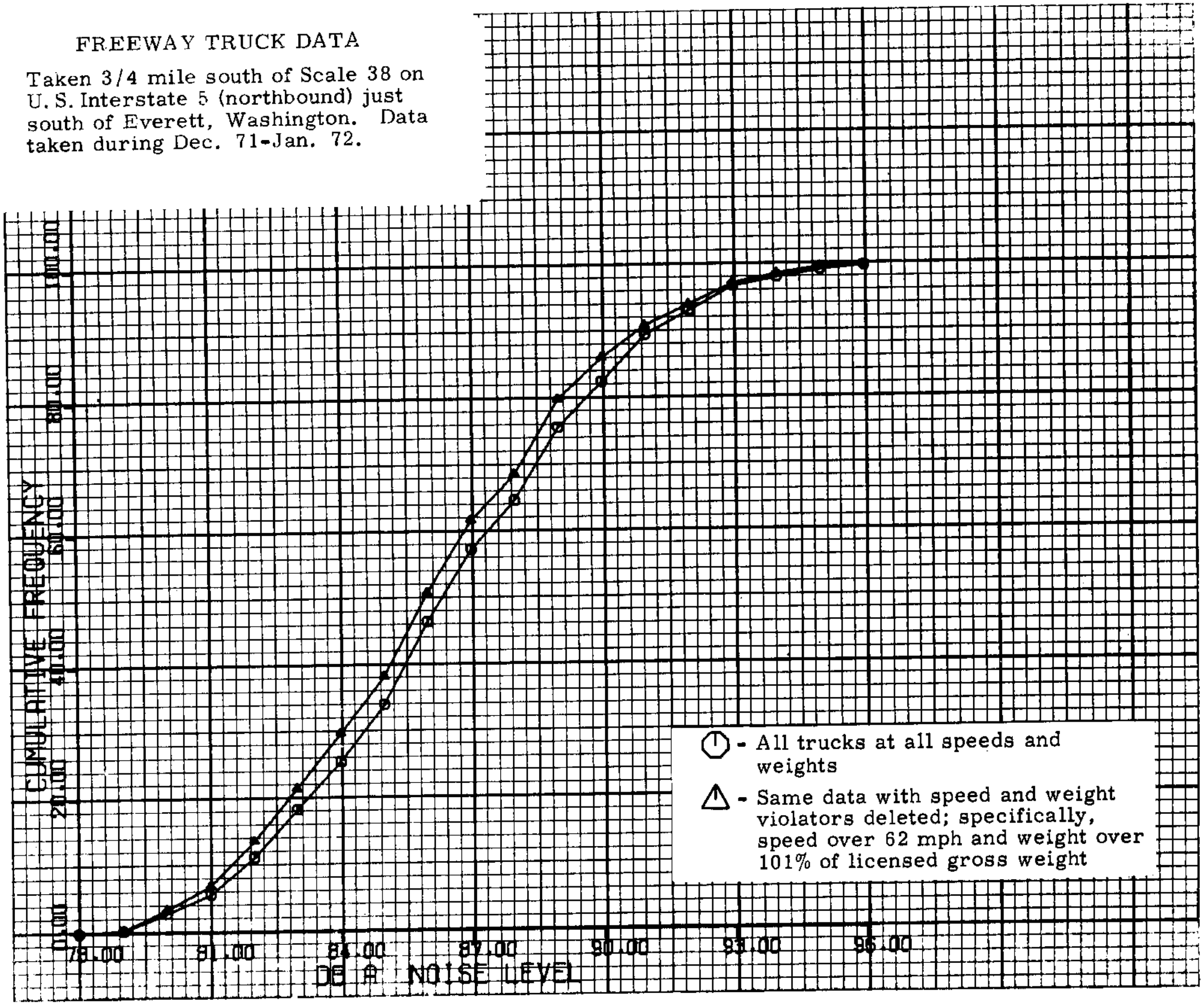

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U. S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
CUMULATIVE FREQUENCY
0.00
20.00
40.00
60.00
80.00
100.00
78.00
81.00
84.00
87.00
90.00
93.00
96.00
DB A NOISE LEVEL
- All trucks at all speeds and weights
- Same data with speed and weight violators deleted; specifically, speed over 62 mph and weight over 101% of licensed gross weight

FIGURE 39.

FREEWAY TRUCK DATA

Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.

Effect on cumulative curve of all low frequency noise of vehicles

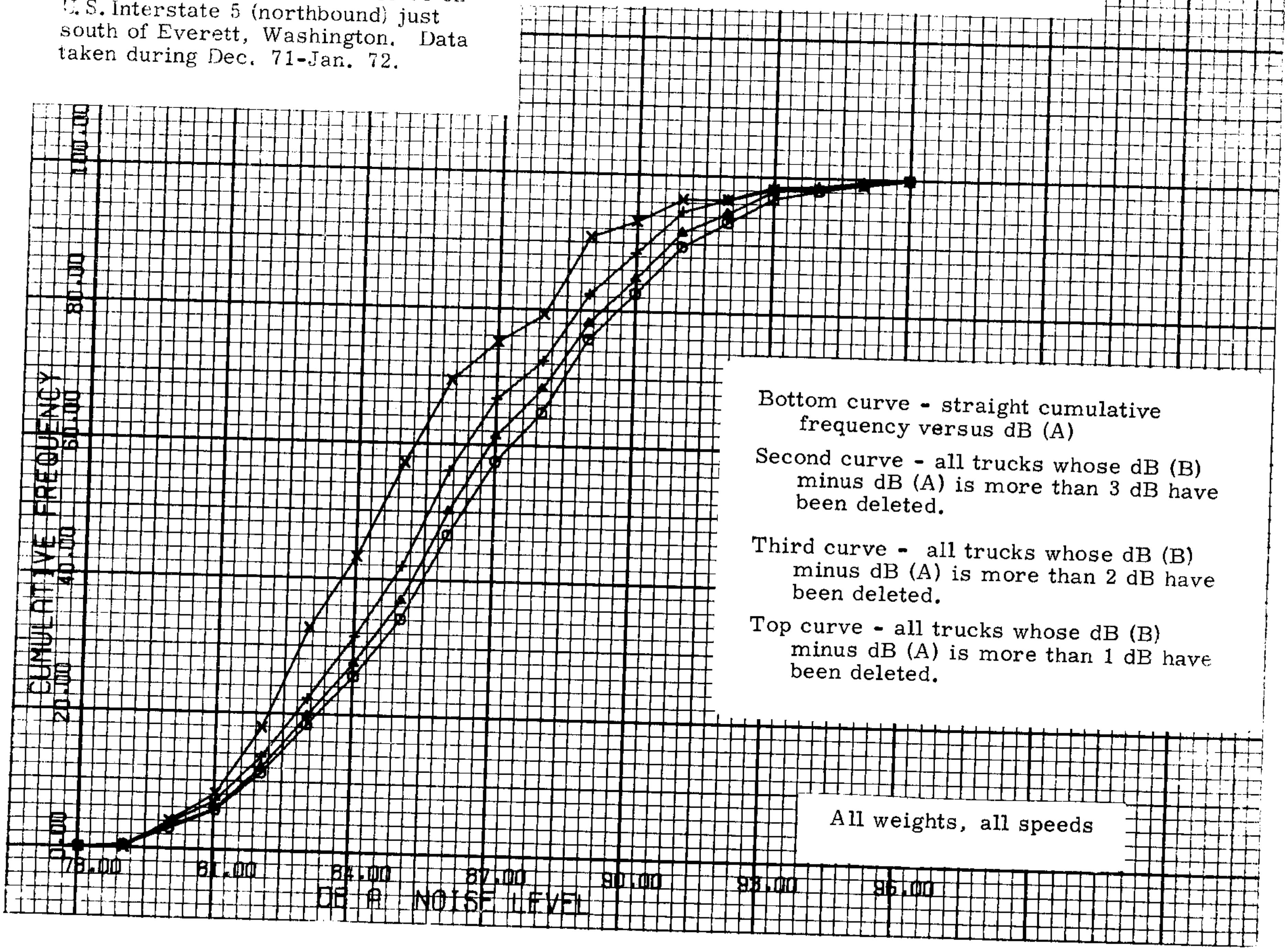


FIGURE 40.

first step to be taken in quieting our highways, but it should not be viewed as a panacea for truck and highway noise problems.

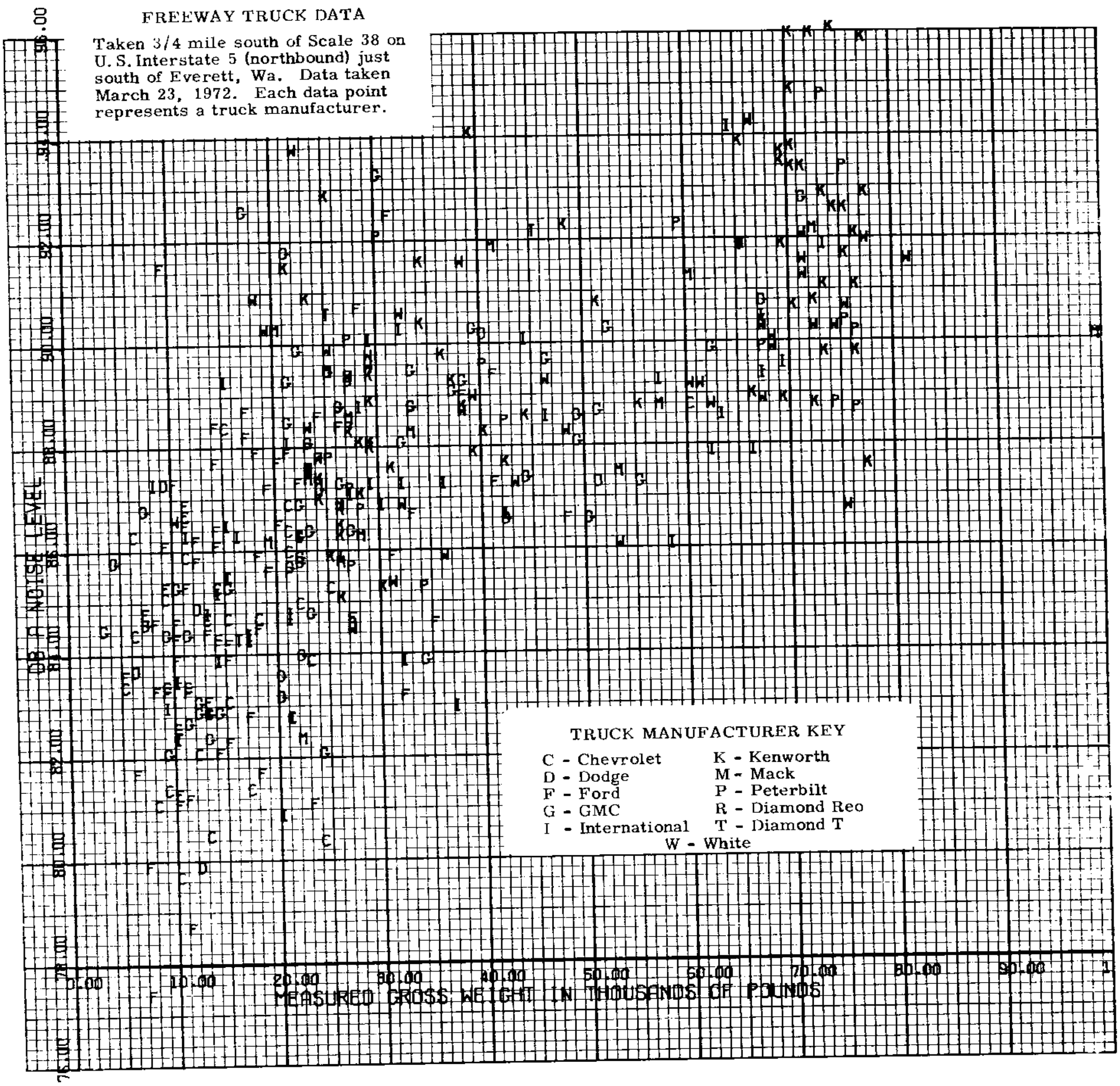
During some of the later data-taking stages, attempts were made to ascertain some of the makes of the trucks involved in the survey. Although we were not able to obtain the make in all cases, in many cases we were able to, and Figs. 41 through 43 present this information. Figure 41 is a plot of the dBA noise level versus gross weight of the trucks taken March 23 at the Everett site; each data point, instead of using the class symbol, uses a symbol to identify the manufacturer in accordance with the following scheme: K = Kenworth, W = White, etc., as shown in the key on each of these three figures. Figure 42 is a similar type of plot taken from Cle Elum measurements. Figure 43 is a similar plot taken from the Fife data. There is no simple, clear conclusion to be drawn from these data. The heavier trucks in this state are frequently built by Kenworth as indicated by the many K's appearing in the heavier weight category. These trucks vary from rather quiet to noisy. There are a number of White trucks which are fairly quiet, but there are also some noisy W's. I am sure these data would be of great interest to the individual truck manufacturers. It is possible to make cumulative plots from the original data cards for each of the different manufacturers and other types of analyses from the fundamental information available. However, funds are not sufficient on this particular contract to pursue this further. It is left to the reader to review these charts and form his own opinion.

Figure 44 is a histogram of the trucks measured at 6th Ave. and Hanford St. in the industrial section of Seattle. Figure 45 is a plot of the noise level of these trucks taken on this main arterial which has a 35 mph speed limit. The lower speed trucks were almost all below 90 dBA; 88% of them were quieter than 85 dBA; 57% were quieter than 80 dBA; and 27% were quieter than 75 dBA. The 50% cumulative frequency point was about 79 dBA.

Figure 46 is the histogram of automobiles measured at the Everett and Cle Elum sites. As previously mentioned, the other sites generally had too much traffic to make valid automobile measurements--the car to be measured had to be in the curb lane with no other vehicle in the other lanes at the same time. Figure 46 indicates that the most likely noise level is between 79 and 80 dBA (in this category there were 150 cars out of the sample size of 878). Figure 47 gives a cumulative frequency plot of the data shown in Fig. 46. This shows that 92% of the cars were quieter than 82 dBA; the 50% point occurred at 79.5 dBA (half of the cars were noisier than 79.5 and half were quieter); and only 10% of the cars were quieter than 76.5 dBA.

Figure 48 is a similar cumulative frequency plot but it includes only the Everett data rather than a combination of the Everett and Cle Elum measurements. These data show the 50% point about 1 dBA quieter than the combined data. The probable explanation of this is that virtually all the cars, including the high-speed ones, were in the curb lane at Cle Elum, but at Everett it was usually only the slower cars which used the curb lane. There also could be differences in the "noisiness" of the road surface at the two locations; this could be especially important for automobile data, since at these speeds tire noise predominates in most car noise levels.

Figure 49 is a plot of the Cle Elum car data where the noise level is plotted as a function of the vehicle's speed. This gives a more clear-cut correlation of the noise versus speed than was true in the case of trucks. There has been some controversy within the highway acoustic "trade" concerning the mathematical relationship between car noise and speed. These data indicate that noise power increasing with the cube of traffic speed is a better fit than increasing with the square of speed, as some advocates have proposed. This result seems reasonable since the power consumed by viscous drag in most viscous hydrodynamic systems increases with the cube of velocity.



FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U. S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972. Each data point represents a truck manufacturer.
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
TRUCK MANUFACTURER KEY
C - Chevrolet
D - Dodge
F - Ford
G - GMC
I - International
K - Kenworth
M - Mack
P - Peterbilt
R - Diamond Reo
T - Diamond T
W - White

FIGURE 41.

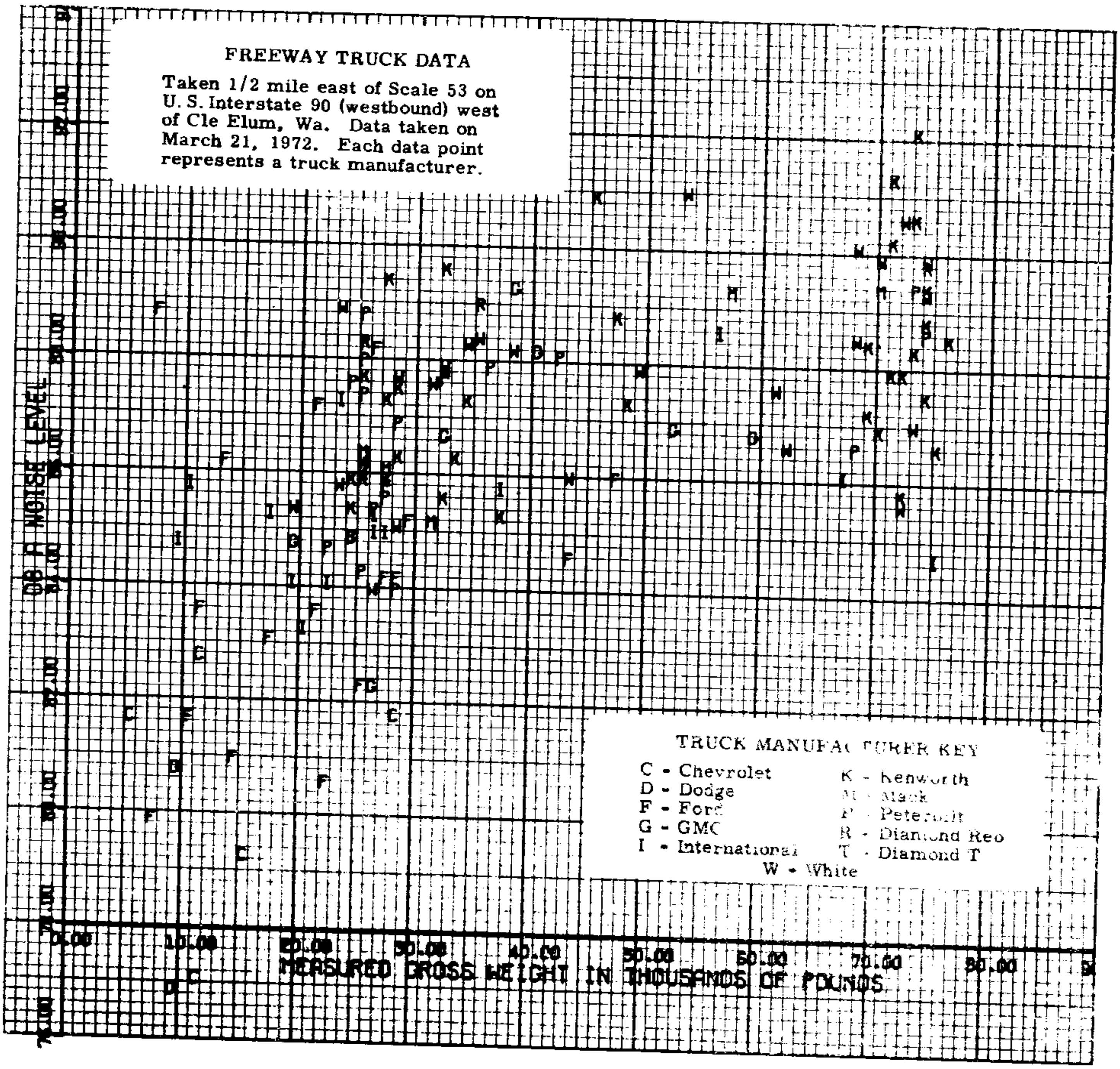
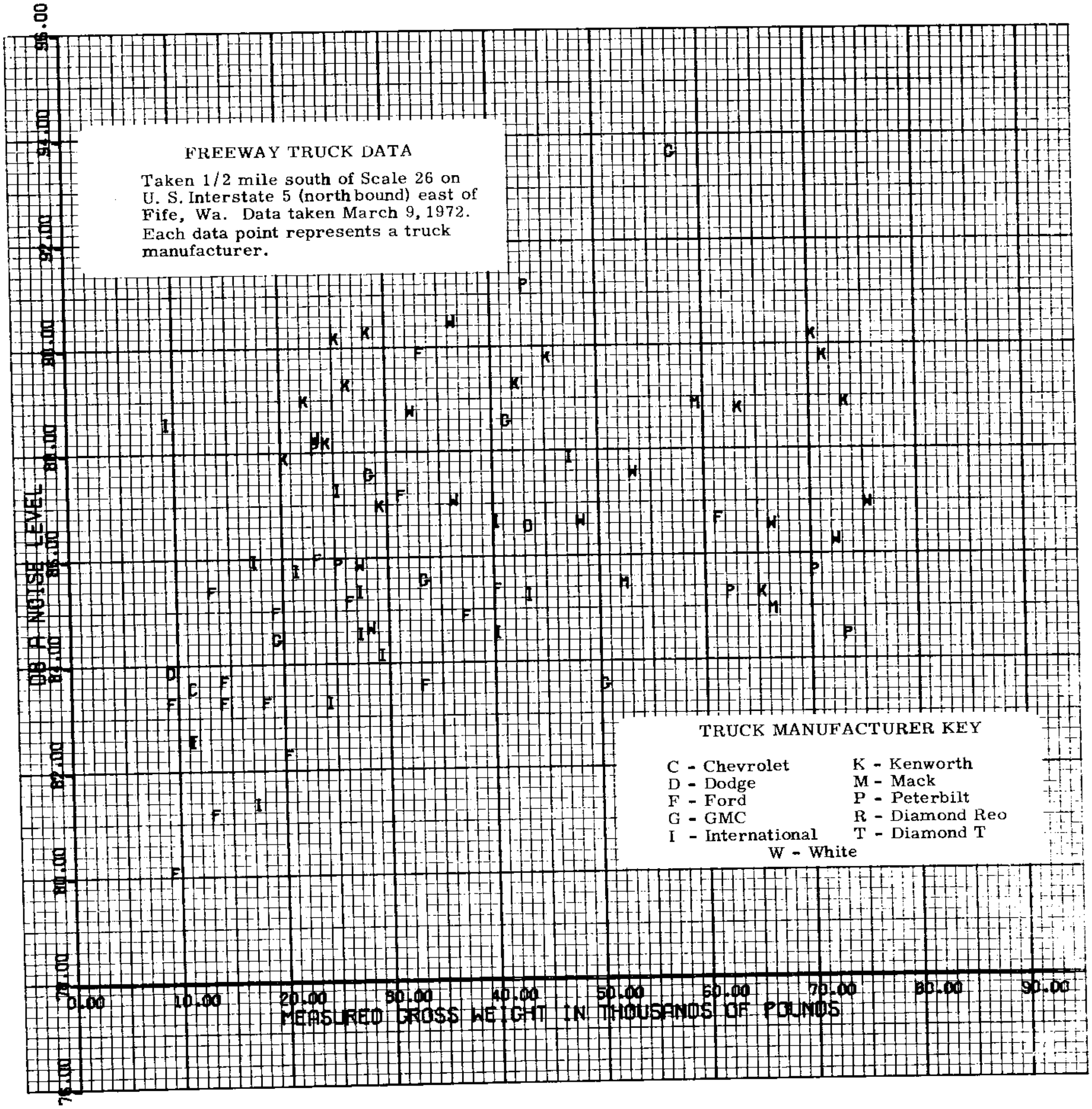
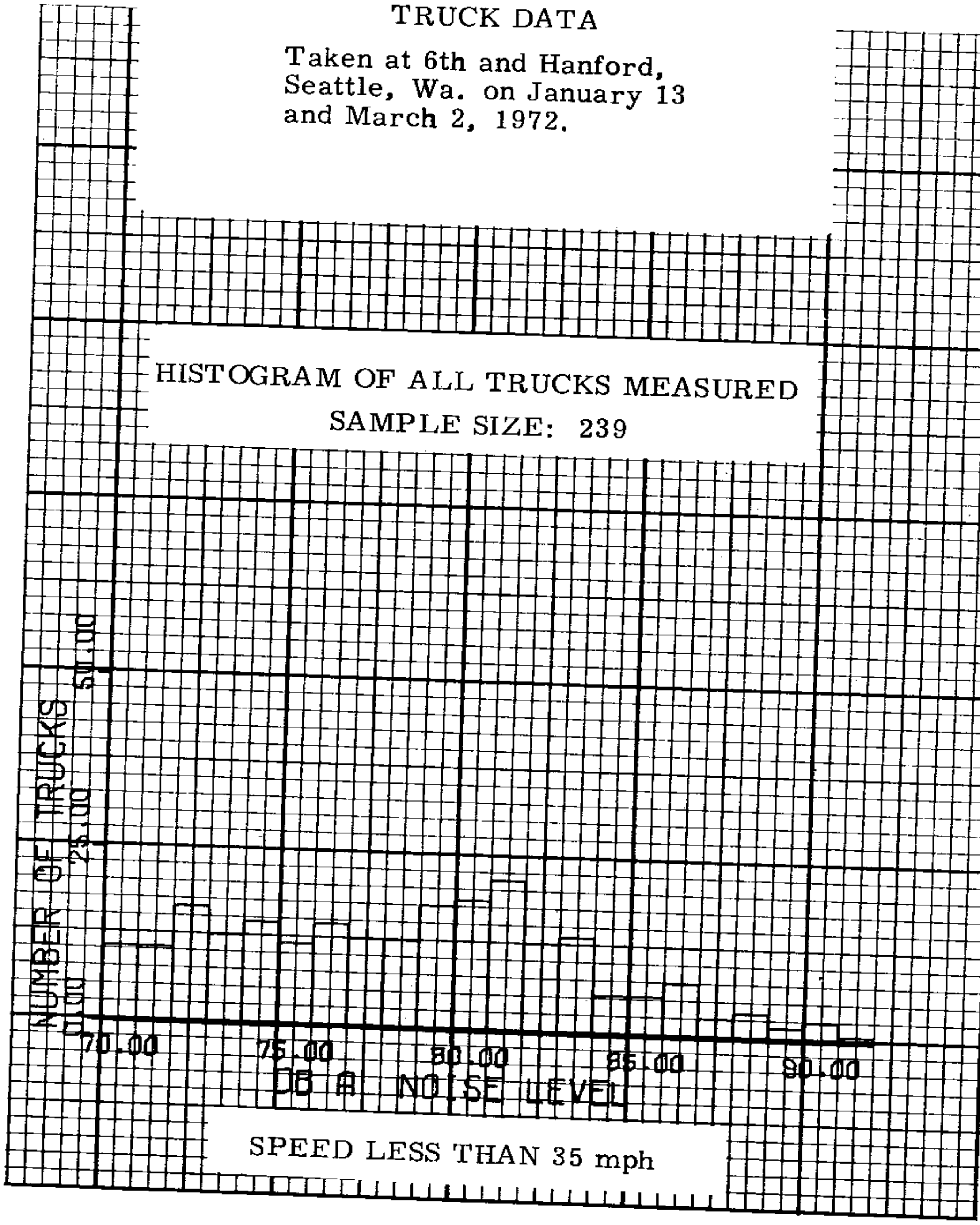

FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U.S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972. Each data point represents a truck manufacturer.
TRUCK MANUFACTURER KEY
C - Chevrolet
D - Dodge
F - Ford
G - GMC
I - International
K - Kenworth
M - Mack
P - Peterbilt
R - Diamond Reo
T - Diamond T
W - White
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00

FIGURE 42.



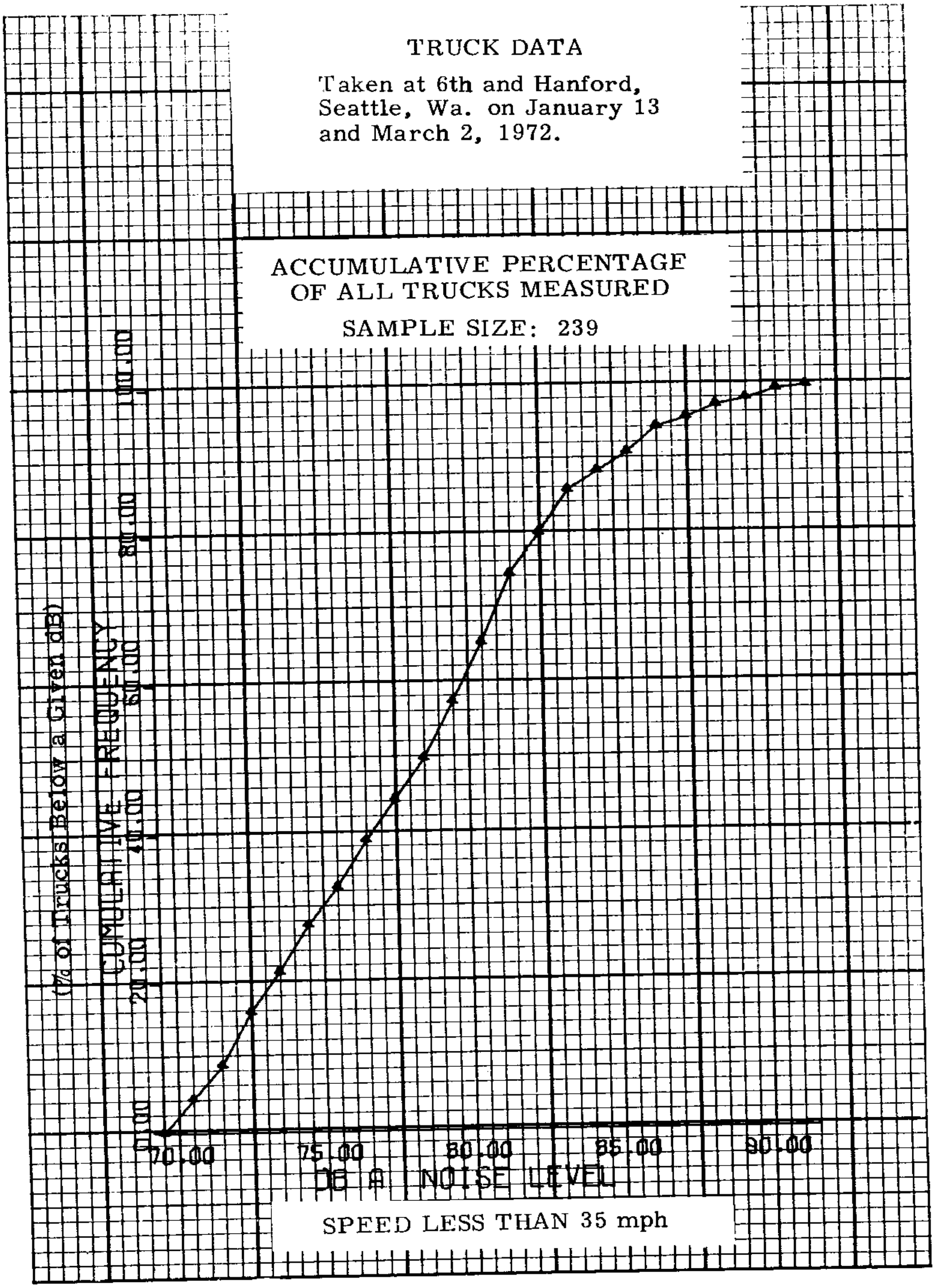
FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U. S. Interstate 5 (north bound) east of Fife, Wa. Data taken March 9, 1972. Each data point represents a truck manufacturer.
TRUCK MANUFACTURER KEY
C - Chevrolet
D - Dodge
F - Ford
G - GMC
I - International
K - Kenworth
M - Mack
P - Peterbilt
R - Diamond Reo
T - Diamond T
W - White
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS

FIGURE 43.



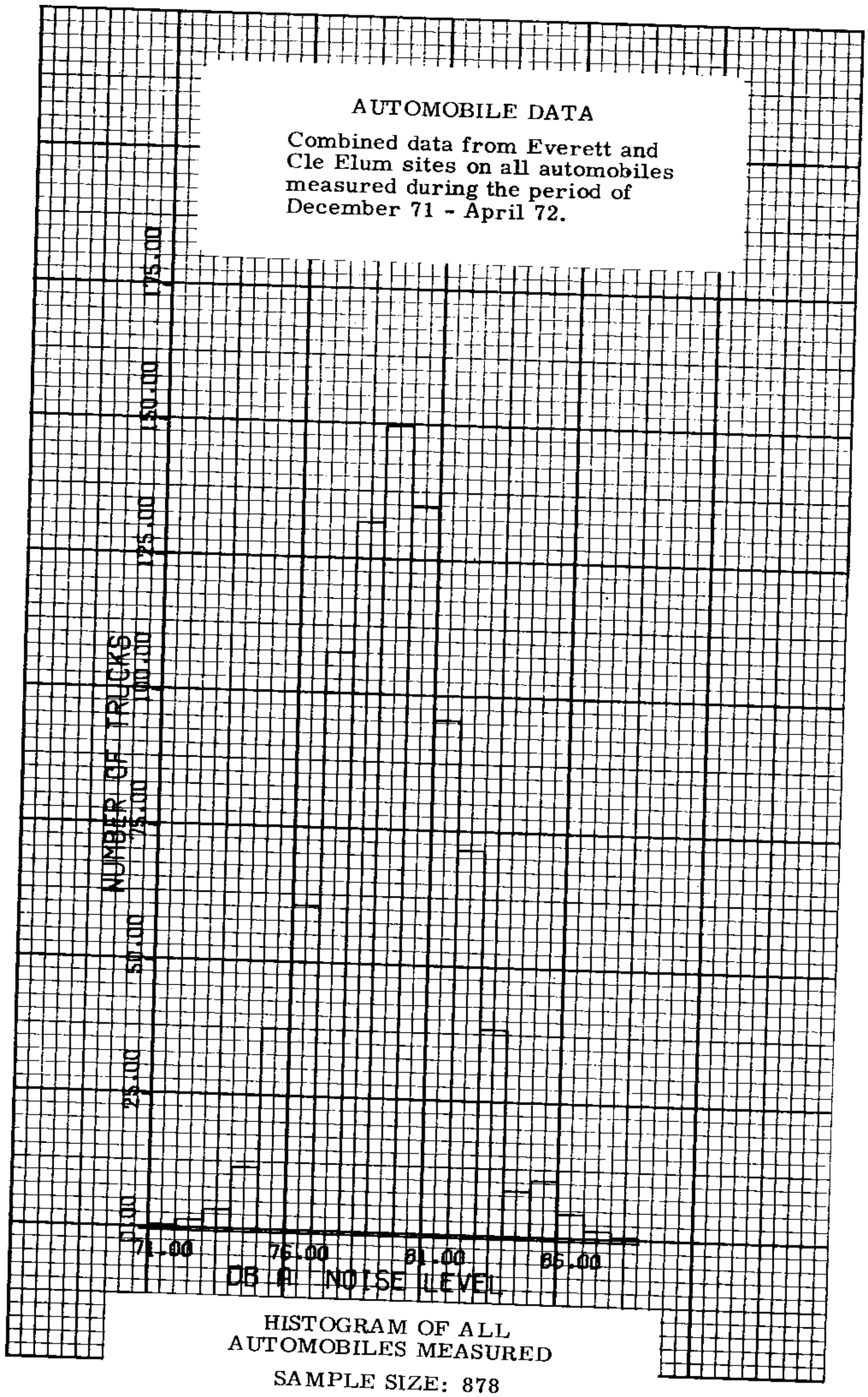
TRUCK DATA
Taken at 6th and Hanford, Seattle, Wa. on January 13 and March 2, 1972.
HISTOGRAM OF ALL TRUCKS MEASURED
SAMPLE SIZE: 239
NUMBER OF TRUCKS
0.00
25.00
50.00
70.00
75.00
80.00
85.00
90.00
DB A NOISE LEVEL
SPEED LESS THAN 35 mph

FIGURE 44.



TRUCK DATA
Taken at 6th and Hanford, Seattle, Wa. on January 13 and March 2, 1972.
ACCUMULATIVE PERCENTAGE OF ALL TRUCKS MEASURED
SAMPLE SIZE: 239
(% of Trucks Below a Given dB)
CUMULATIVE FREQUENCY
0.00
20.00
40.00
60.00
80.00
100.00
70.00
75.00
80.00
85.00
90.00
DB A NOISE LEVEL
SPEED LESS THAN 35 mph

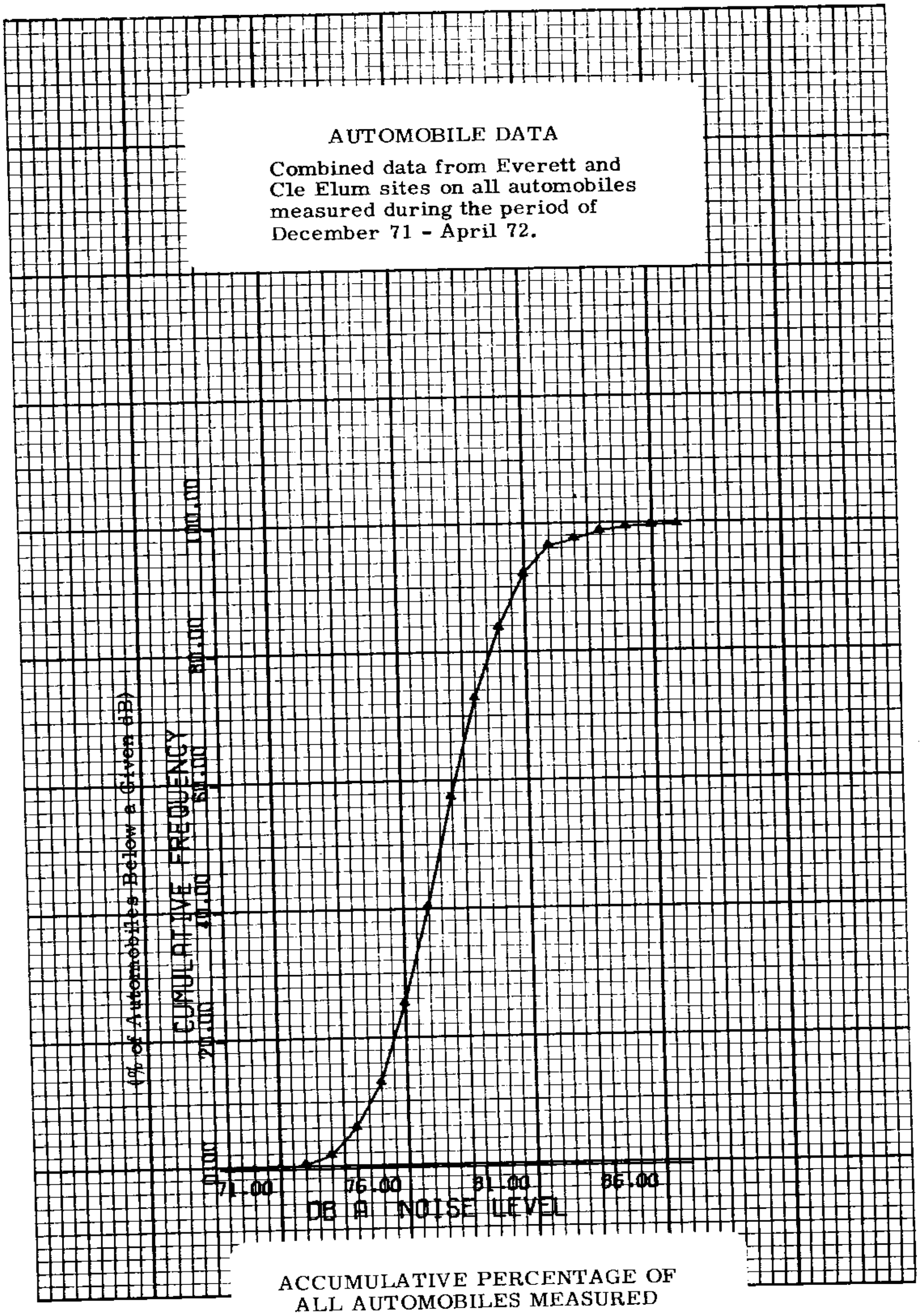
FIGURE 45.



HISTOGRAM OF ALL AUTOMOBILES MEASURED

SAMPLE SIZE: 878

FIGURE 46.



ACCUMULATIVE PERCENTAGE OF ALL AUTOMOBILES MEASURED

SAMPLE SIZE: 878

FIGURE 47.

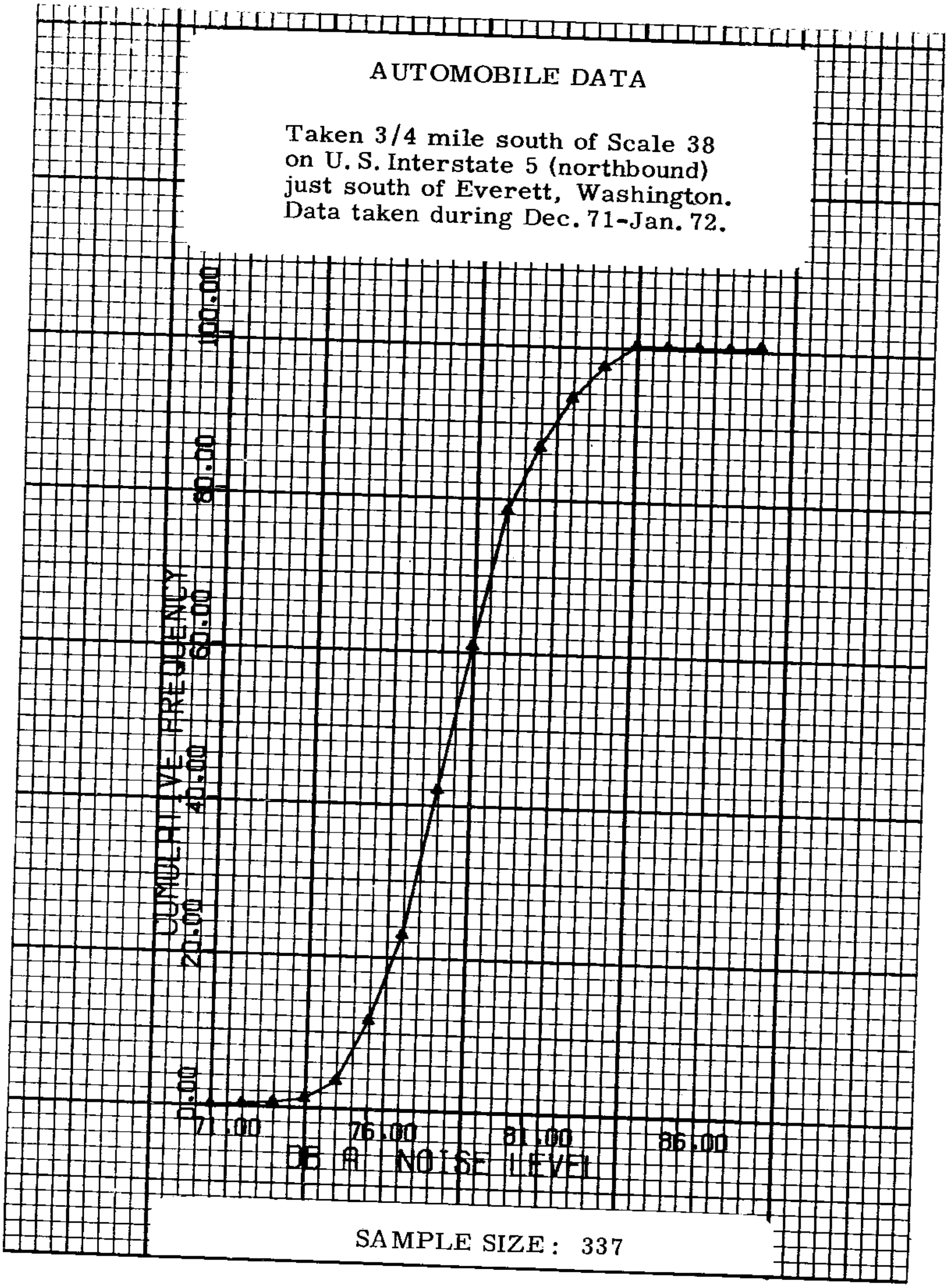

AUTOMOBILE DATA
Taken 3/4 mile south of Scale 38 on U. S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
CUMULATIVE FREQUENCY
0.00
20.00
40.00
60.00
80.00
100.00
71.00
76.00
81.00
86.00
DB A NOISE LEVEL
SAMPLE SIZE: 337

FIGURE 48.

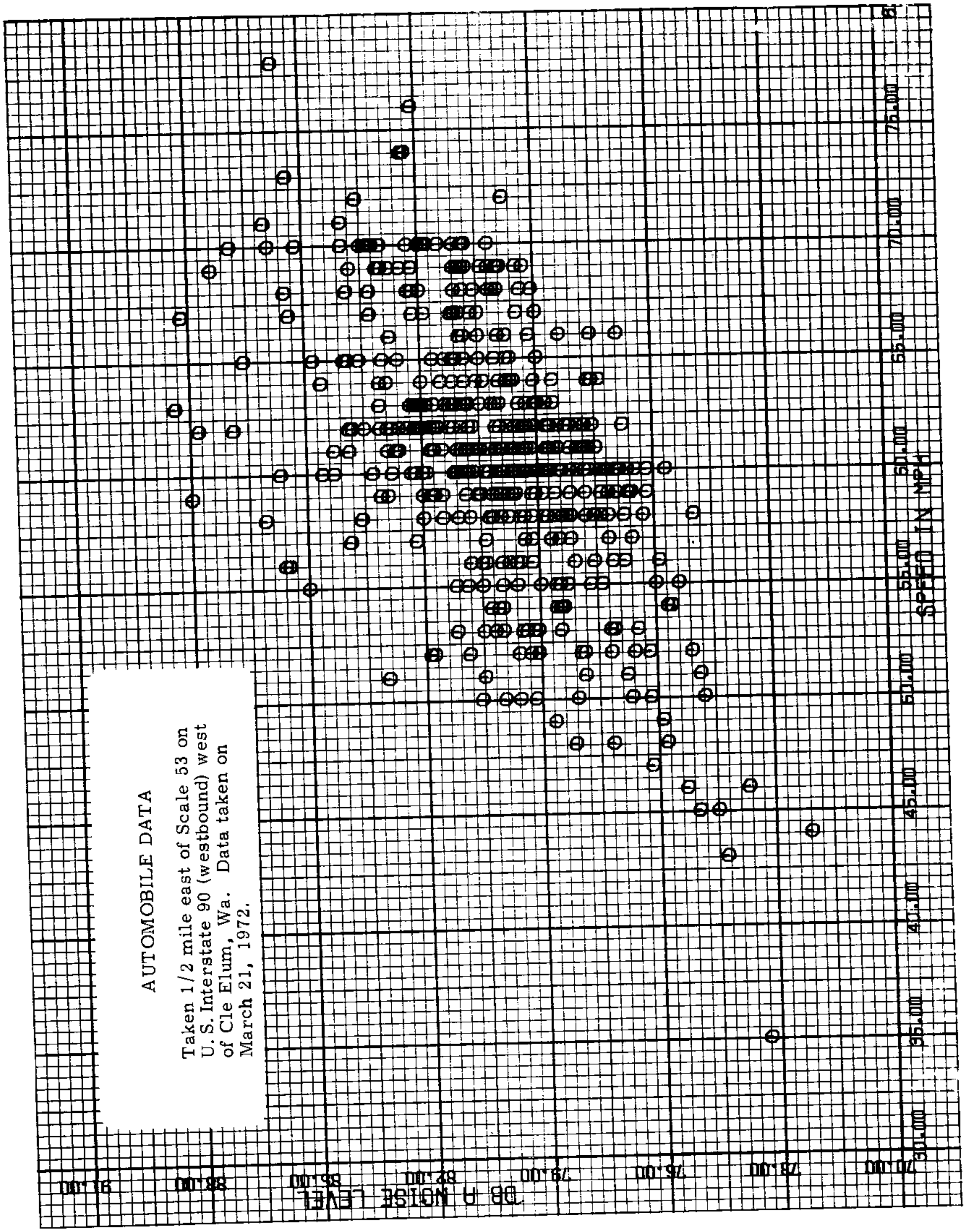

AUTOMOBILE DATA
Taken 1/2 mile east of Scale 53 on U.S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
SPEED IN MPH
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
DB A NOISE LEVEL
70.00
73.00
76.00
79.00
82.00
85.00
88.00
91.00

FIGURE 49.

TYPICAL PHOTOGRAPHS

Figure 50 is a photograph of one of the quiet trucks; its noise level was 85.1 dBA when traveling at 52 mph. The H in the license number indicates it is a diesel truck; its measured weight was 31,000 lb; and it is a Mack truck. This photograph was taken at Cle Elum and gives an example of one of the quieter trucks traveling at more or less full-speed and weighing over 30,000 lb.

Figure 51, also taken at Cle Elum, is a gasoline-powered truck manufactured by Chevrolet and weighing 11,000 lb. It was extremely quiet (77 dBA) even though it was going 50 mph. Figure 52 is another fairly quiet truck (83 dBA), going 50 mph. It weighed 34,000 lb, was gasoline-powered, and was manufactured by GMC. Apparently, GMC gasoline-powered trucks tend to be quiet although their diesel trucks are noisier. Its B-scale measurement was 87, which indicates the truck probably could have been even quieter with better muffling.

Figure 53 shows an example of a truck at the other end of the scale. This is a diesel truck going 51 mph, weighing 22,000 lb. It is on the noisy side at 93.7 dBA. The dBB reading is virtually the same--this means that it is putting out comparatively little low-frequency sound. It may be relatively well-muffled, but other sounds are overriding the exhaust to make this a rather noisy vehicle.

Figures 54 through 61 show a total of 72 different trucks, together with their noise data, speed, weight, and license number. Looking through these pictures will help give an idea of what some of the quiet, noisy, and mid-range trucks look like. As can be seen, the external appearance of a truck does not give a positive indication of the noise it radiates as it moves along the State's highways.

Fig. 50. Ga. # HI667 (Cle Elum)
3:41 p.m. 85.1 dBA
52 mph 31,000 lb

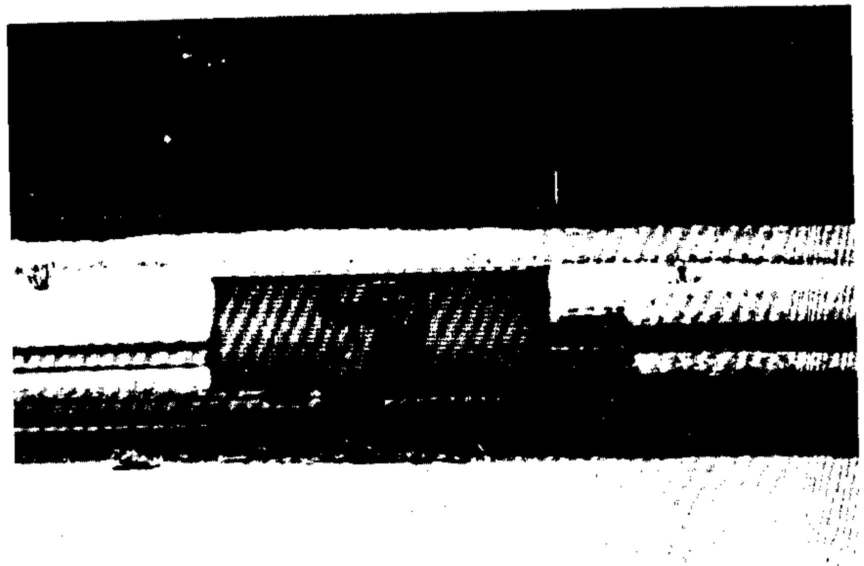


Fig. 51. # T76835 (Cle Elum)
3:45 p.m. 77 dBA
54 mph 11,000 lb

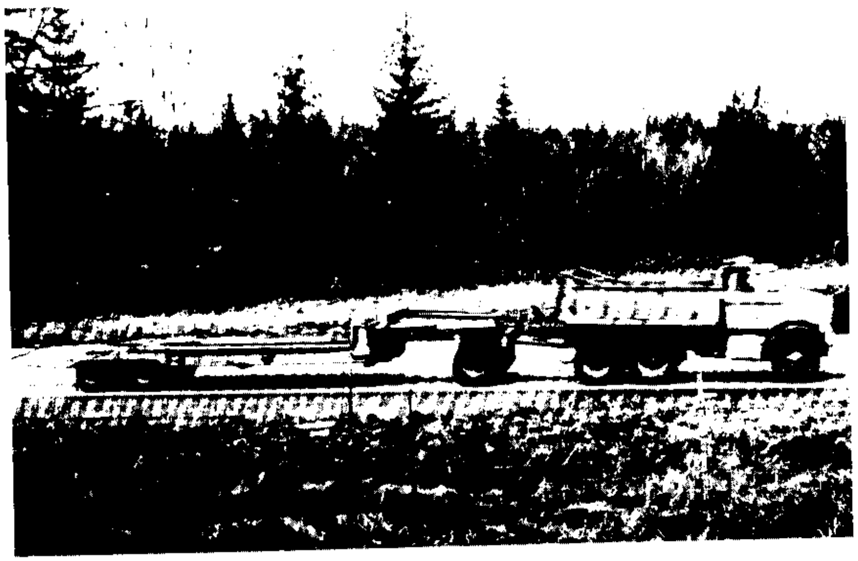


Fig. 52. # A68613 (Everett)
10:09 a.m. 83.8 dBA
50 mph 34,000 lb

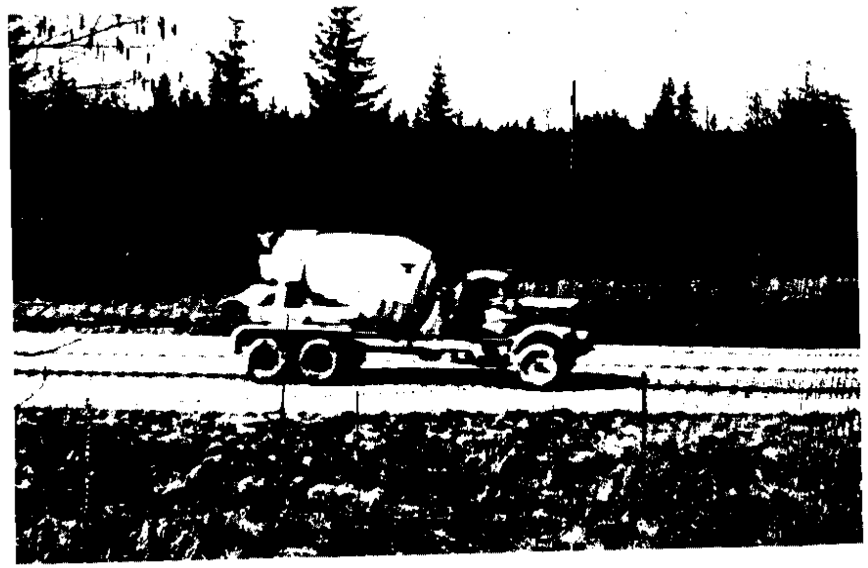
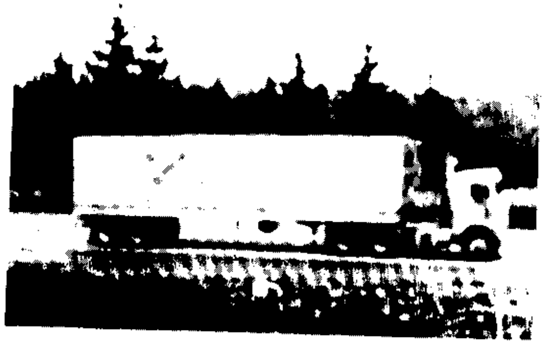
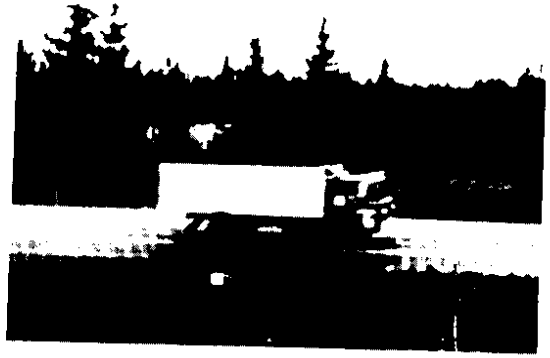


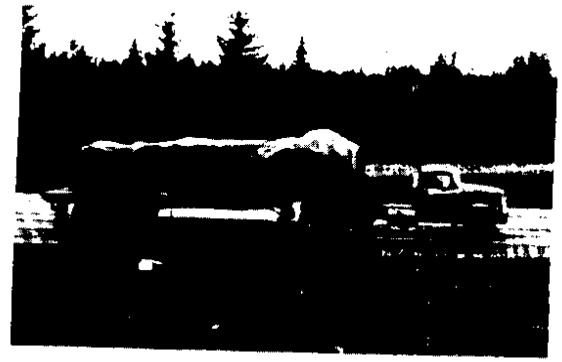
Fig. 53. # H11093 (Everett)
12:47 p.m. 93.7 dBA
51 mph 22,000 lb



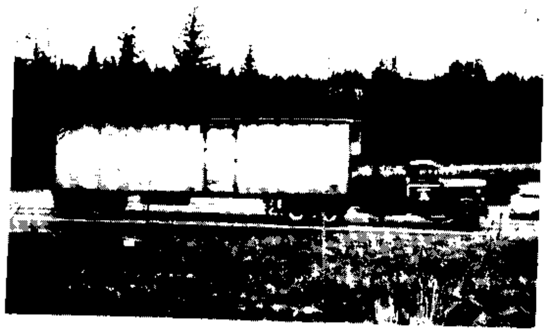
H24393
9:03 a.m. 53 mph
88.7 dBA 62,000 lb



A05653
9:04 a.m. 65 mph
86.3 dBA 14,000 lb



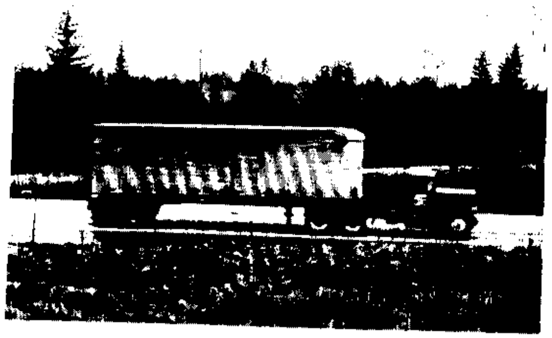
T77806
9:04 a.m. 66 mph
88.6 dBA 51,000 lb



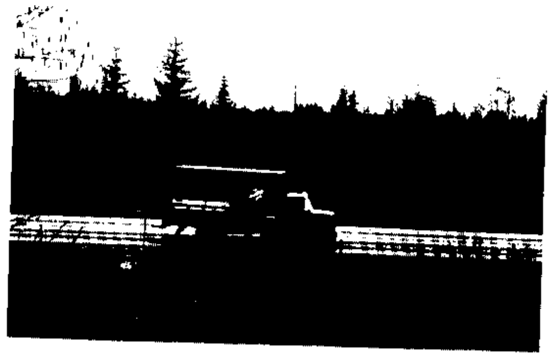
T230315
9:05 a.m. 47 mph
89.6 dBA 70,000 lb

H23424
9:05 a.m. 47 mph
87.2 dBA 29,000 lb

H14839
9:07 a.m. 59 mph
90.2 dBA 52,000 lb



H8820
9:07 a.m. 57 mph
91.5 dBA 38,000 lb

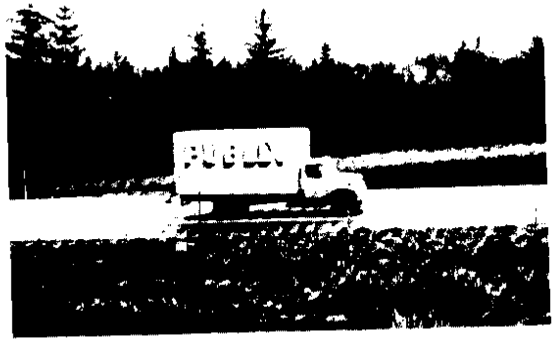


L84270
9:08 a.m. 62 mph
84.7 dBA 13,000 lb

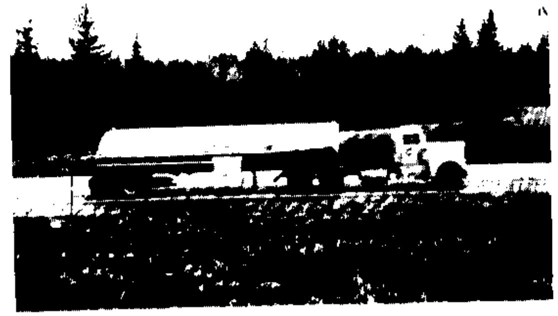
A51620
9:08 a.m. 60 mph
85.0 dBA 9,000 lb

FIGURE 54.

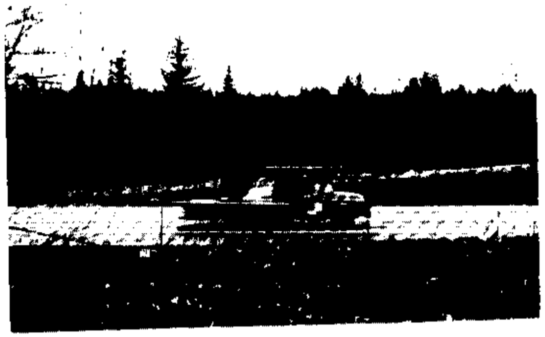
Ore. # T267420
9:09 a.m. 90.3 dBA
58 mph 68,000 lb



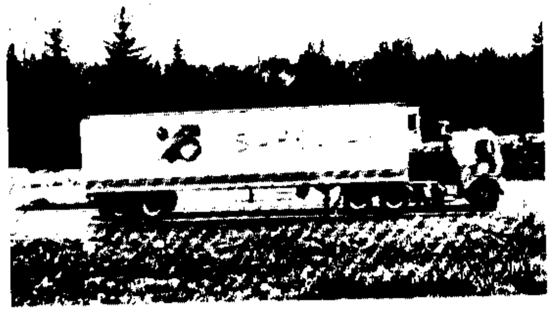
A53694
9:10 a.m. 82.9 dBA
51 mph 9,000 lb



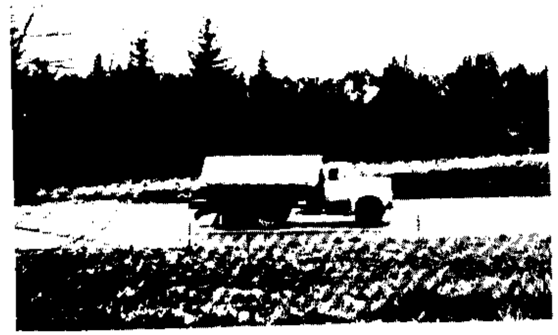
H5220
9:11 a.m. 91.6 dBA
60 mph 75,000 lb



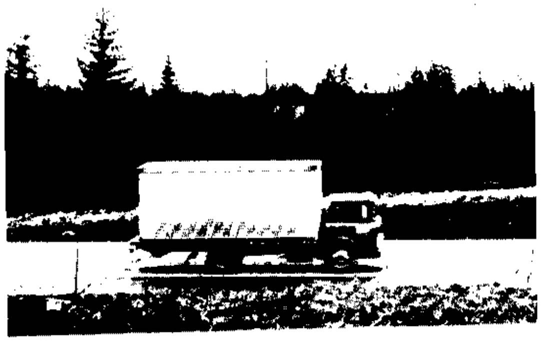
P10242
9:11 a.m. 84.6 dBA
55 mph 21,000 lb



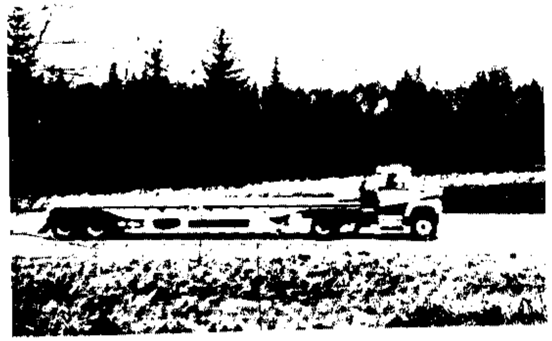
H22234
9:12 a.m. 89.1 dBA
52 mph 60,000 lb



A69276
9:12 a.m. 86.6 dBA
38 mph 42,000 lb



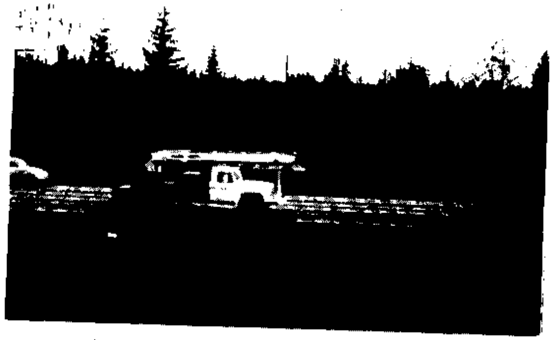
A99264
9:12 a.m. 86.3 dBA
55 mph 21,000 lb



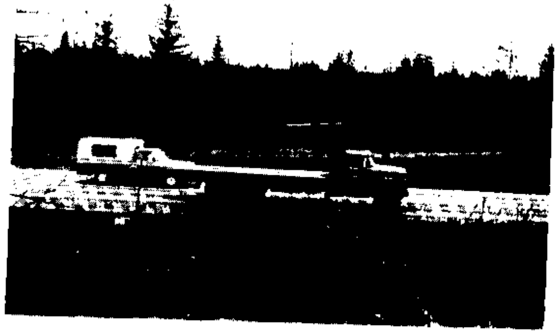
H19990
9:13 a.m. 88.5 dBA
60 mph 24,000 lb

H23752
9:17 a.m. 90.7 dBA
52 mph 67,000 lb

FIGURE 55.



U15606
9:18 a.m.
53 mph
84.1 dBA
14,000 lb

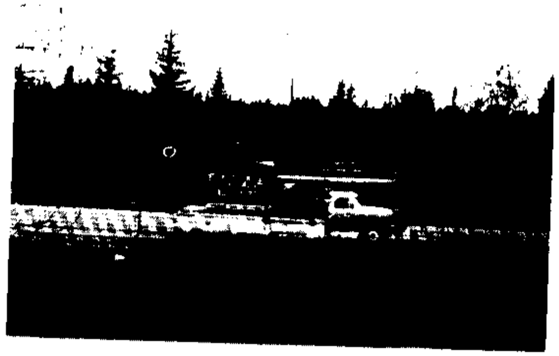


H14333
9:19 a.m.
61 mph
92.5 dBA
17,000 lb

H23044
9:20 a.m.
50 mph
91.4 dBA
21,000 lb

H24007
9:22 a.m.
50 mph
87.2 dBA
55,000 lb

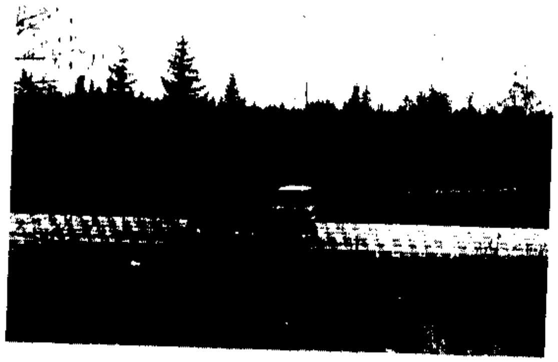
GD6977
9:23 a.m.
51 mph
84.7 dBA
21,000 lb



U42191
9:23 a.m.
63 mph
85.2 dBA
25,000 lb

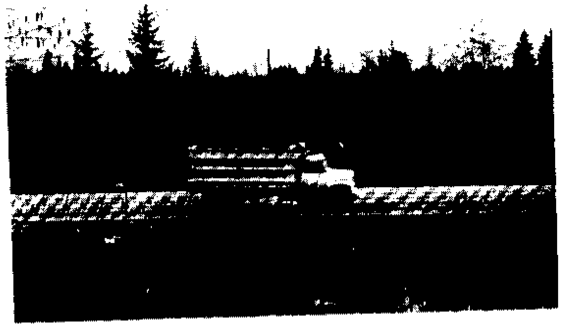
GB6095
9:25 a.m.
49 mph
85.8 dBA
31,000 lb

B.C. # P20032
9:26 a.m.
55 mph
87.8 dBA
39,000 lb

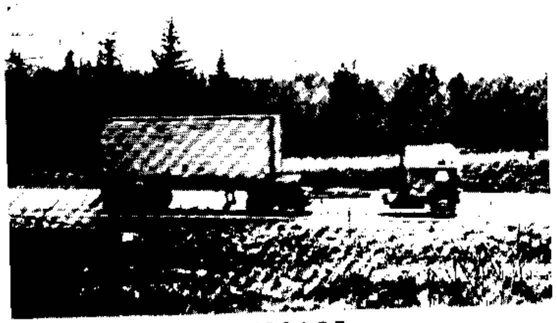


D3649
9:27 a.m.
57 mph
84.2 dBA
12,000 lb

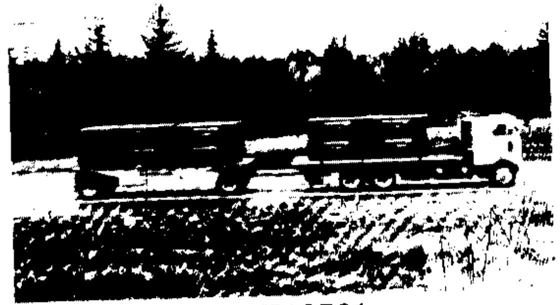
FIGURE 56.



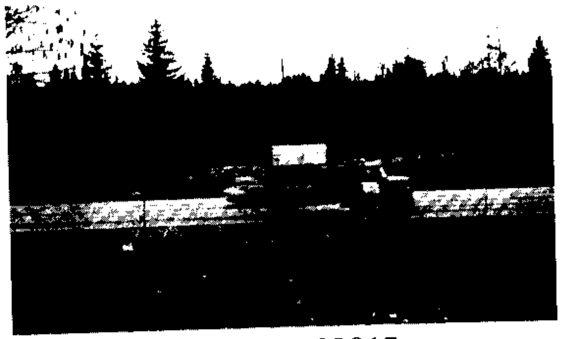
GC1389
9:27 a.m.
62 mph
86.4 dBA
15,000 lb



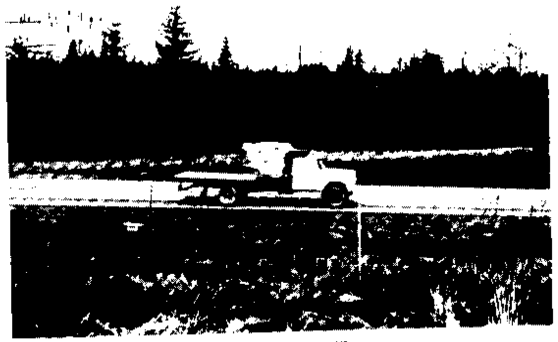
H22065
9:28 a.m.
57 mph
89.7 dBA
29,000 lb



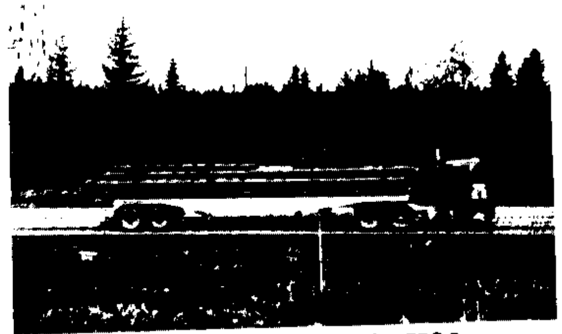
H12761
9:32 a.m.
60 mph
93.3 dBA
75,000 lb



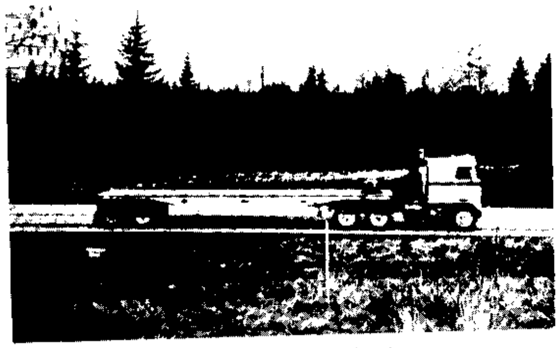
U52917
9:32 a.m.
56 mph
85.8 dBA
26,000 lb



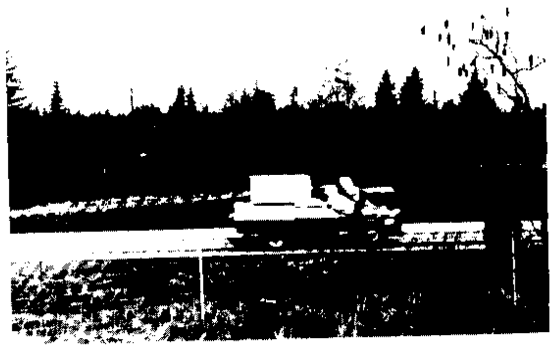
A44217
9:39 a.m.
58 mph
84.8 dBA
12,000 lb



Mont. # PA1H38
9:40 a.m.
57 mph
91.8 dBA
73,000 lb



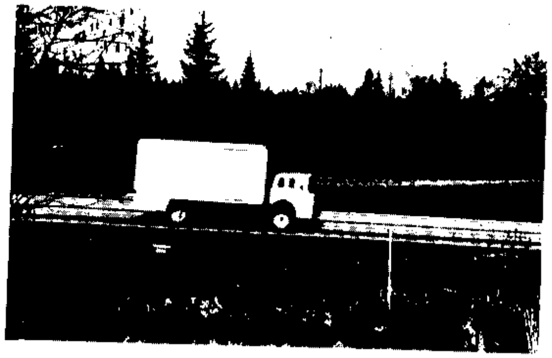
H15200
9:42 a.m.
55 mph
86.4 dBA
26,000 lb



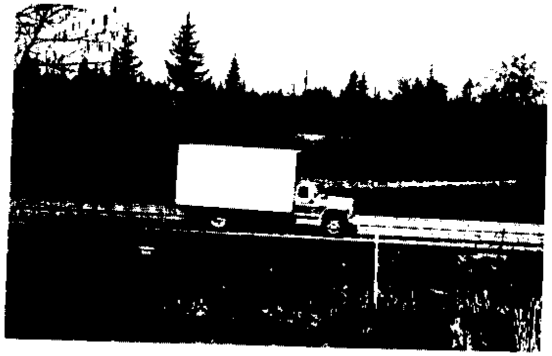
G98900
9:42 a.m.
52 mph
87.2 dBA
26,000 lb

H22230
9:42 a.m.
50 mph
89.1 dBA
61,000 lb

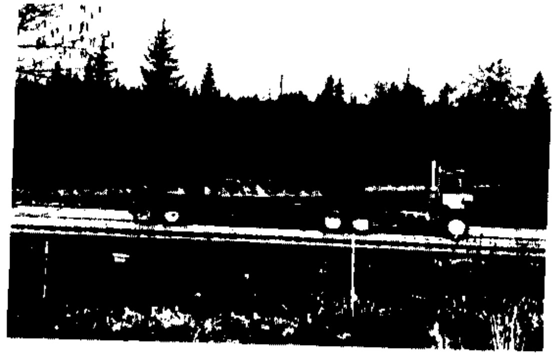
FIGURE 57.



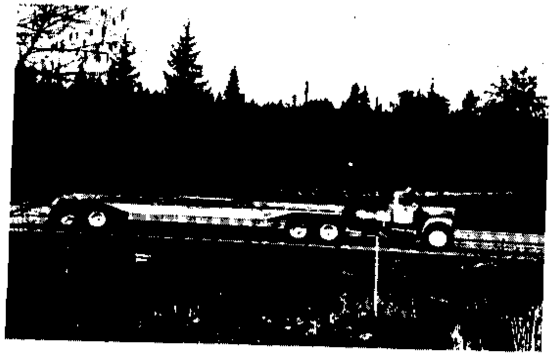
H17725
9:45 a.m. 55 mph
83.8 dBA 15,000 lb



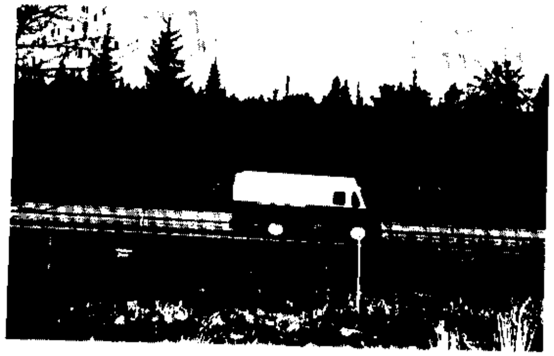
U52500
9:46 a.m. 52 mph
82.4 dBA 10,000 lb



H24205
9:46 a.m. 56 mph
92.7 dBA 71,000 lb

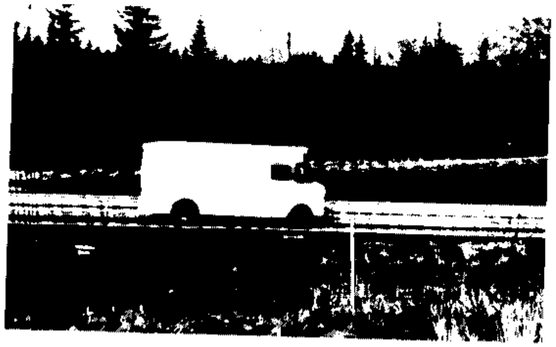


H0288
9:47 a.m. 50 mph
85.7 dBA 26,000 lb

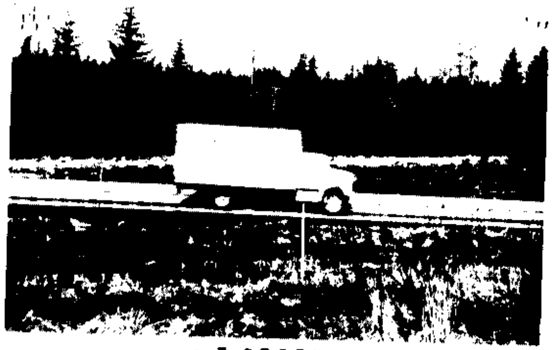


L01444
9:48 a.m. 62 mph
83.6 dBA 7,000 lb

H18117
9:49 a.m. 52 mph
92.5 dBA 75,000 lb



GD5817
9:50 a.m. 70 mph
84.5 dBA 7,000 lb

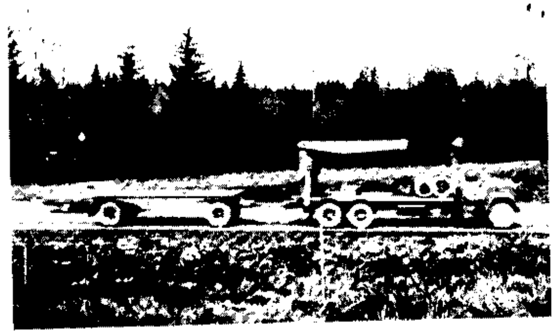


L03837
9:52 a.m. 63 mph
86.0 dBA 14,000 lb

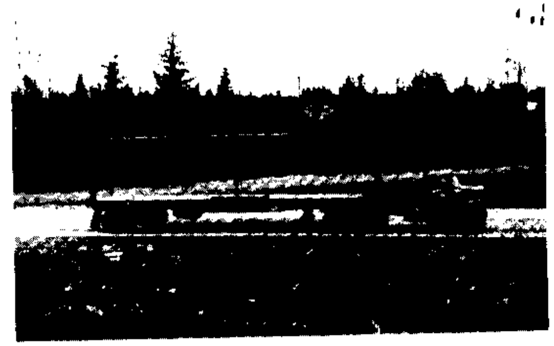
U30008
10:08 a.m. 56 mph
84.2 dBA 14,000 lb

FIGURE 58.

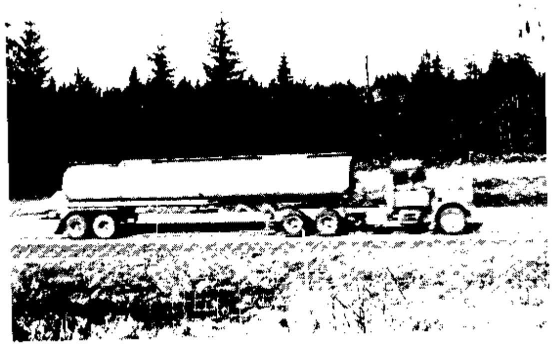
A68613
10:09 a.m. 50 mph
83.8 dBA 34,000 lb



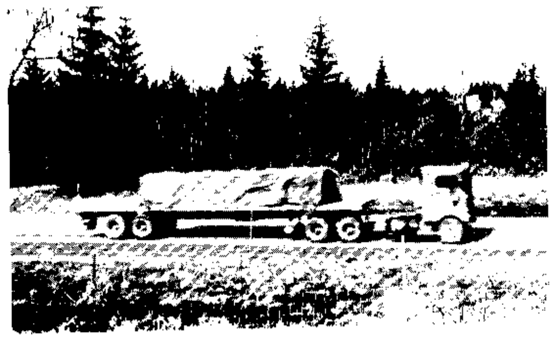
H18393
10:11 a.m. 60 mph
89.0 dBA 37,000 lb



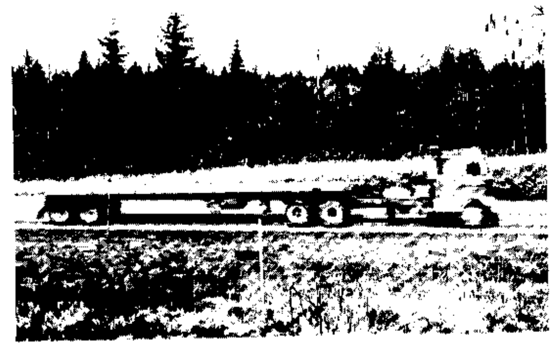
H11789
10:12 a.m. 54 mph
87.0 dBA 27,000 lb



H19845
10:27 a.m. 57 mph
88.7 dBA 74,000 lb

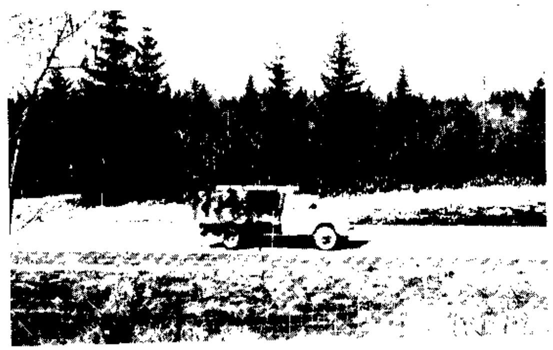


H17002
10:28 a.m. 59 mph
88.4 dBA 42,000 lb

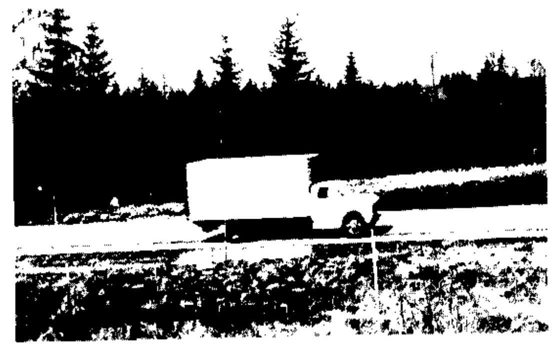


Ore. # T244702
10:29 a.m. 60 mph
87.7 dBA 24,000 lb

B.C. # 904-952
10:29 a.m. 54 mph
86.5 dBA 42,000 lb

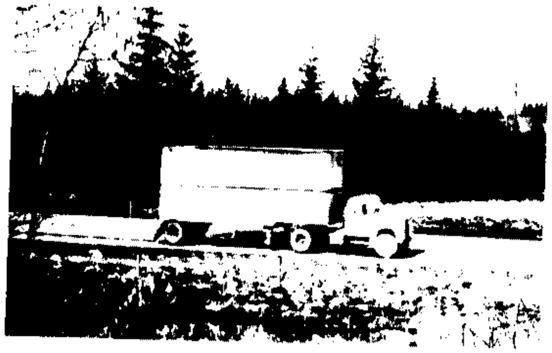


A36970
10:29 a.m. 59 mph
81.1 dBA 11,000 lb

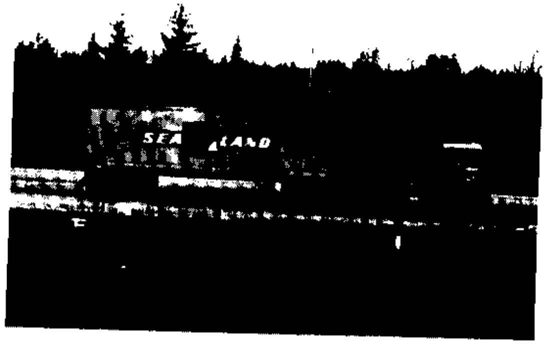


L83658
10:31 a.m. 61 mph
82.5 dBA 10,000 lb

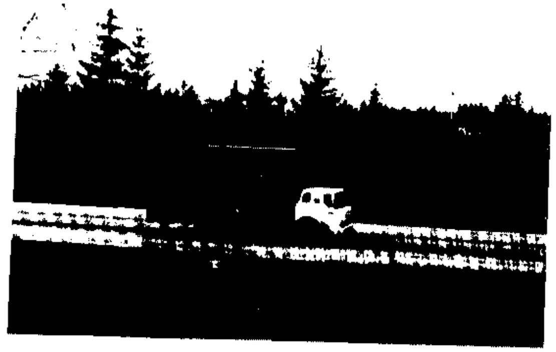
FIGURE 59.



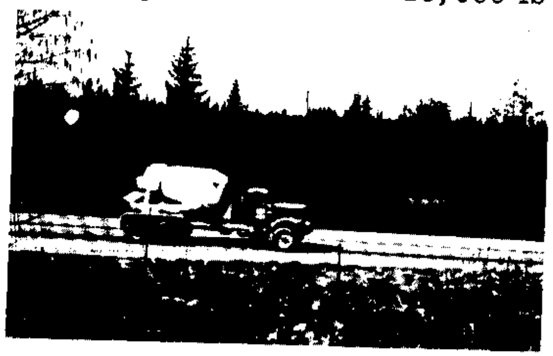
A53583
10:31 a.m. 80.8 dBA
51 mph 20,000 lb



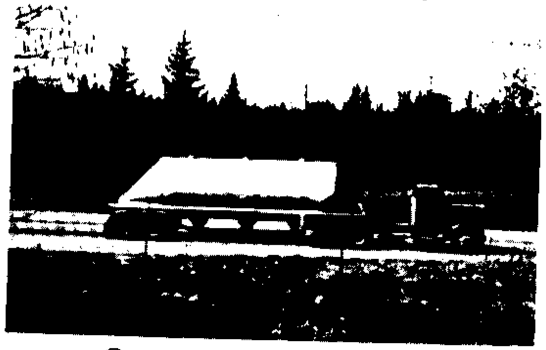
Ore. # T303483
12:45 p.m. 90.5 dBA
59 mph 32,000 lb



L84321
12:45 p.m. 85.8 dBA
58 mph 18,000 lb



H11093
12:47 p.m. 93.7 dBA
51 mph 22,000 lb



Ore. # 88842
12:48 p.m. 89.7 dBA
52 mph 73,000 lb

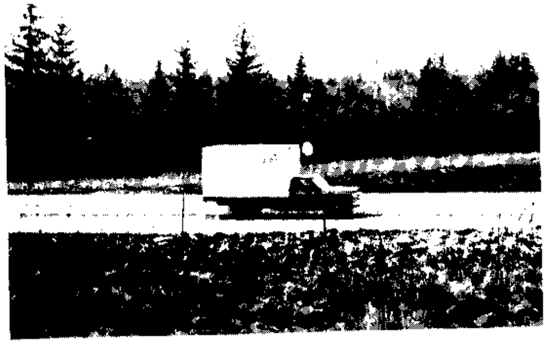
L03901
12:49 p.m. 83.3 dBA
55 mph 11,000 lb

H21281
12:49 p.m. 89.5 dBA
62 mph 40,000 lb

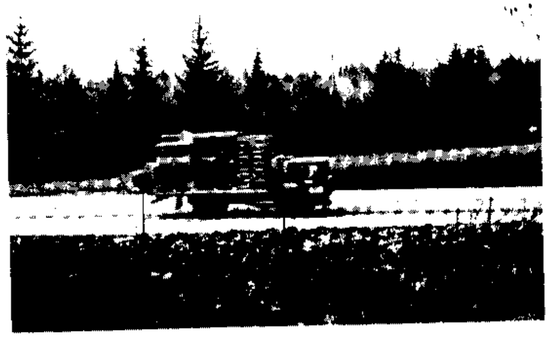
H17800
12:50 p.m. 89.8 dBA
64 mph 68,000 lb

L99514
12:57 p.m. 83.8 dBA
50 mph 23,000 lb

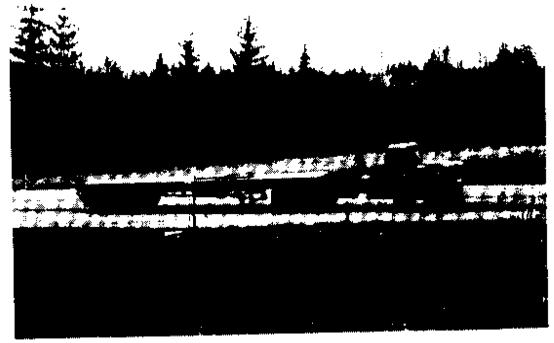
FIGURE 60.



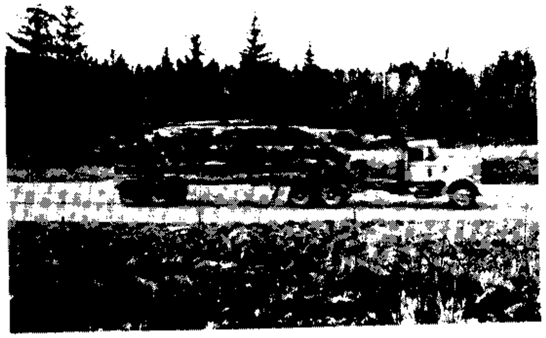
\# A01692
12:57 p.m. 59 mph
84.3 dBA 9,000 lb



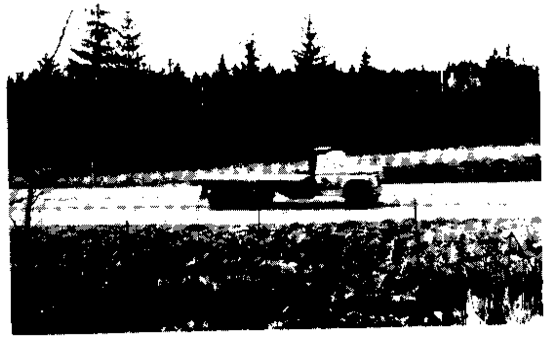
\# T58547
12:57 p.m. 55 mph
88.3 dBA 26,000 lb



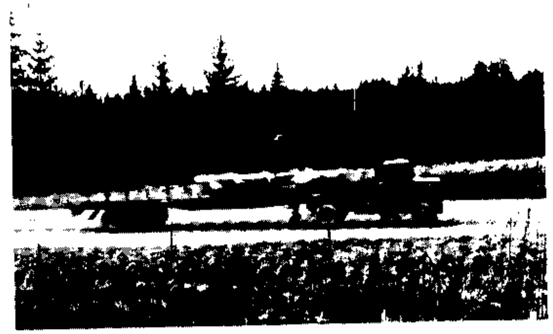
\# H14230
12:59 p.m. 56 mph
87.1 dBA 27,000 lb



\# H14943
1:01 p.m. 59 mph
89.8 dBA 67,000 lb

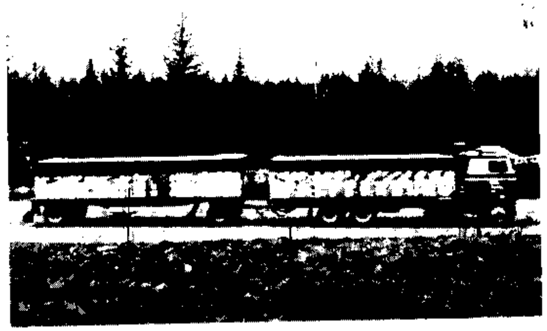


\# L37658
1:02 p.m. 61 mph
88.1 dBA 17,000 lb

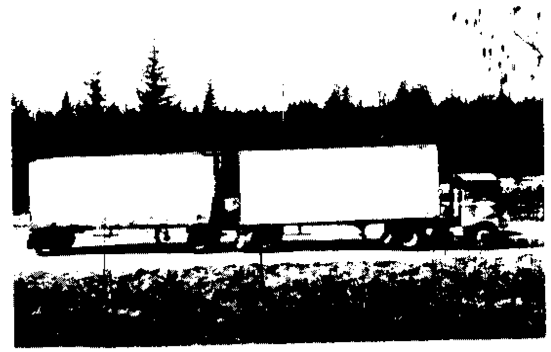


\#H17920
1:02 p.m. 58 mph
88.5 dBA 27,000 lb

\# H16596
1:03 p.m. 51 mph
86.3 dBA 23,000 lb



\# H17676
1:04 p.m. 61 mph
90.1 dBA 76,000 lb



\# H4981
1:05 p.m. 51 mph
87.0 dBA 28,000 lb

FIGURE 61.

CURRENT LEGISLATION

Forty-eight states and six Canadian provinces were queried about their legislation on highway vehicle noise. As of December 1971, 15 states and 3 provinces had no motor vehicle regulation whatsoever, while 10 states and 2 provinces had minimal noise regulation which prohibits the emission of excessive or unusual noise and requires a muffler. The legislatures in two states and two provinces have authorized the establishment of noise levels for motor vehicles although no noise levels have yet been established. Specific decibel levels for the noise emitted by motor vehicles have been set by six states as follows:

State	Trucks with speed over 35 mph	Cars with speed over 35 mph	
California*	90 dBA at 50 ft	82 dBA at 50 ft	
Idaho	92 dBA at 20 ft	(for any vehicle)	
Minnesota	90 dBA at 50 ft	86 dBA at 50 ft	
Nevada	90 dBA at 50 ft	82 dBA at 50 ft	(patterned after Calif.)
New York	88 dBA at 50 ft	(for any vehicle moving less than 35 mph)	
Pennsylvania	92 dBA at 50 ft	86 dBA at 50 ft	

Appendix F is a compilation of all the responses to our request for this information.

*California sets the lowest noise levels thus far.

MUFFLERS

As part of this survey, letters were sent to a large number of muffler manufacturers requesting information from them on their mufflers, particularly those expected to be used on trucks. The data requested included (1) model numbers, (2) acoustic performance (how many dB and what frequencies, etc.), (3) effect on engine (back-pressure generated), (4) mechanical specifications such as weight and size, (5) life expectancy, and (6) cost.

The returns from the manufacturers were rather disappointing in that none of them would give cost information, some claiming there were no list prices, that all transactions were the result of negotiations; others would simply say that their costs were found reasonable by their customers.

In addition, few of the major muffler manufacturers gave any exact noise specifications for their mufflers. Nevertheless, it is anticipated that as more states enact noise legislation, these manufacturers will become more concerned with publishing the exact noise attenuation capabilities of their line of mufflers. At the present time, Donaldson, Riker, Alexander-Tagg, and Stemco give some noise specifications for their mufflers along with having a line of mufflers which "satisfy" California's 88 dBA noise limit. Donaldson gives the most detailed and comprehensive noise reduction and back-pressure specifications for their mufflers. AMF Beaird also gives extensive specifications; however, they are mainly concerned with stationary and marine-based applications.

There are five main considerations in muffler design: (1) physical design or mechanical specifications, such as size and weight, (2) noise attenuation, (3) engine back-pressure, (4) muffler life, and (5) cost. The final performance of a muffler is a trade-off of the above five factors.

In general, if very good acoustic performance together with very low back-pressure is desired, the cost, weight, and size of the muffler will go up. Or, lower cost for the same acoustic performance could be attained if a higher back-pressure could be tolerated. There are no technical mysteries here. A muffler could be built to conform to almost any desired noise level if enough cost, space, and weight were allowed. The information from the manufacturers, however, is too sketchy at present to provide any curves of cost versus performance for this report.

It should be emphasized that the exhaust is only one source of noise. The engine radiates noise directly as does the piping between the engine and the muffler (if it is not sufficiently rigid and heavy). In addition, there is tire noise, etc. It is not economically justified to reduce the exhaust noise more than perhaps 6 dB below the overall truck noise level.

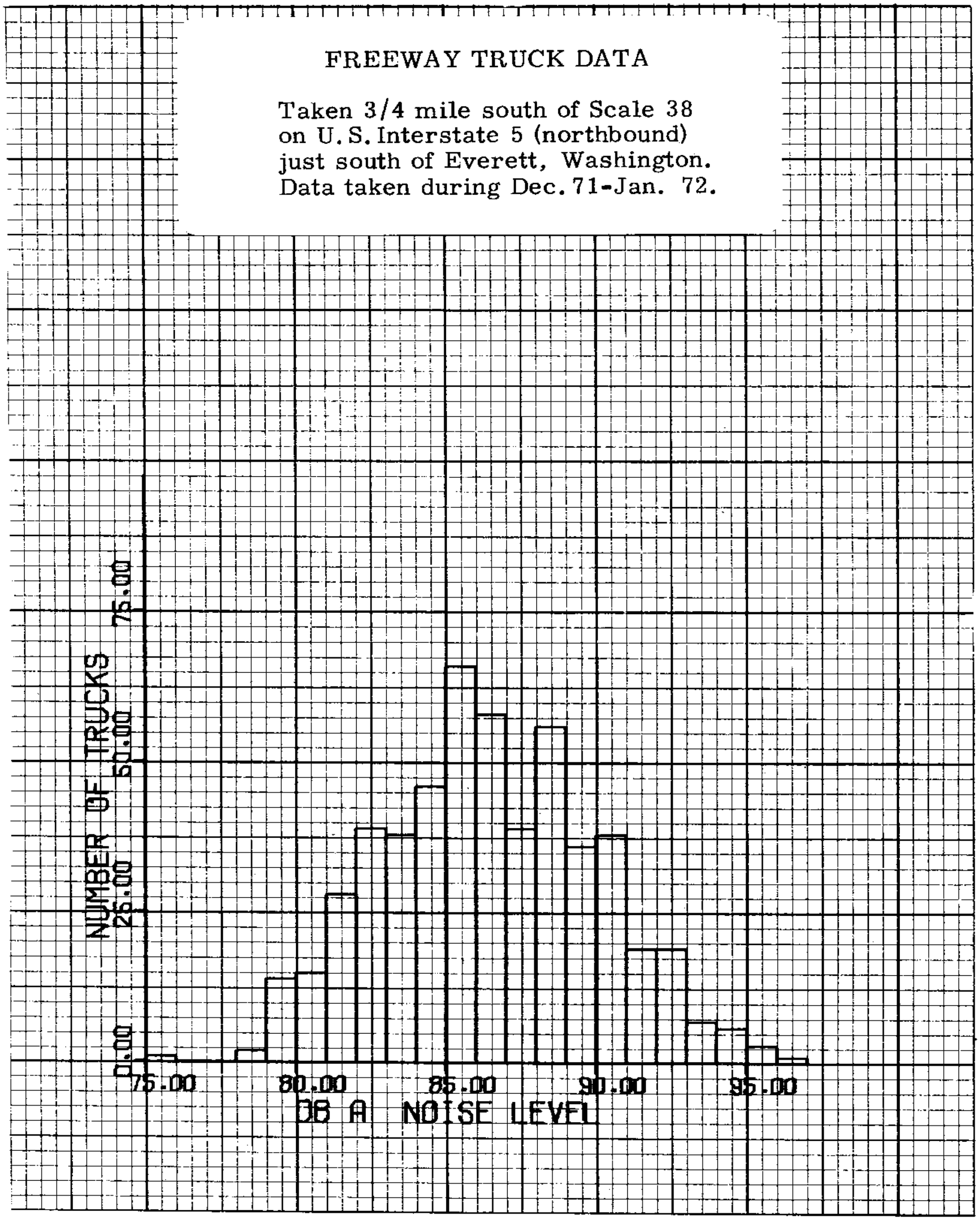
Finally, a belief shared by many of the muffler manufacturers was that exhaust noise could be considerably reduced by educating the driver to the fact that an increase in exhaust noise does not necessarily result in an increase in horsepower or a decrease in back-pressure.

Appendix G is a compilation of the muffler manufacturers' response to our request for data.

APPENDIX A

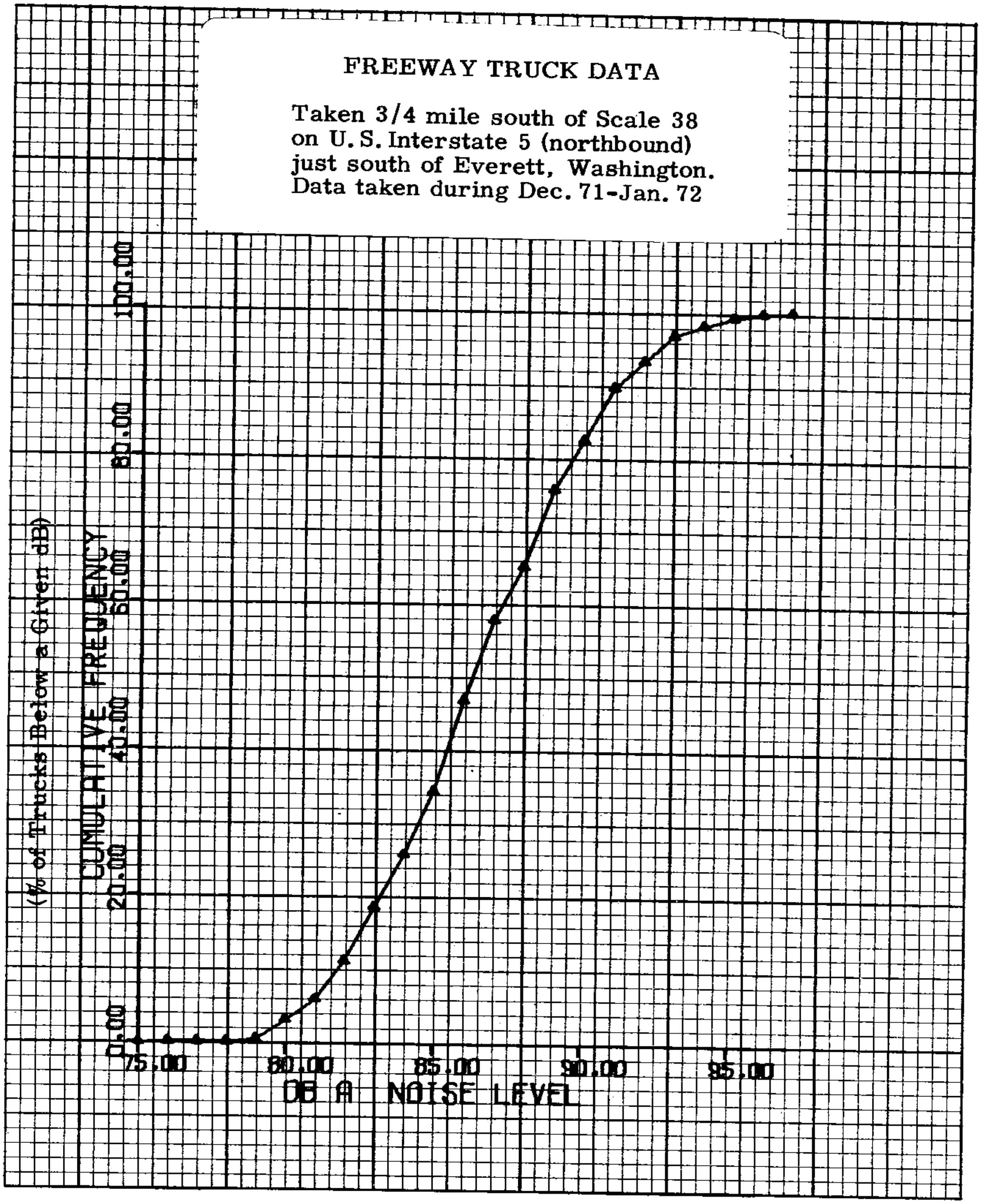
DATA TAKEN DURING DECEMBER 1971 - JANUARY 1972, 3/4 MILE SOUTH OF SCALE 38 ON U.S. INTERSTATE 5 (NORTHBOUND) JUST SOUTH OF EVERETT, WASHINGTON.

(See Figure 17 in main text for key to symbols representing each class of truck.)



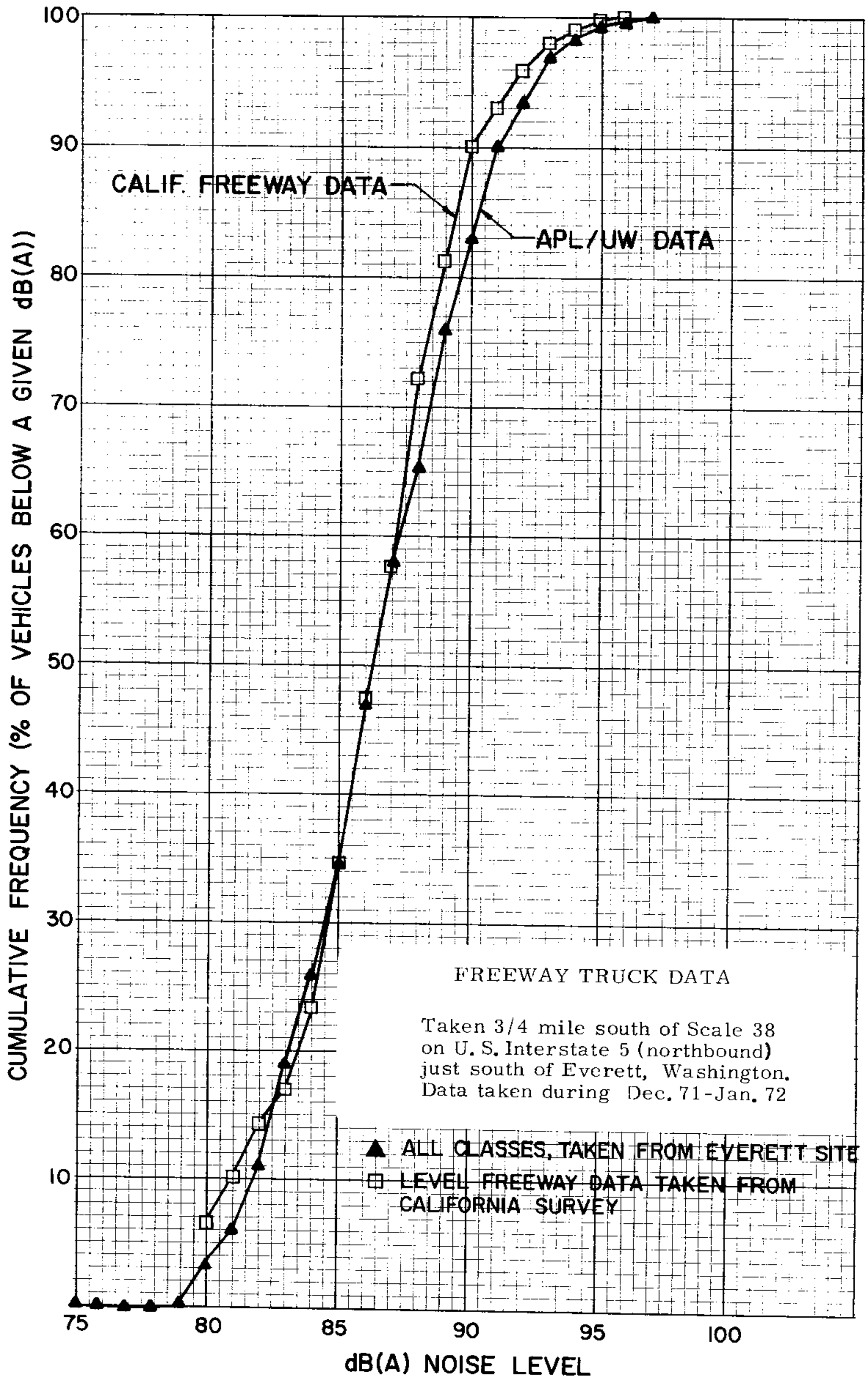
HISTOGRAM OF ALL TRUCKS MEASURED

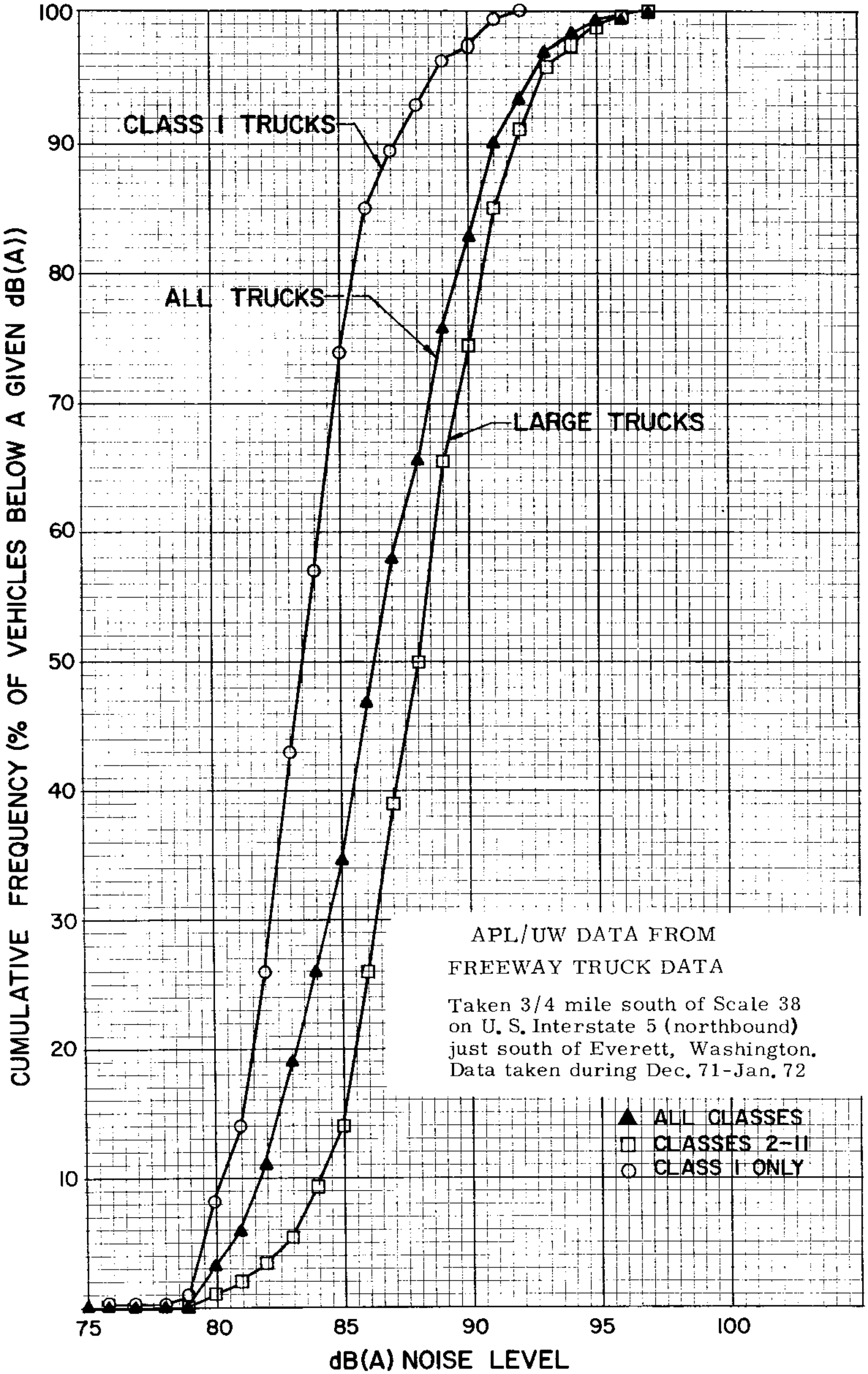
SAMPLE SIZE: 531



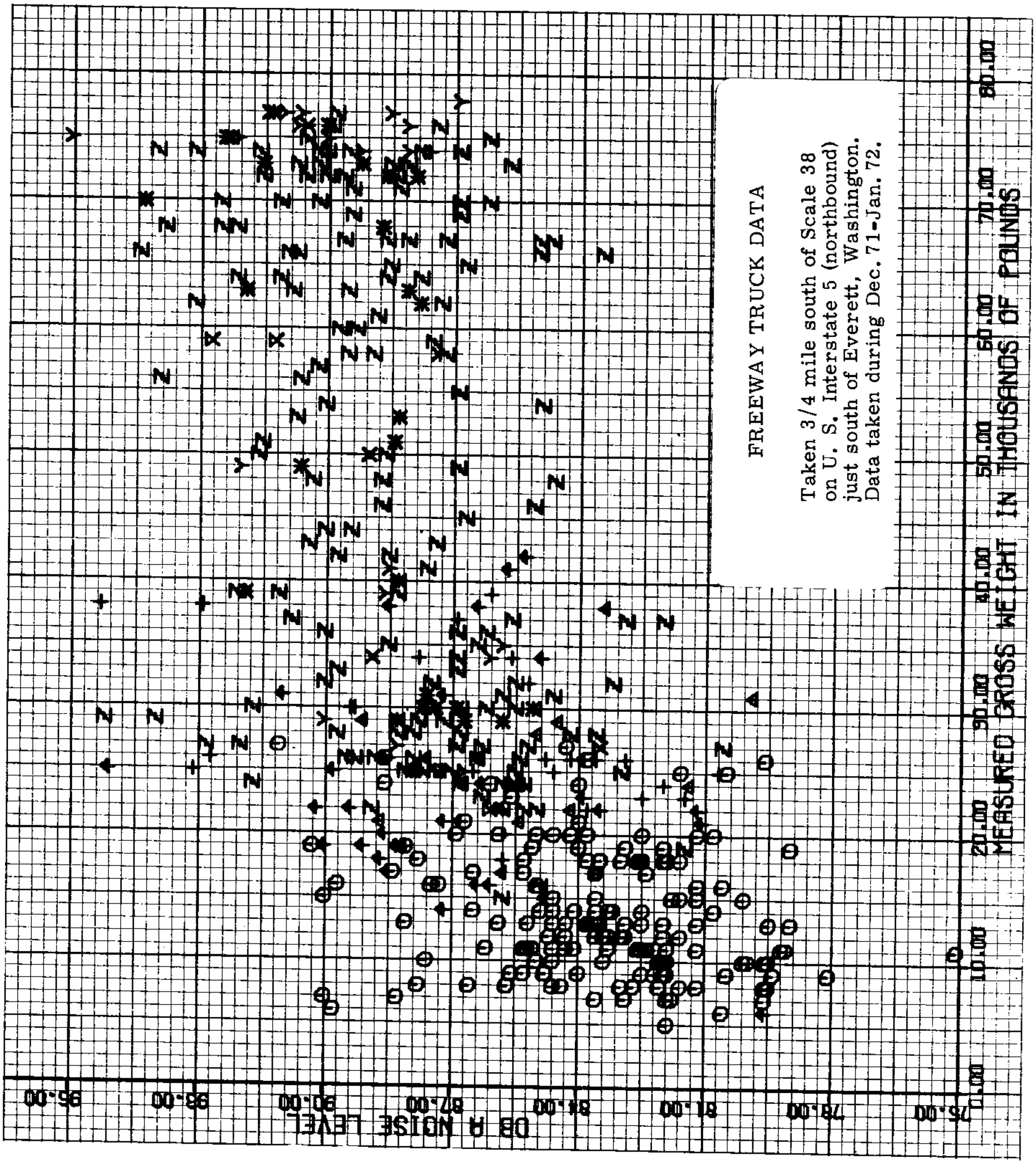
ACCUMULATIVE PERCENTAGE
OF ALL TRUCKS MEASURED

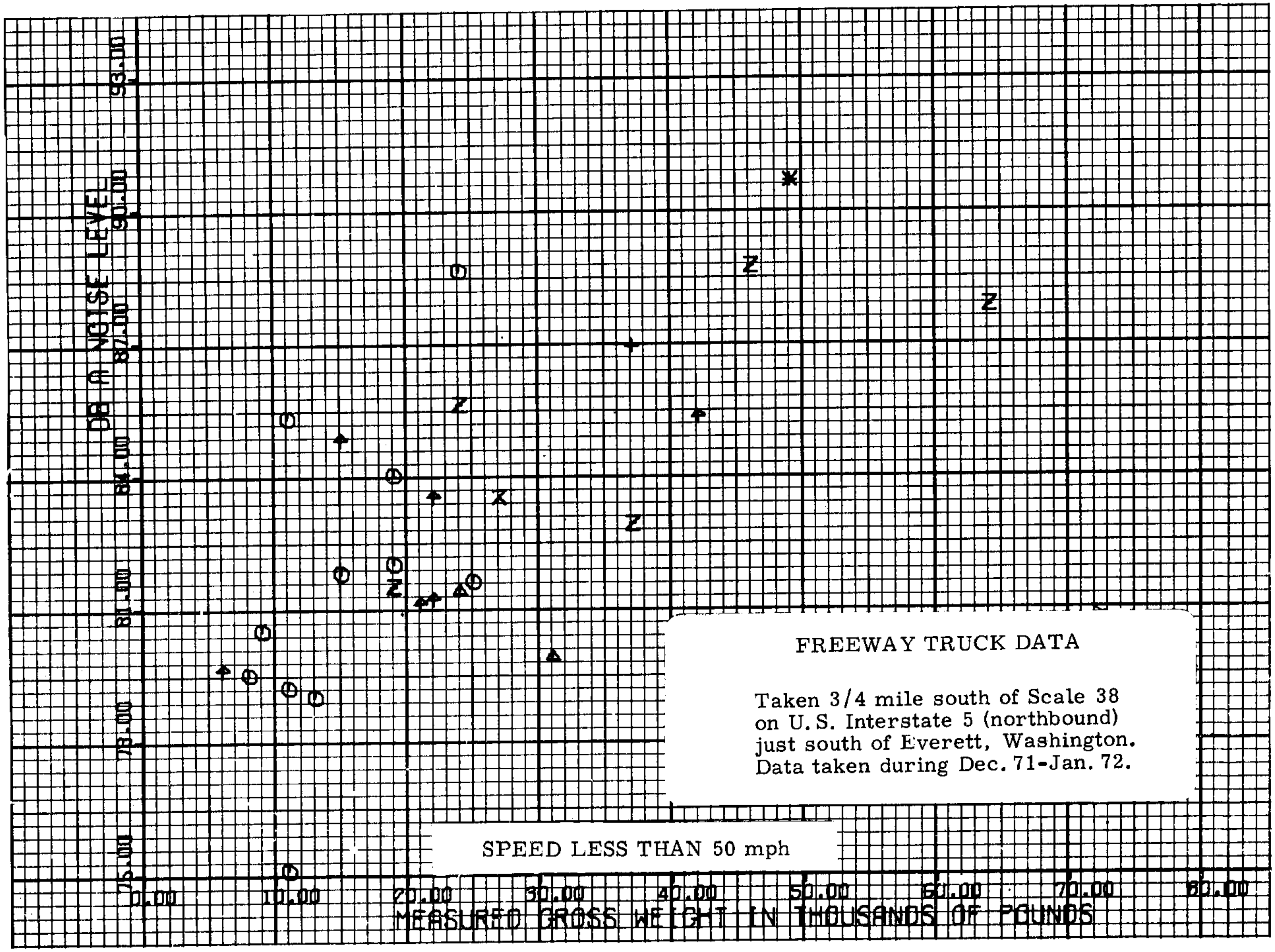
SAMPLE SIZE: 531

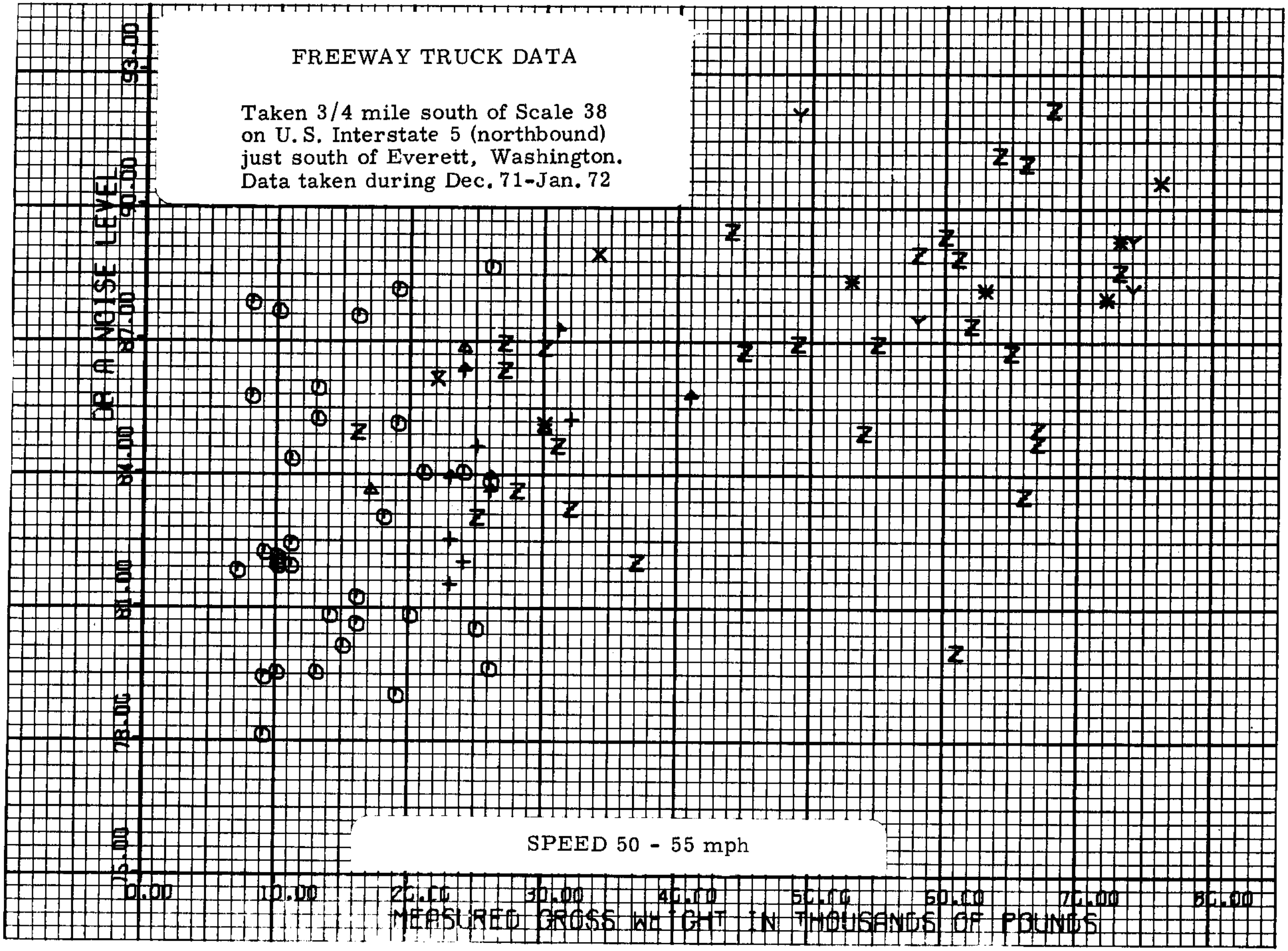

CUMULATIVE FREQUENCY (% OF VEHICLES BELOW A GIVEN dB(A))
100
90
80
70
60
50
40
30
20
10
75
80
85
90
95
100
dB(A) NOISE LEVEL
CALIF. FREEWAY DATA
APL/UW DATA
FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U. S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72
ALL CLASSES, TAKEN FROM EVERETT SITE
LEVEL FREEWAY DATA TAKEN FROM
CALIFORNIA SURVEY

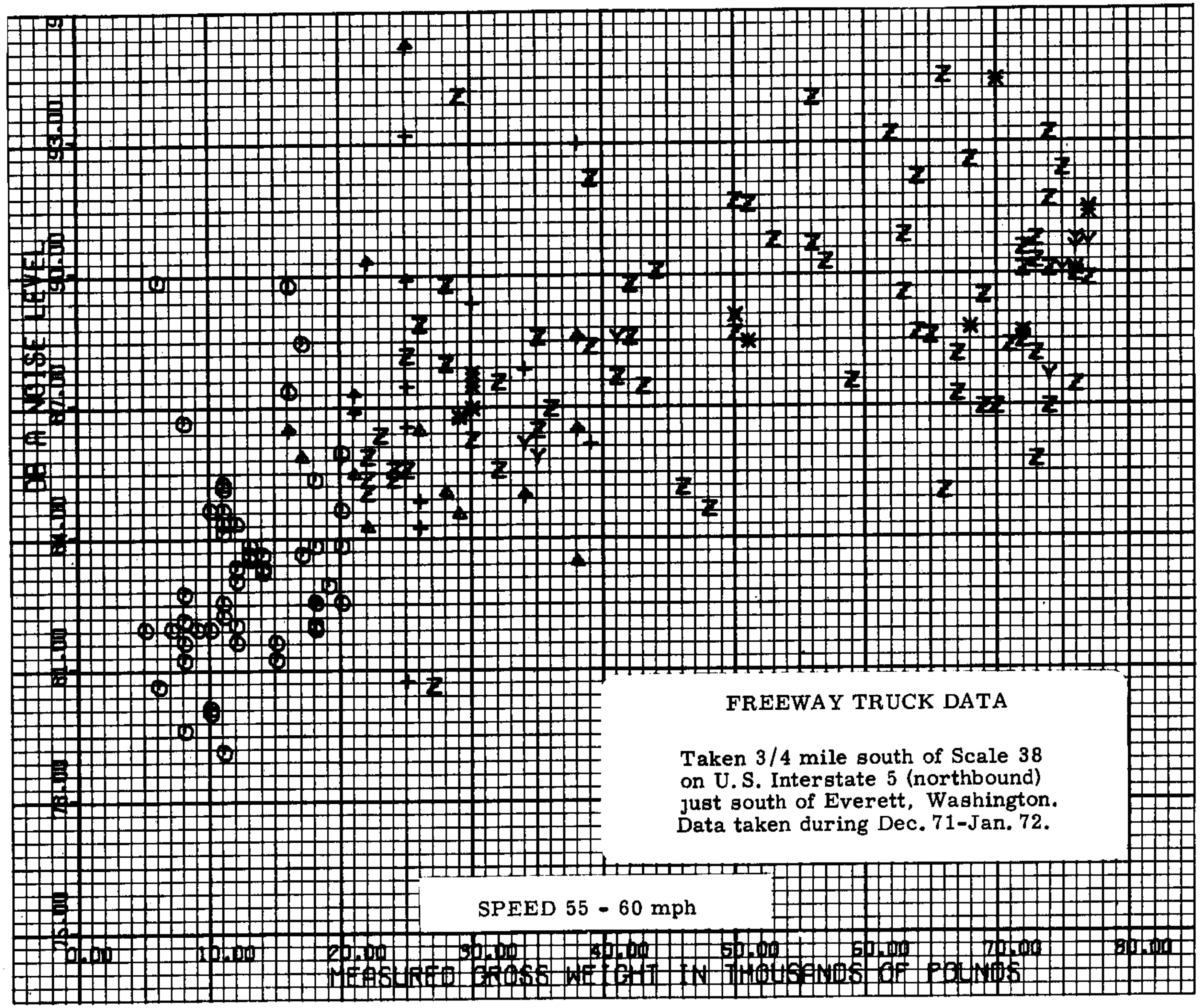


CLASS I TRUCKS
ALL TRUCKS
LARGE TRUCKS
APL/UW DATA FROM
FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U. S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72
ALL CLASSES
CLASSES 2-11
CLASS I ONLY
CUMULATIVE FREQUENCY (% OF VEHICLES BELOW A GIVEN dB(A))
dB(A) NOISE LEVEL
100
90
80
70
60
50
40
30
20
10
75
80
85
90
95
100

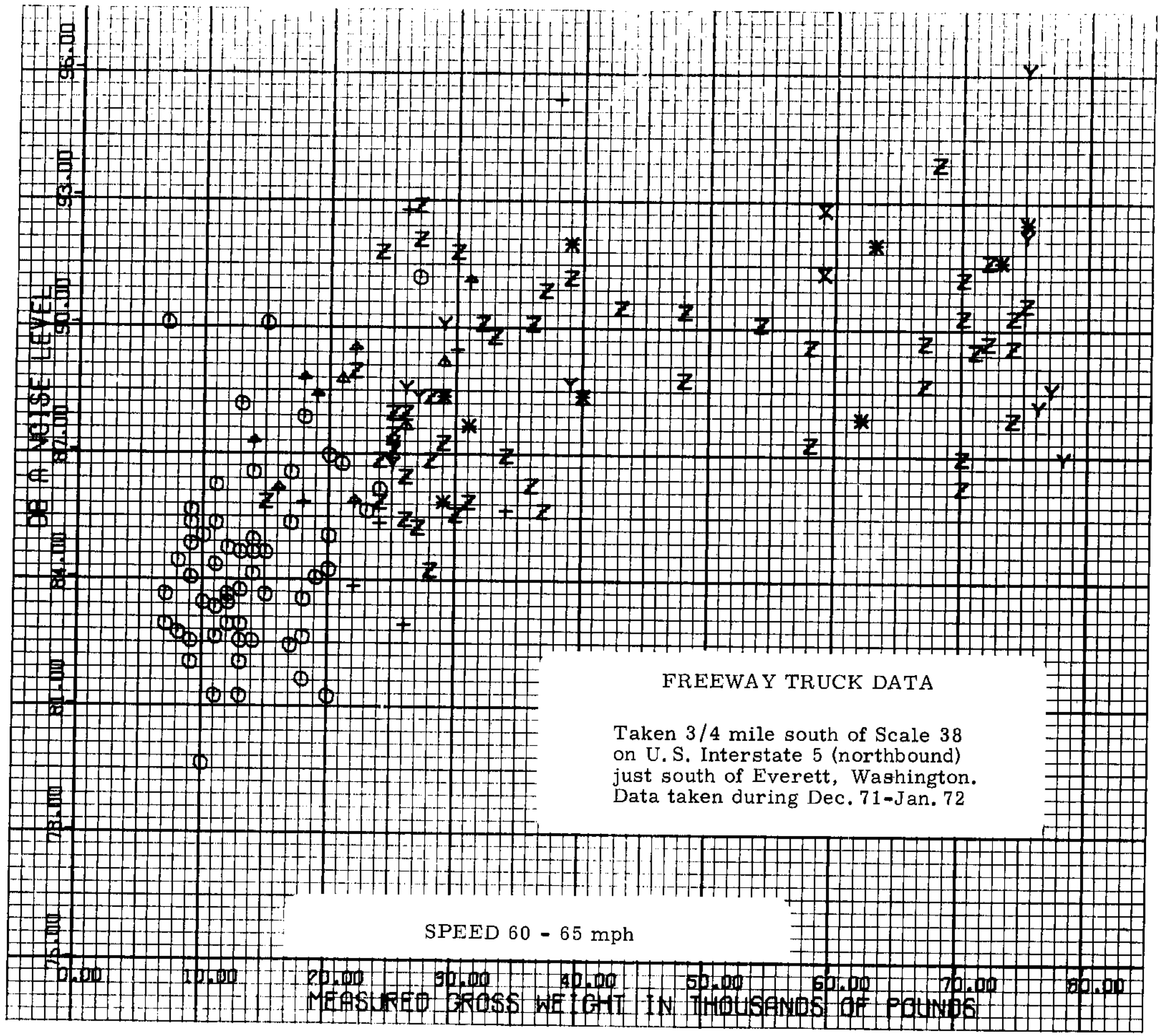

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U. S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
DB A NOISE LEVEL
75.00
78.00
81.00
84.00
87.00
90.00
93.00
96.00

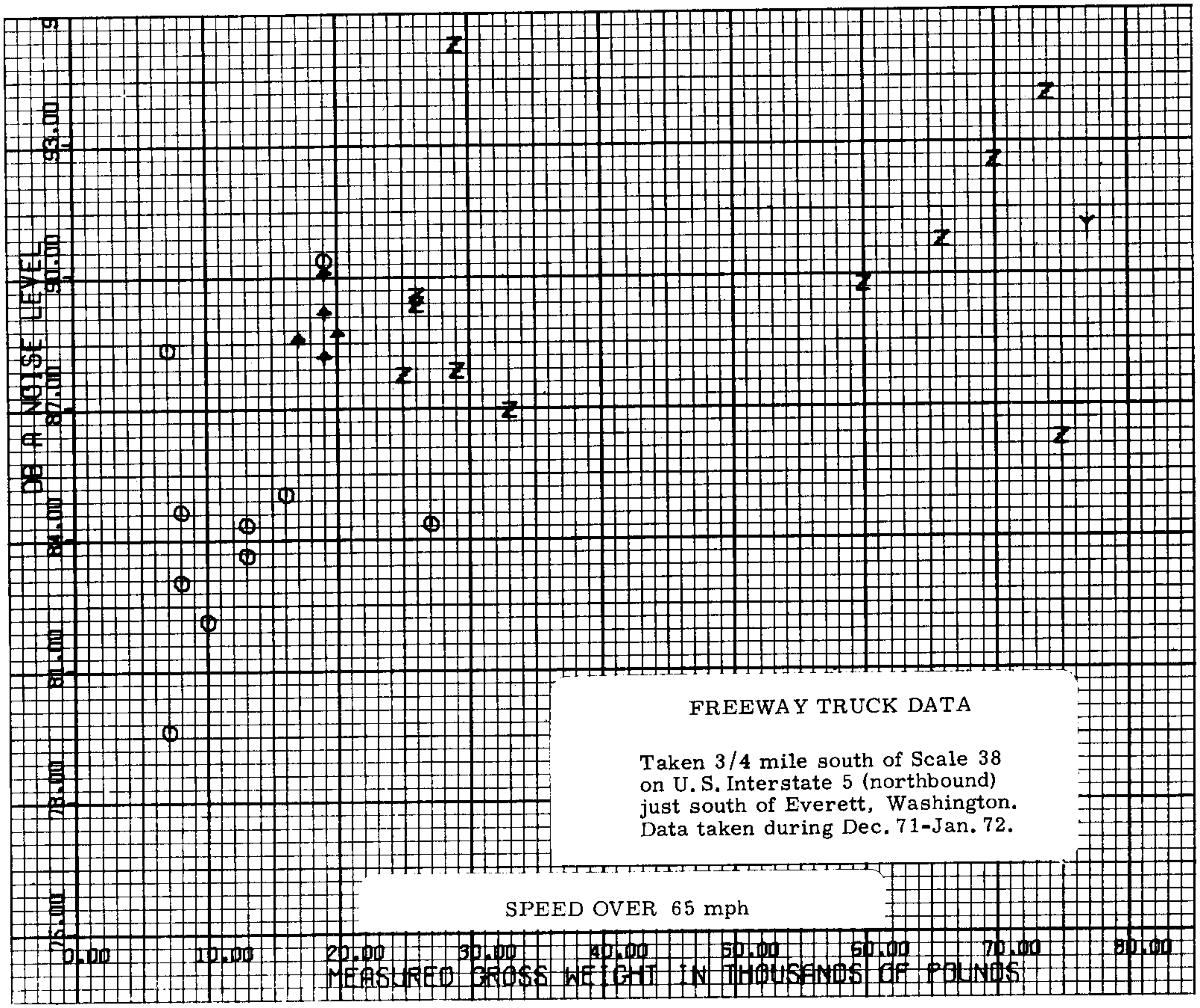

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
SPEED LESS THAN 50 mph
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
75.00
78.00
81.00
84.00
87.00
90.00
93.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72
SPEED 50 - 55 mph
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
93.00
90.00
87.00
84.00
81.00
78.00
75.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00



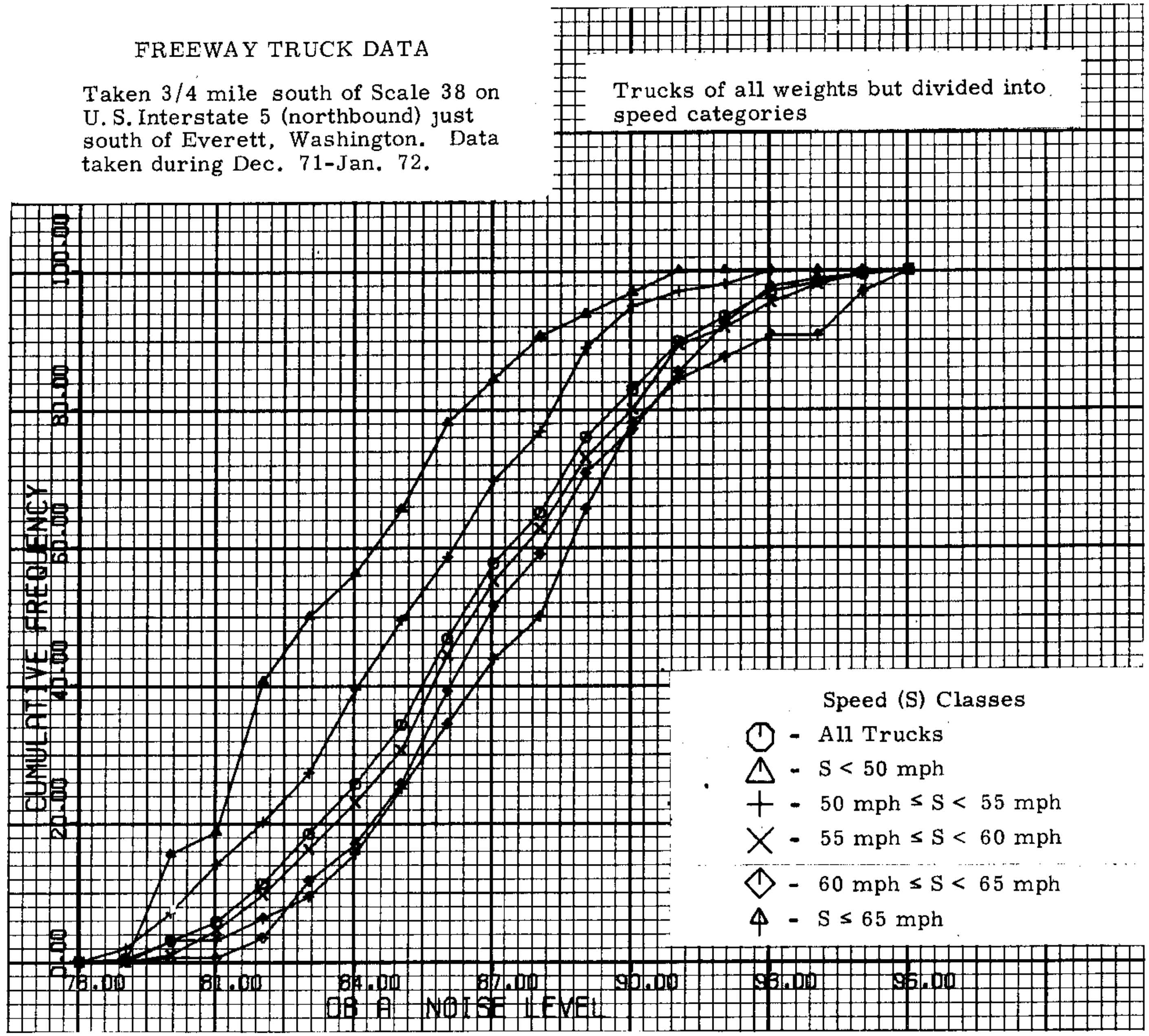
FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
SPEED 55 - 60 mph
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
75.00
78.00
81.00
84.00
87.00
90.00
93.00

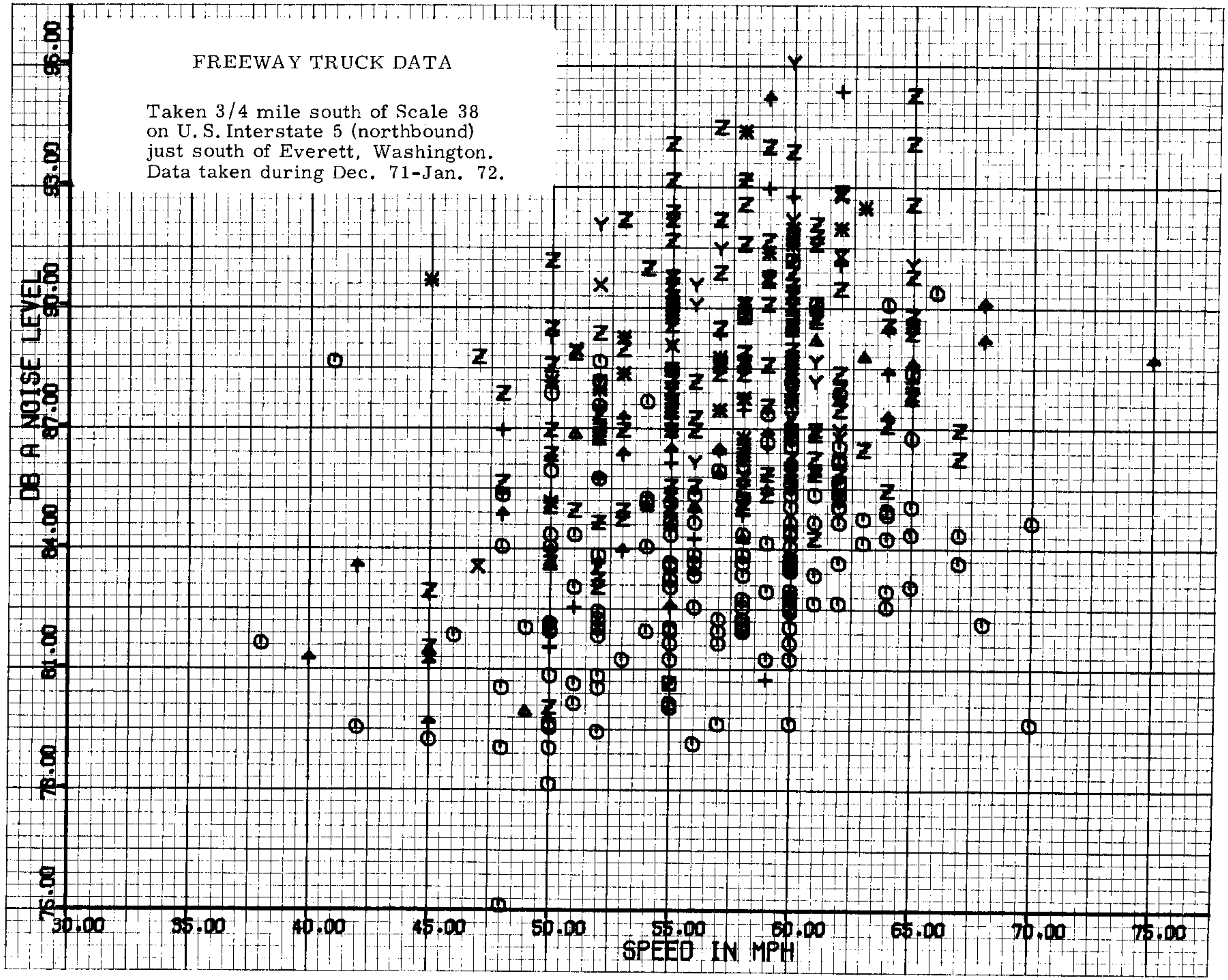

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72
SPEED 60 - 65 mph
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
75.00
78.00
81.00
84.00
87.00
90.00
93.00
96.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00

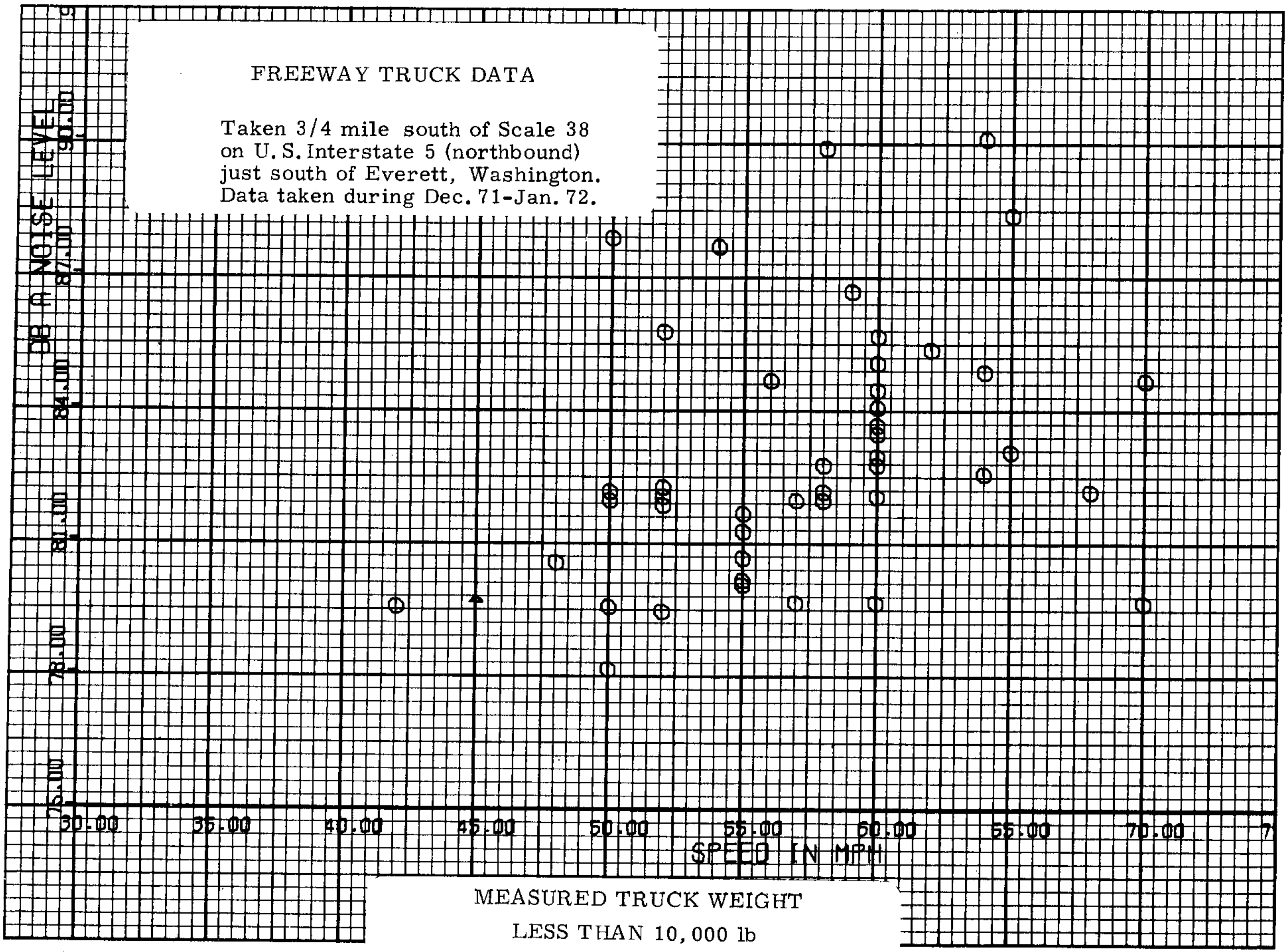

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
SPEED OVER 65 mph
DB A NOISE LEVEL
75.00
78.00
81.00
84.00
87.00
90.00
93.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS

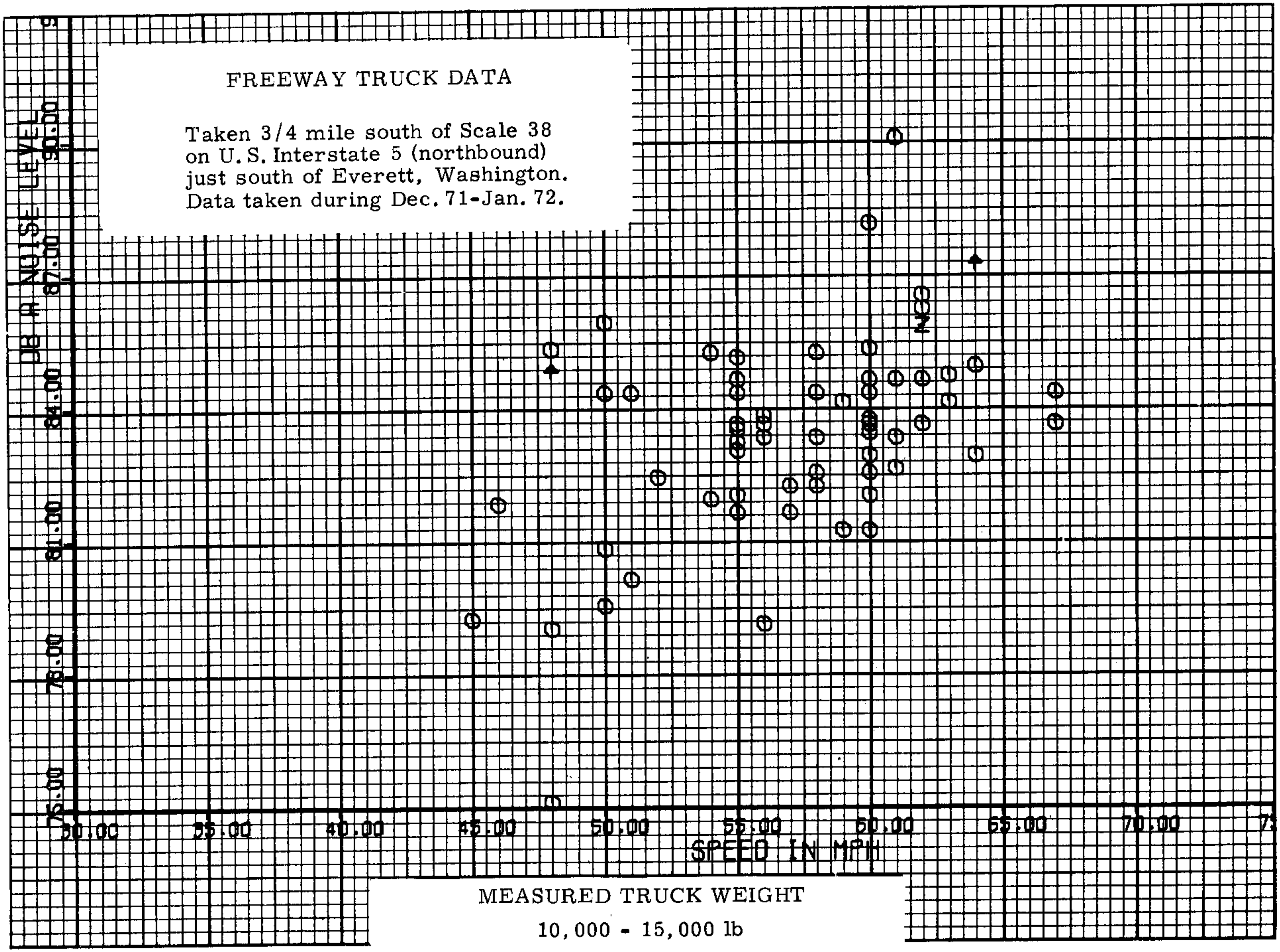
FREEWAY TRUCK DATA

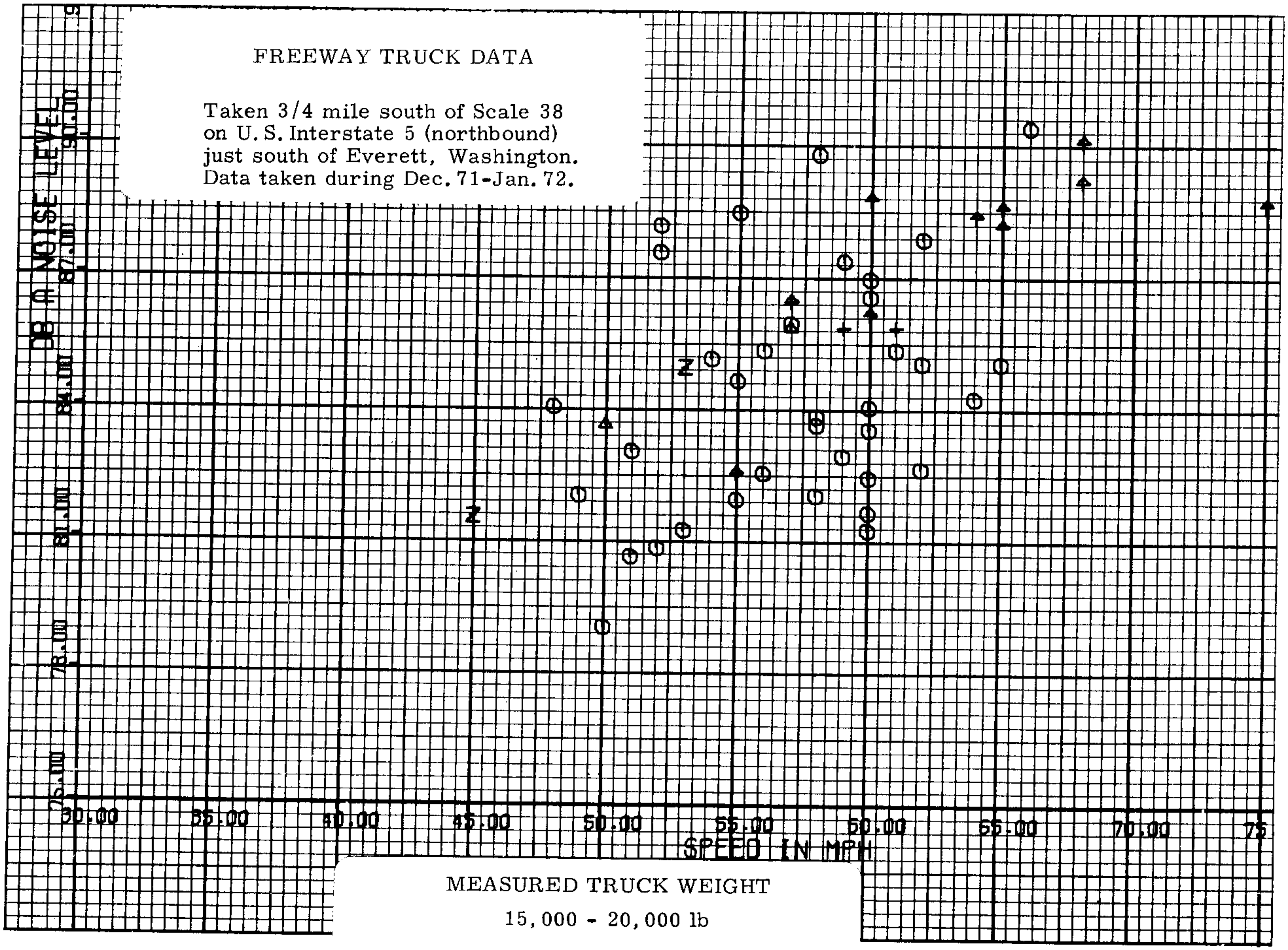
Taken 3/4 mile south of Scale 38 on U. S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.

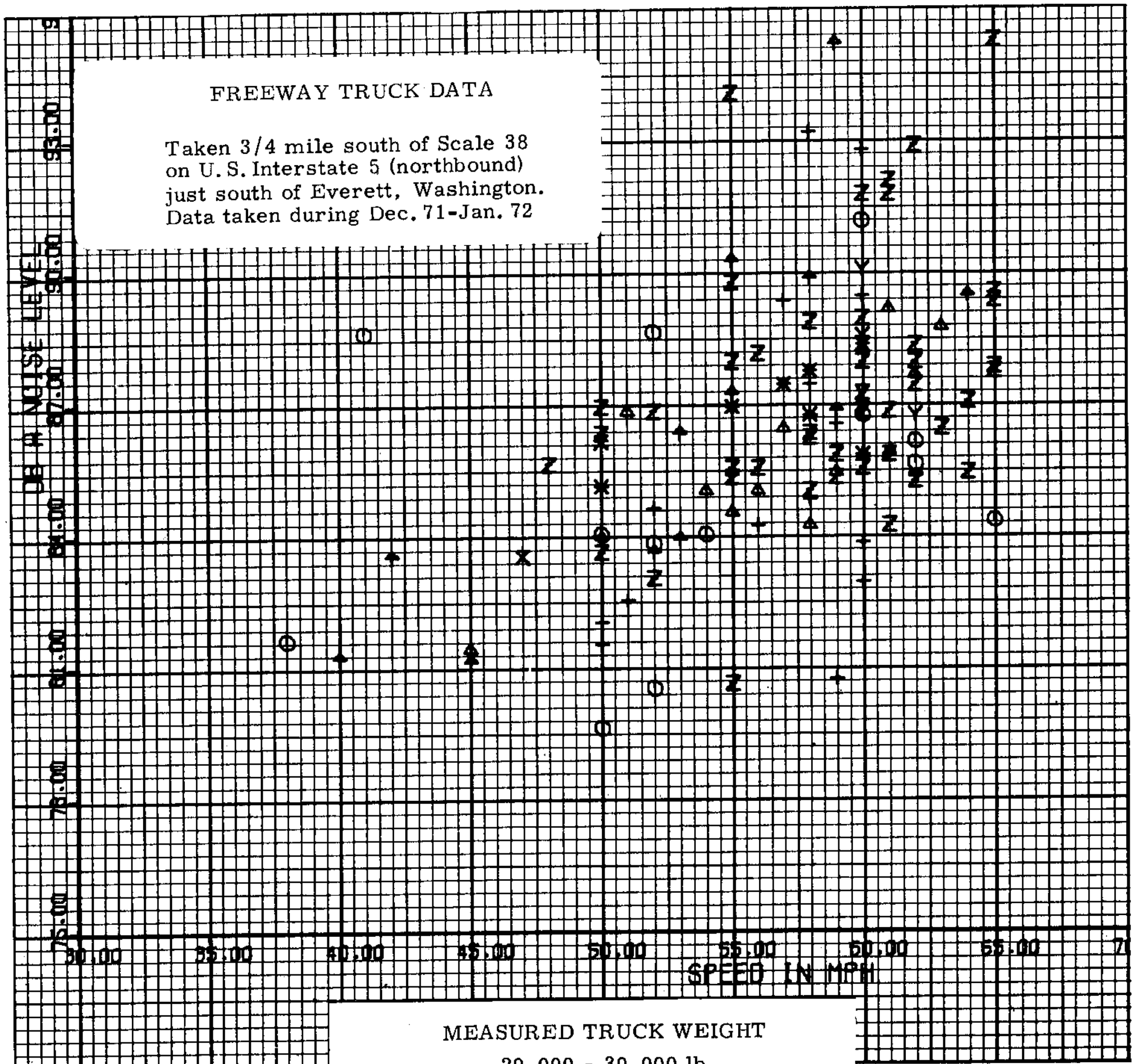



FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
DB A NOISE LEVEL
96.00
93.00
90.00
87.00
84.00
81.00
78.00
75.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
SPEED IN MPH


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
DB A NOISE LEVEL
90.00
87.00
84.00
81.00
78.00
75.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
SPEED IN MPH
MEASURED TRUCK WEIGHT
LESS THAN 10,000 lb

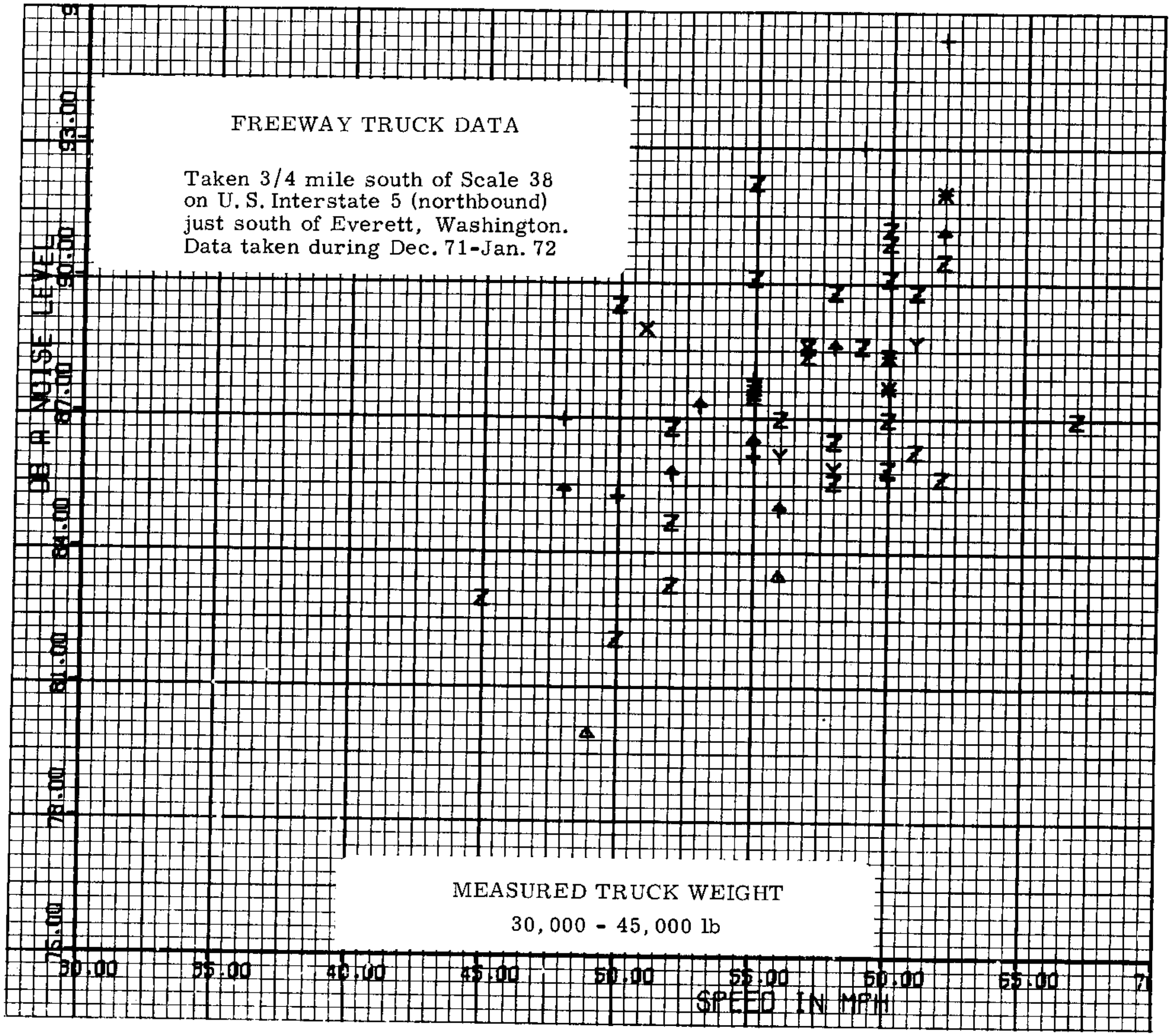

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
DB A NOISE LEVEL
90.00
87.00
84.00
81.00
78.00
75.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
SPEED IN MPH
MEASURED TRUCK WEIGHT
10,000 - 15,000 lb

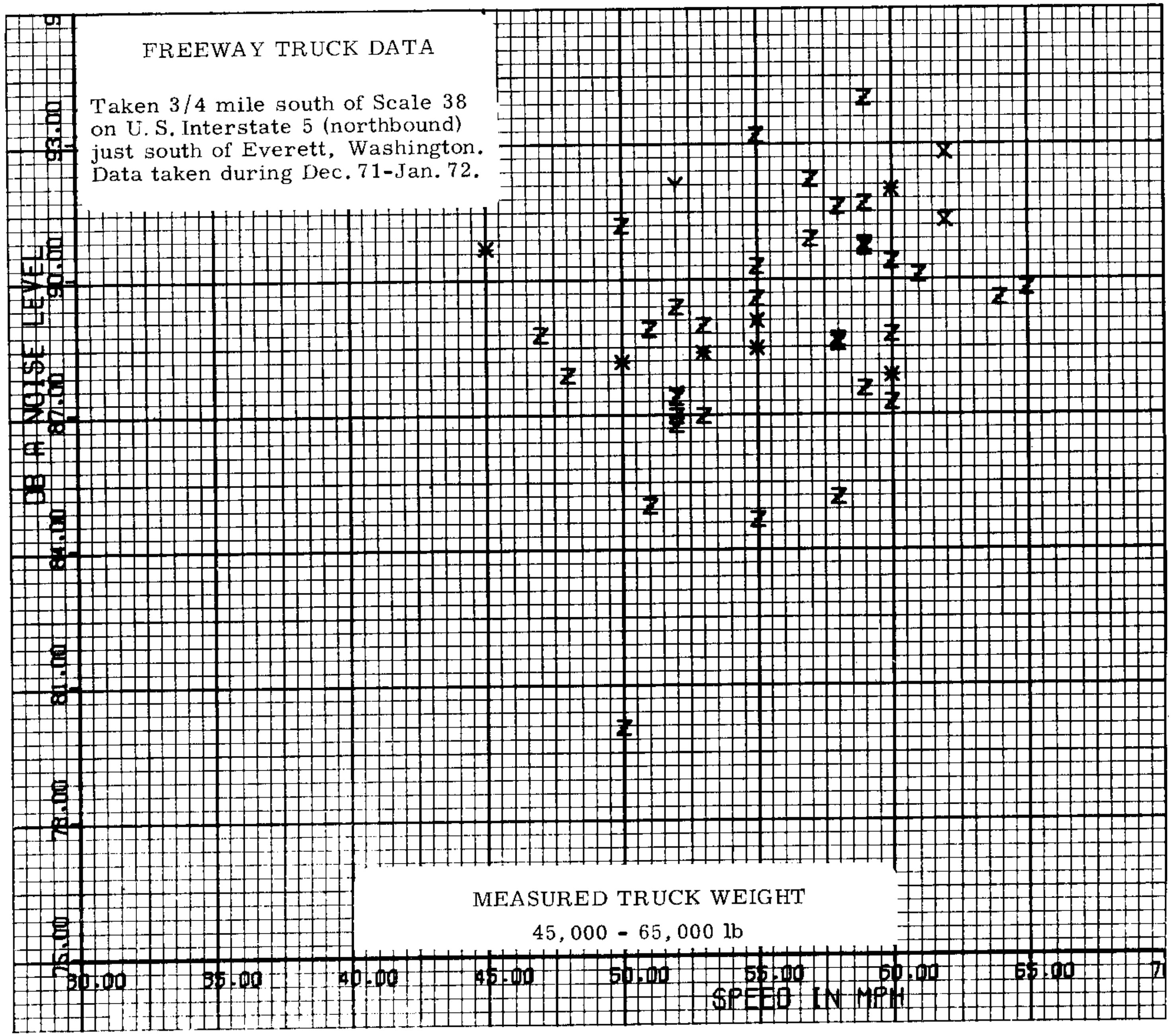

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
DB A NOISE LEVEL
75.00
78.00
81.00
84.00
87.00
90.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75
SPEED IN MPH
MEASURED TRUCK WEIGHT
15,000 - 20,000 lb



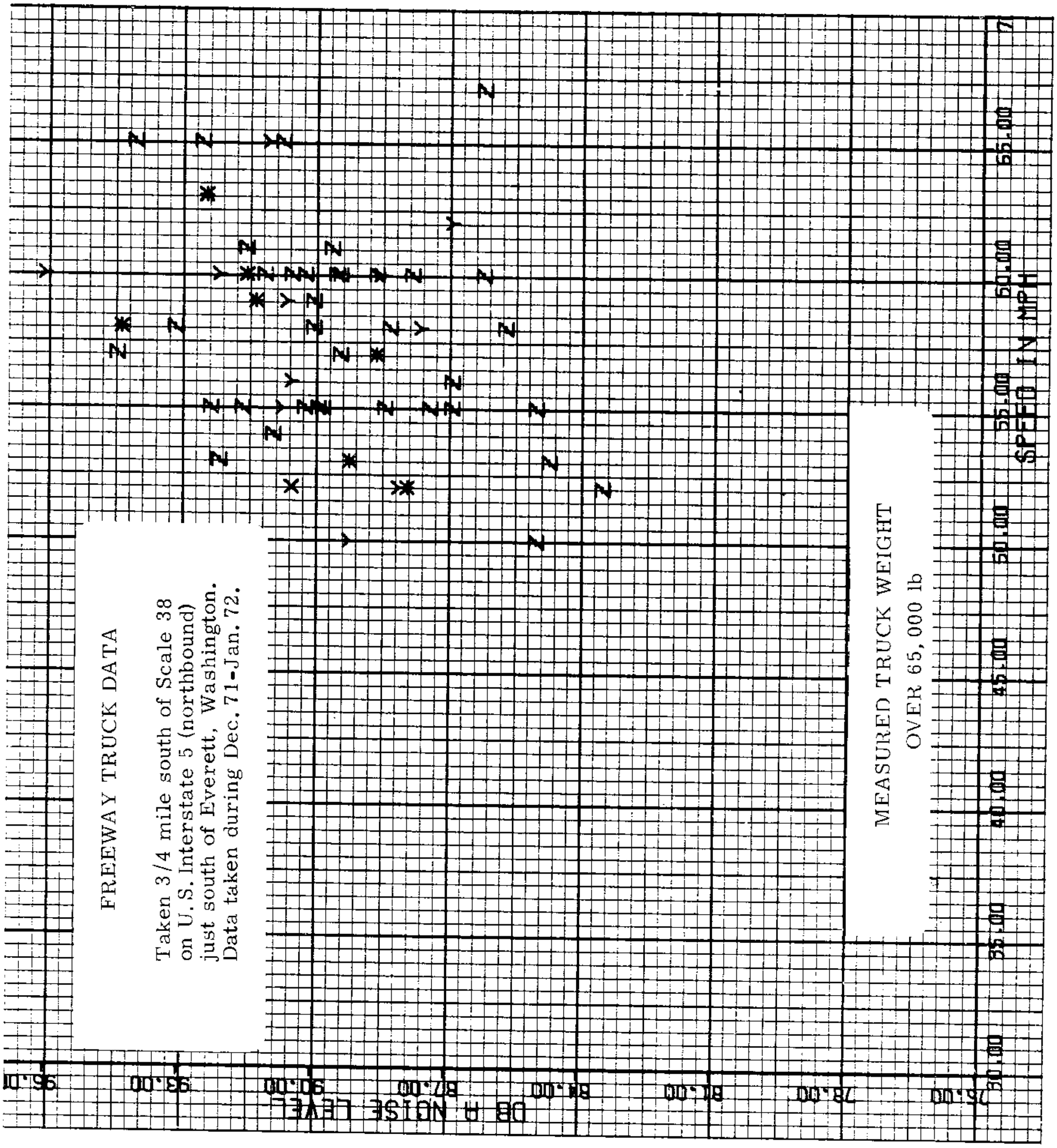
MEASURED TRUCK WEIGHT

20,000 - 30,000 lb


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U. S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72
MEASURED TRUCK WEIGHT
30,000 - 45,000 lb
DB A NOISE LEVEL
93.00
90.00
87.00
84.00
81.00
78.00
75.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
SPEED IN MPH

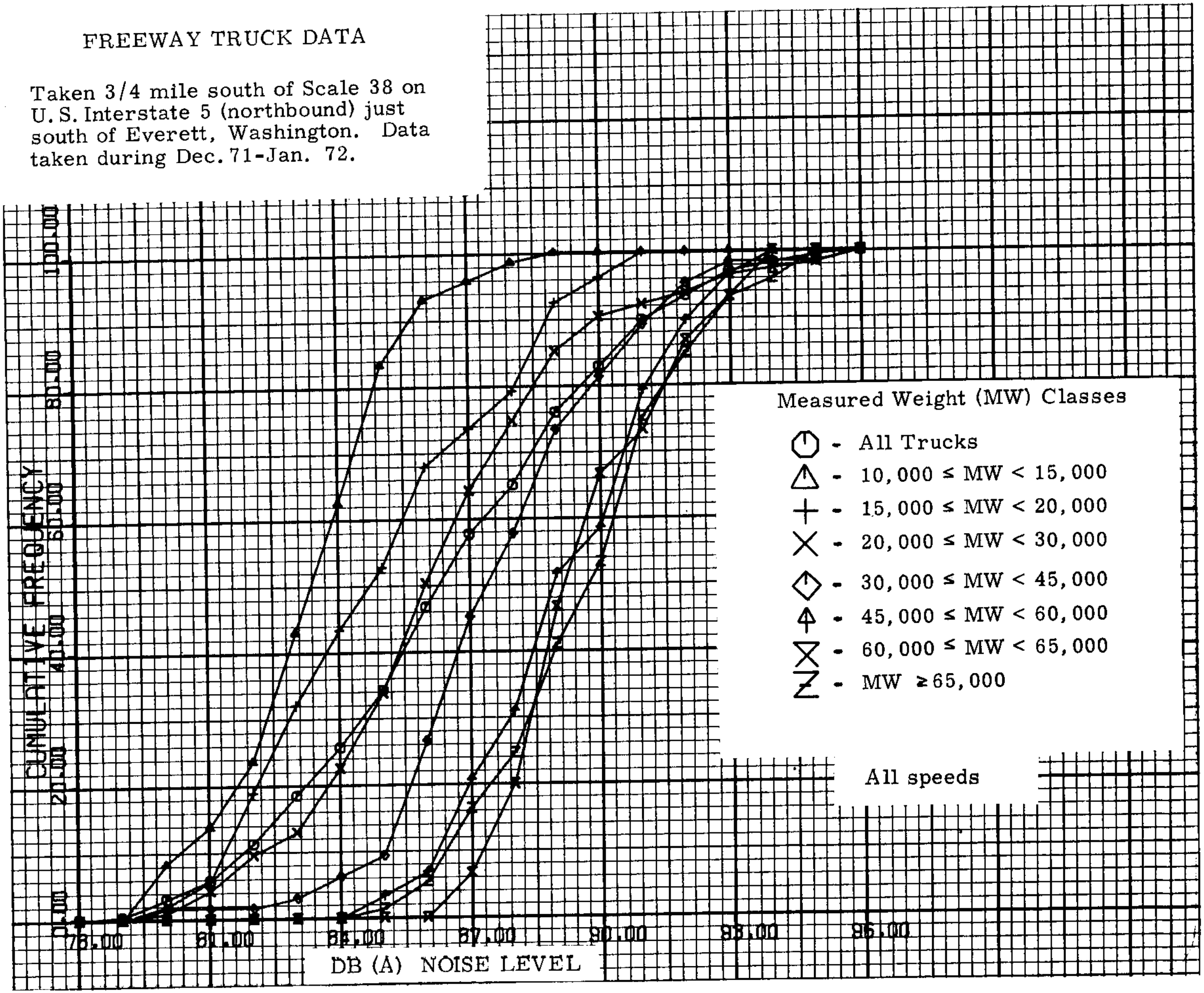


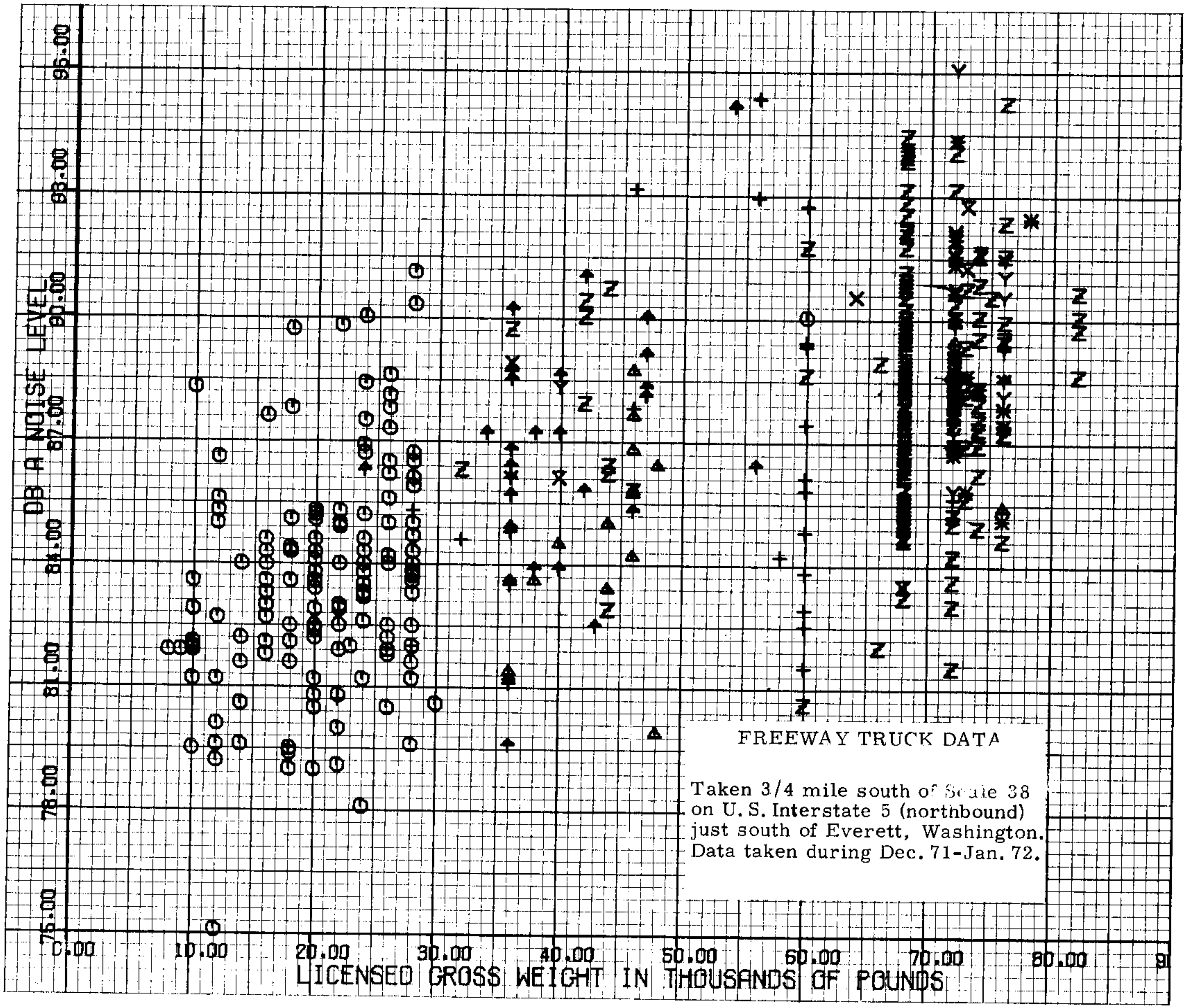
FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
MEASURED TRUCK WEIGHT
45,000 - 65,000 lb
DB A NOISE LEVEL
93.00
90.00
87.00
84.00
81.00
78.00
75.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
SPEED IN MPH

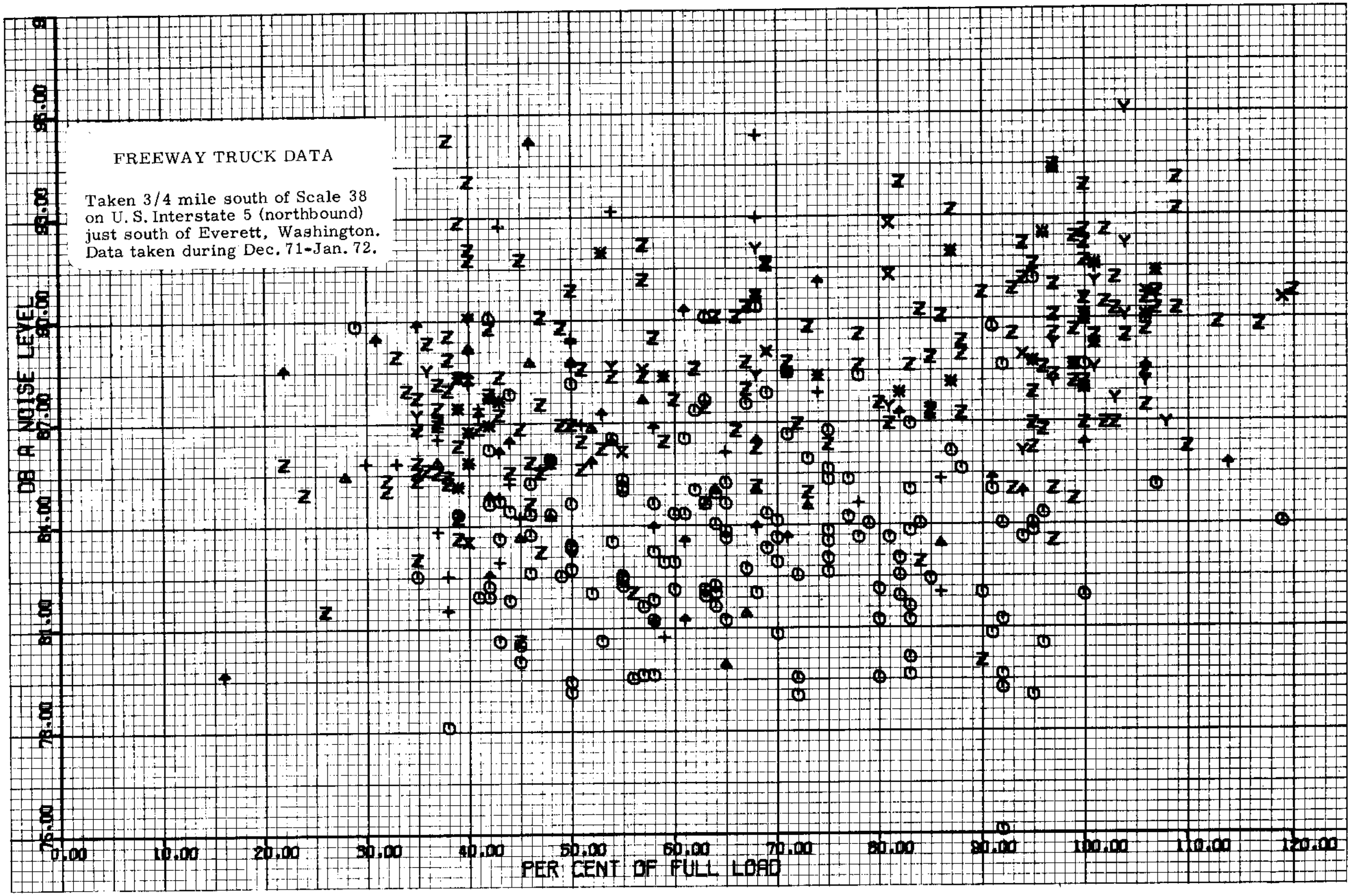

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
MEASURED TRUCK WEIGHT
OVER 65,000 lb
SPEED IN MPH
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
DB A NOISE LEVEL
75.00
78.00
81.00
84.00
87.00
90.00
93.00
96.00

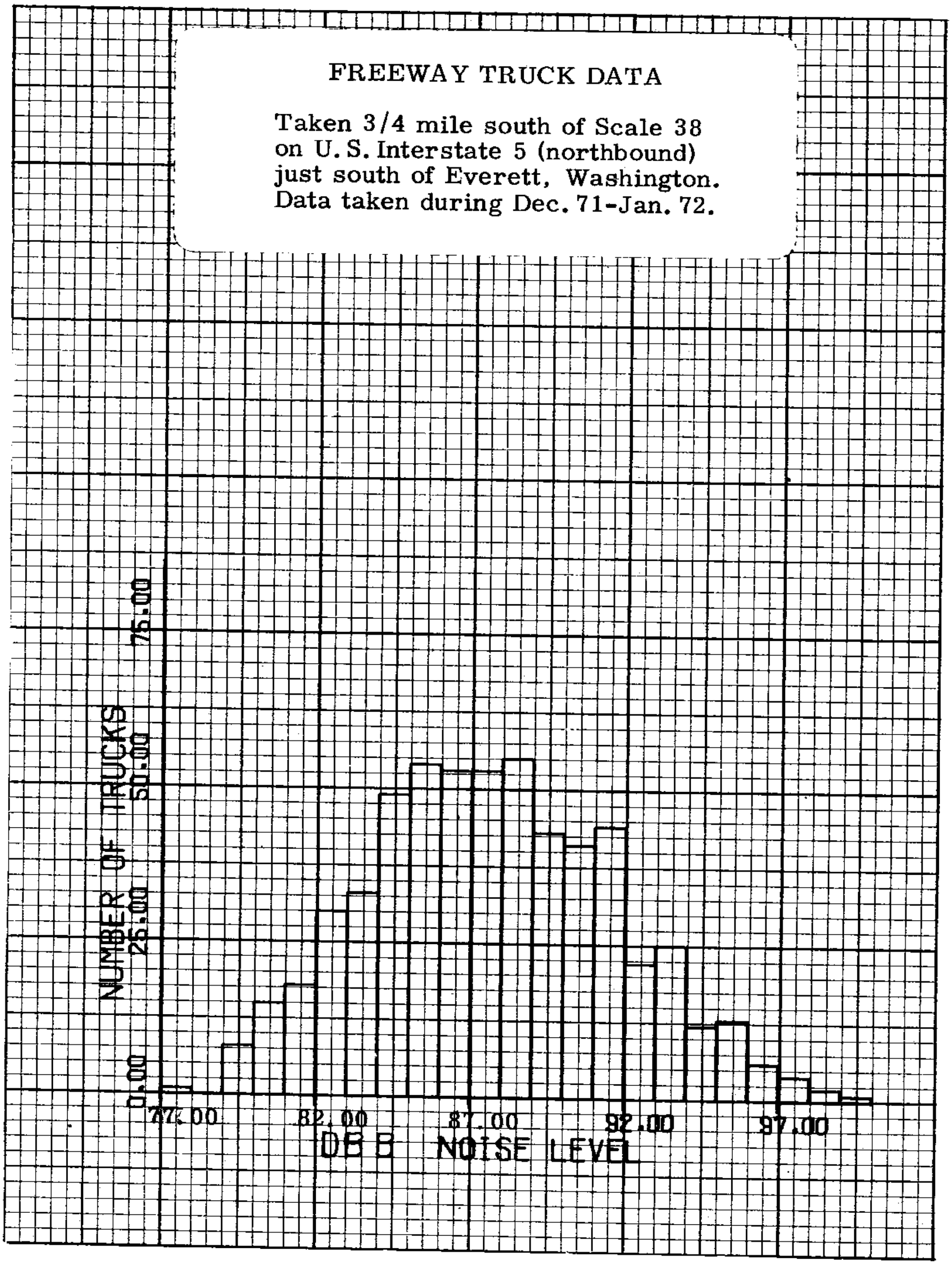
FREEWAY TRUCK DATA

Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.



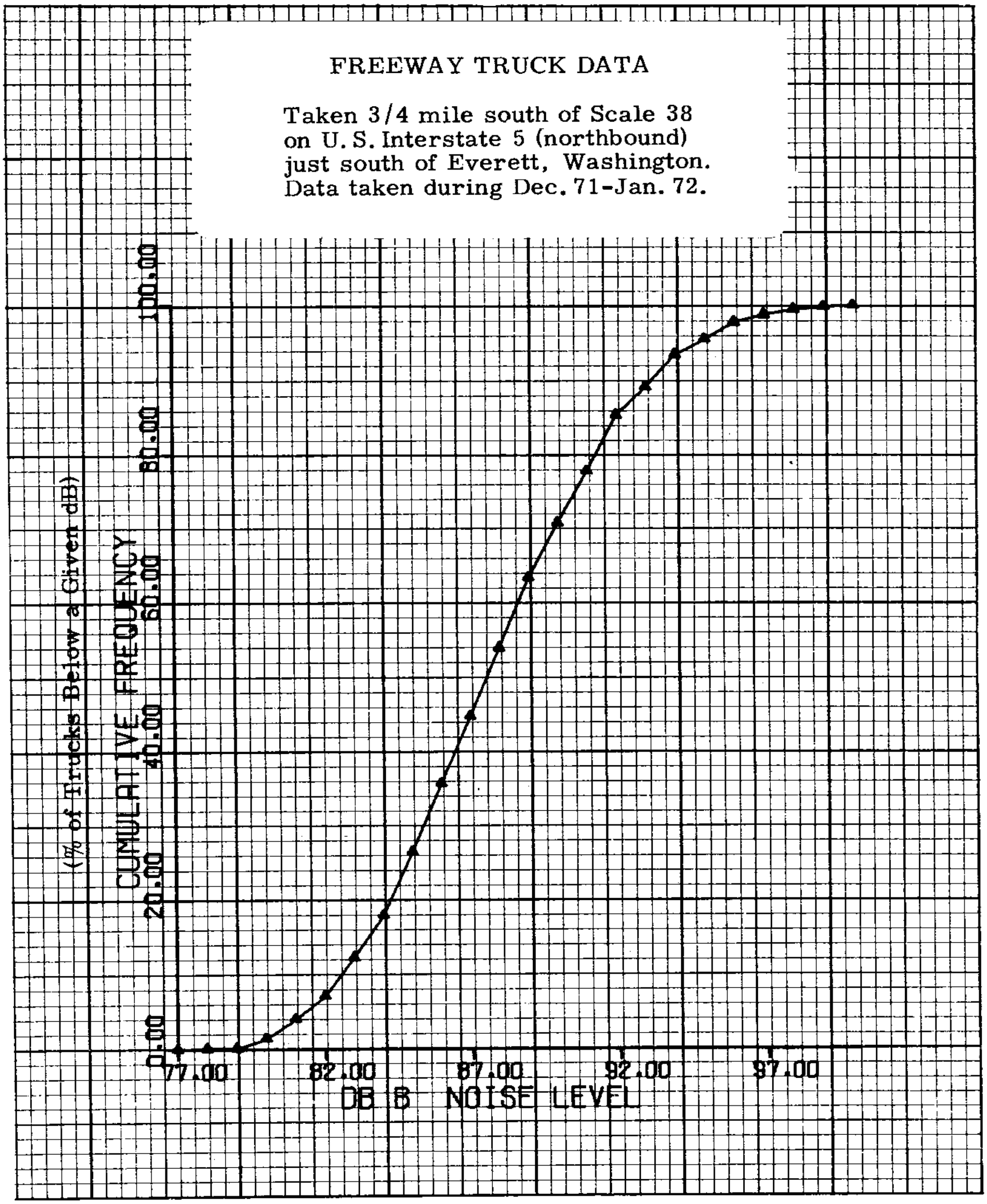

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
DB A NOISE LEVEL
75.00
78.00
81.00
84.00
87.00
90.00
93.00
95.00
LICENSED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
DB A NOISE LEVEL
PER CENT OF FULL LOAD
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
75.00
78.00
81.00
84.00
87.00
90.00
93.00
96.00



ACCUMULATIVE PERCENTAGE
OF ALL TRUCKS MEASURED
B WEIGHTING

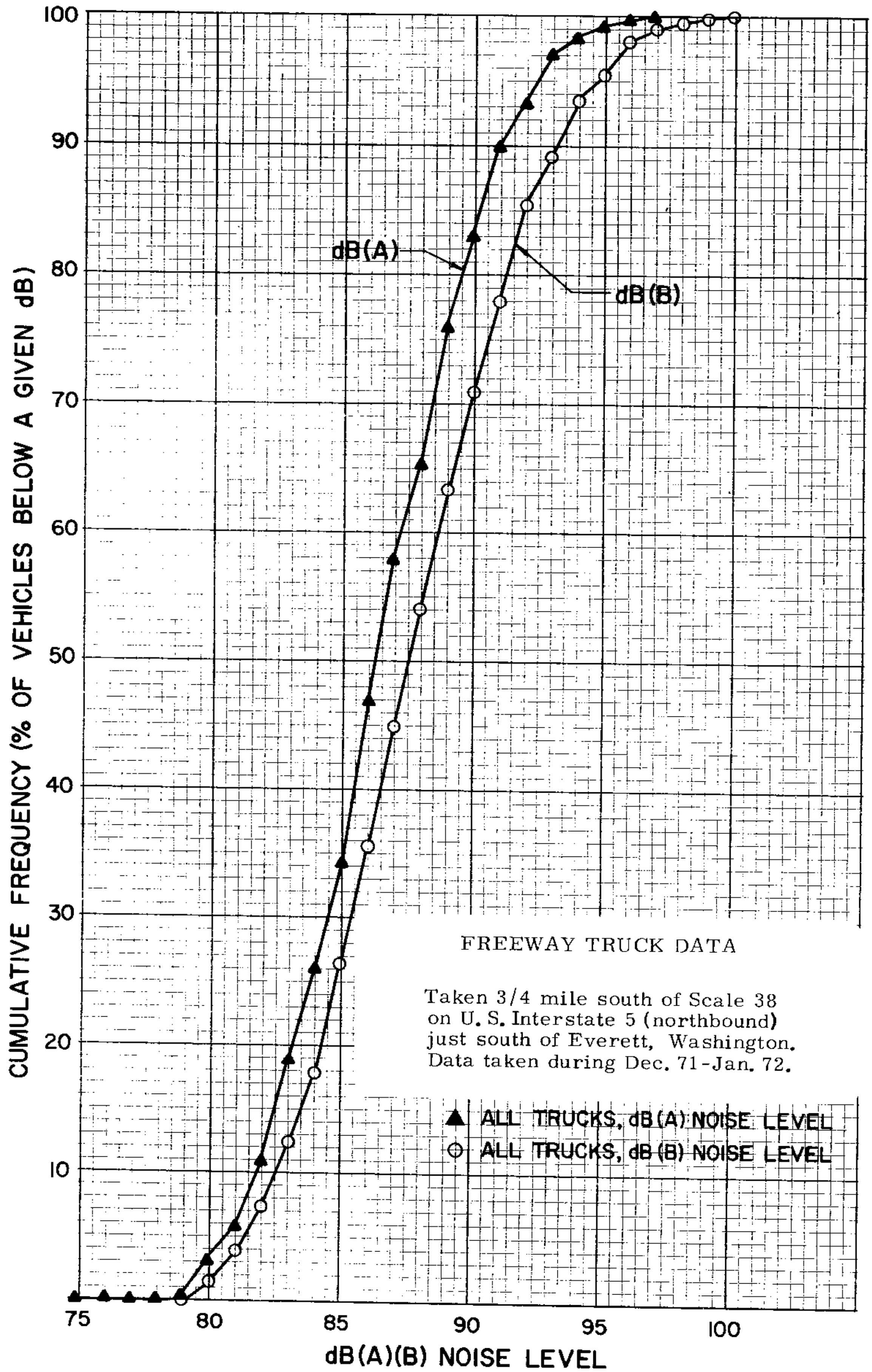
SAMPLE SIZE: 582

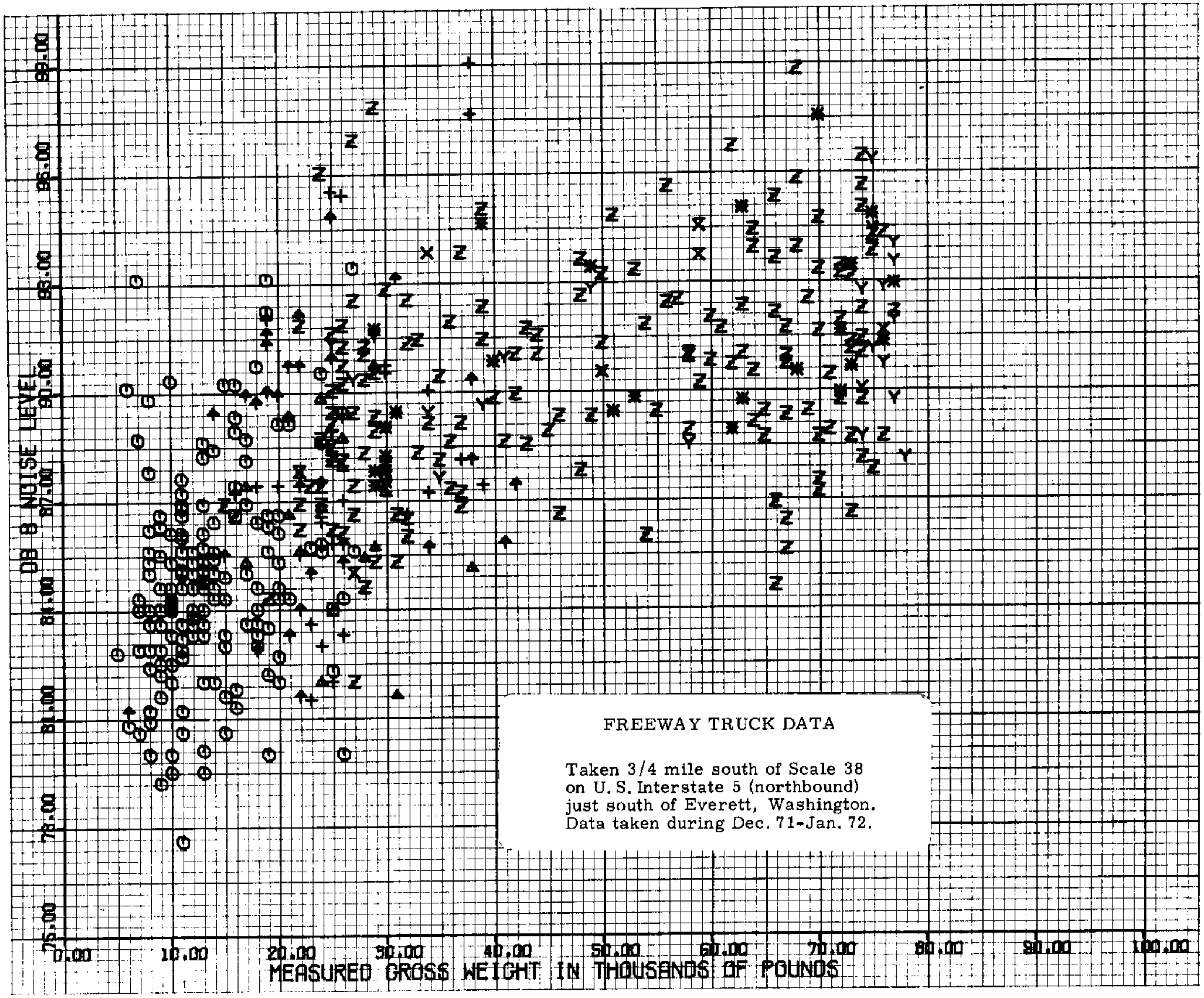


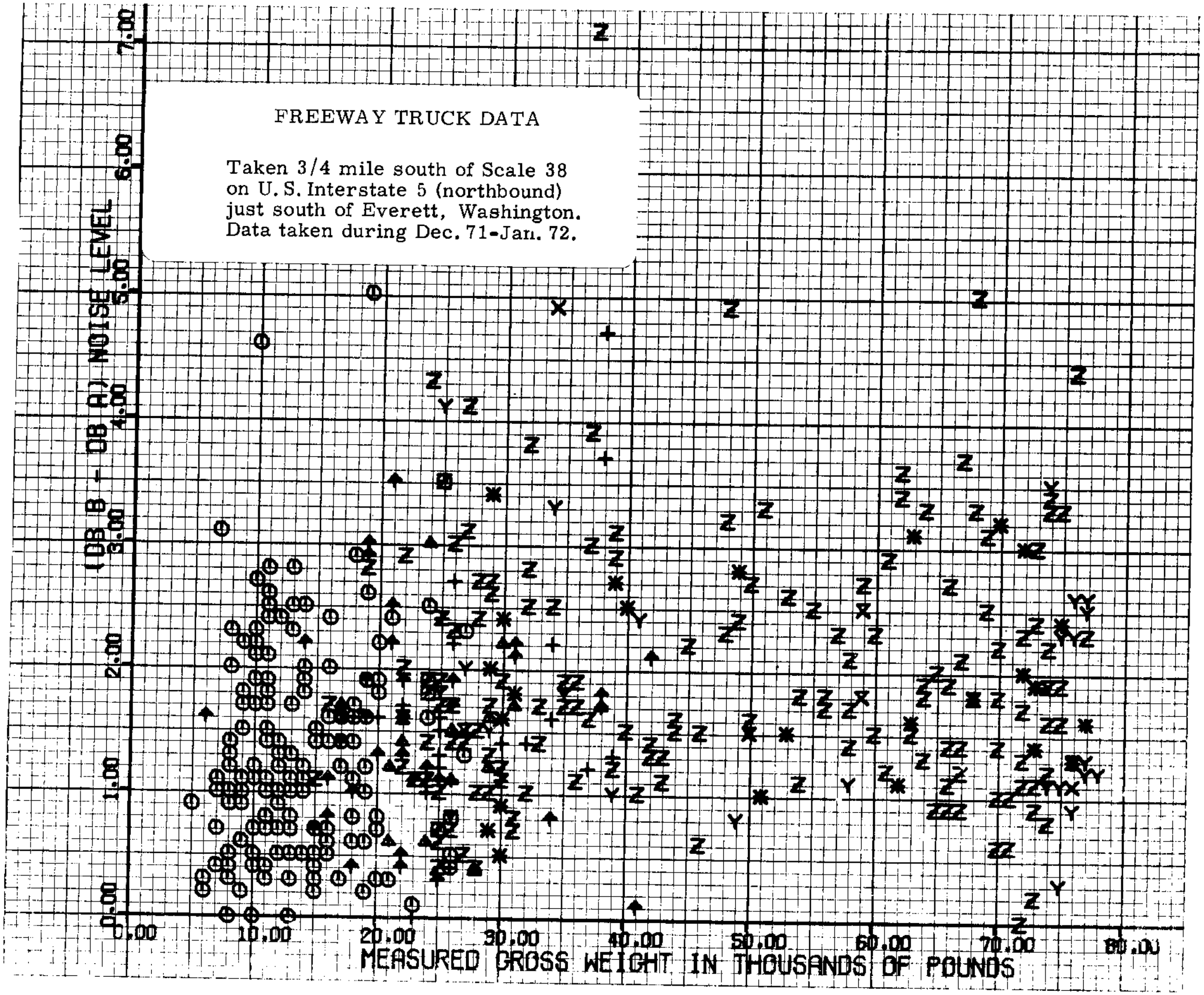
HISTOGRAM OF ALL TRUCKS MEASURED

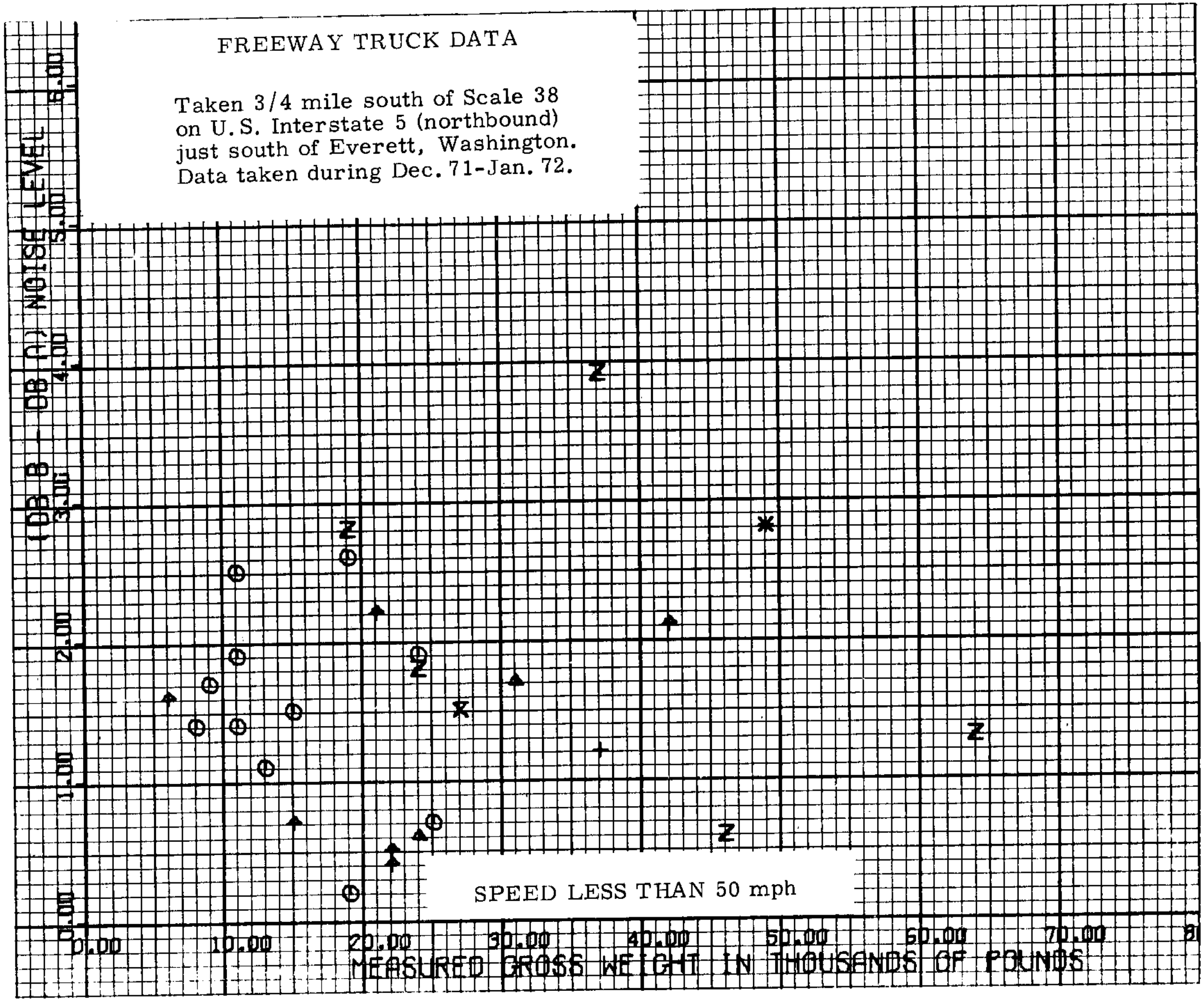
B WEIGHTING

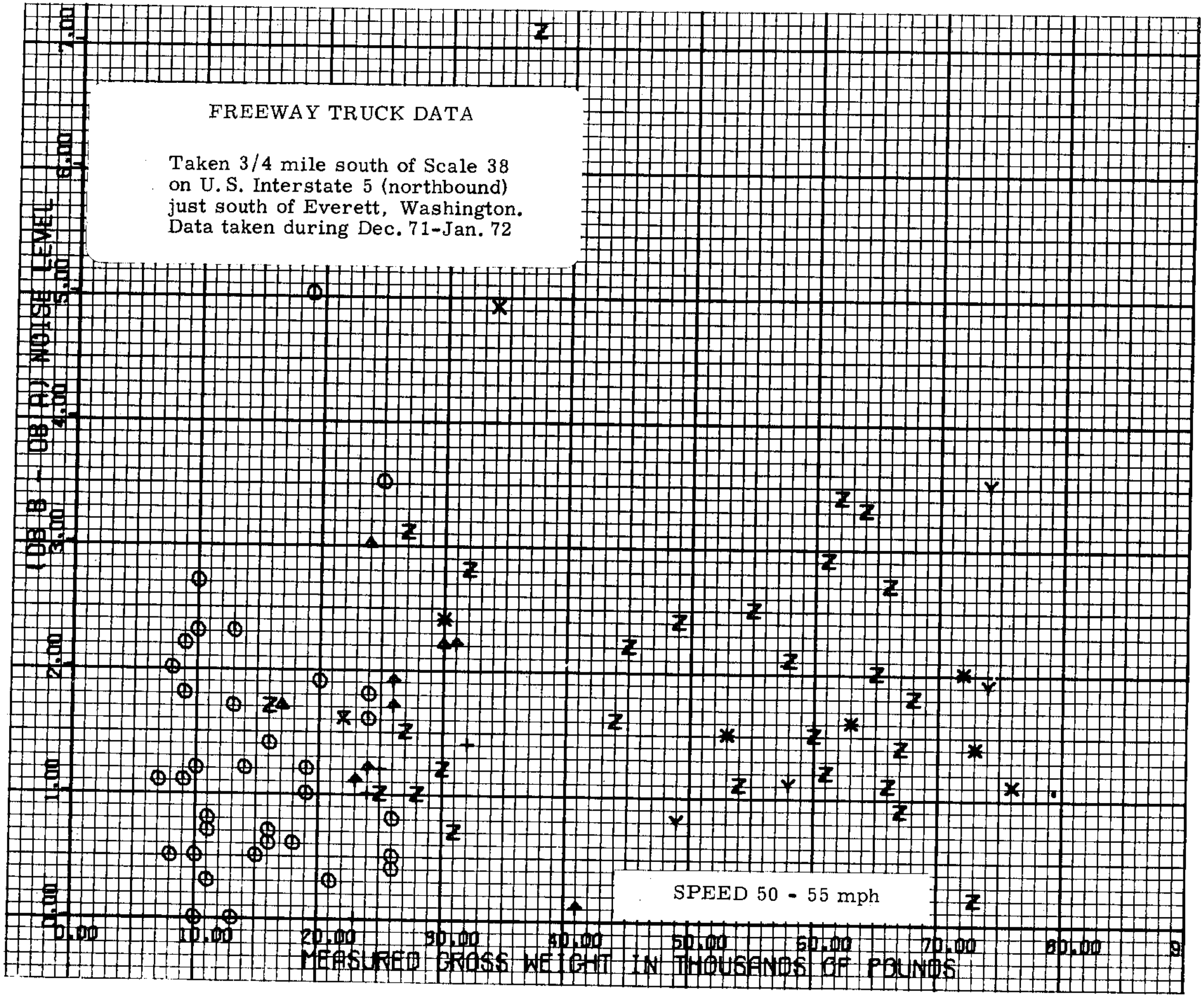
SAMPLE SIZE: 582

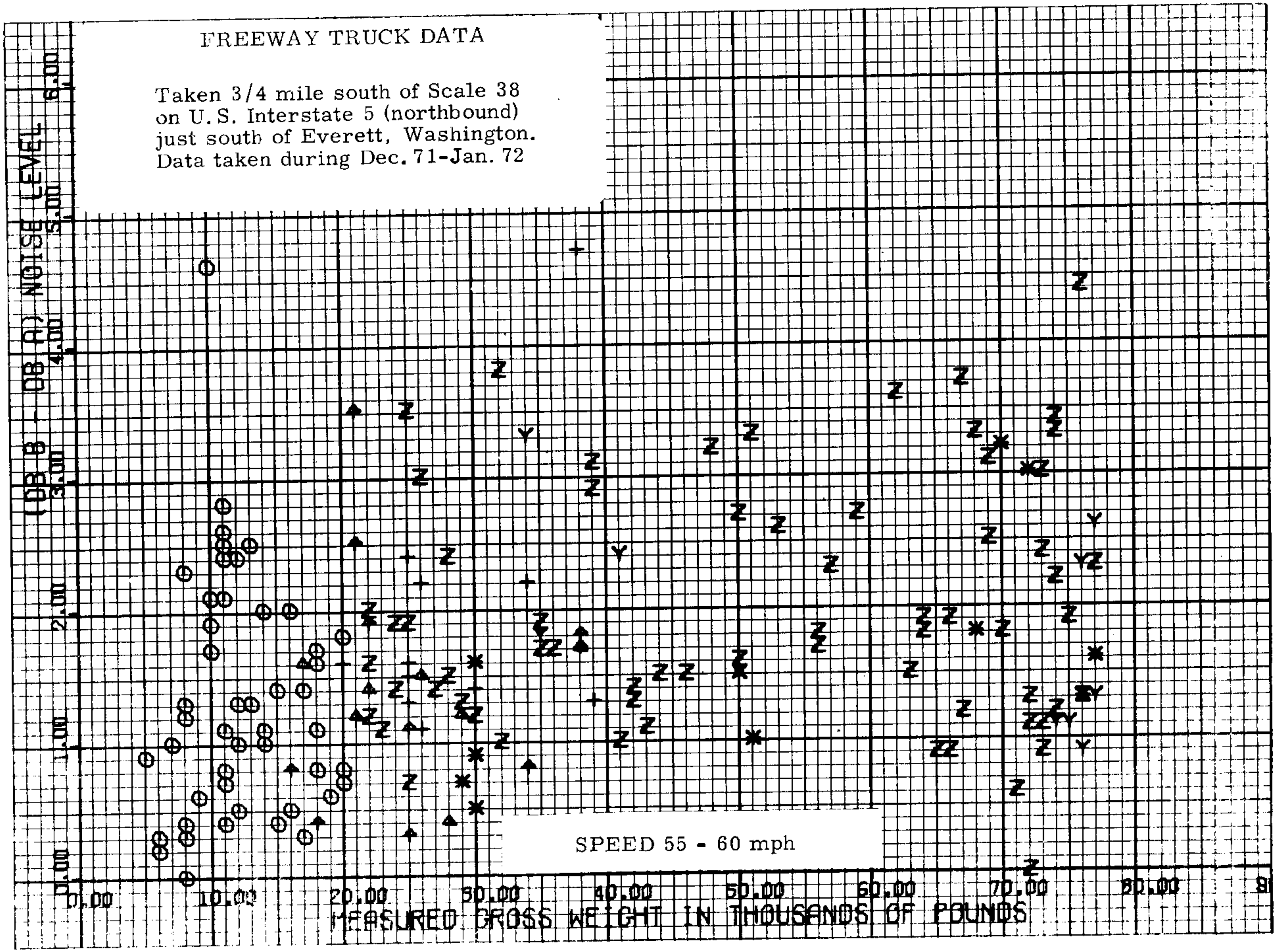

100
90
80
70
60
50
40
30
20
10
CUMULATIVE FREQUENCY (% OF VEHICLES BELOW A GIVEN dB)
dB(A)
dB(B)
FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U. S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
ALL TRUCKS, dB (A) NOISE LEVEL
ALL TRUCKS, dB (B) NOISE LEVEL
75
80
85
90
95
100
dB(A)(B) NOISE LEVEL

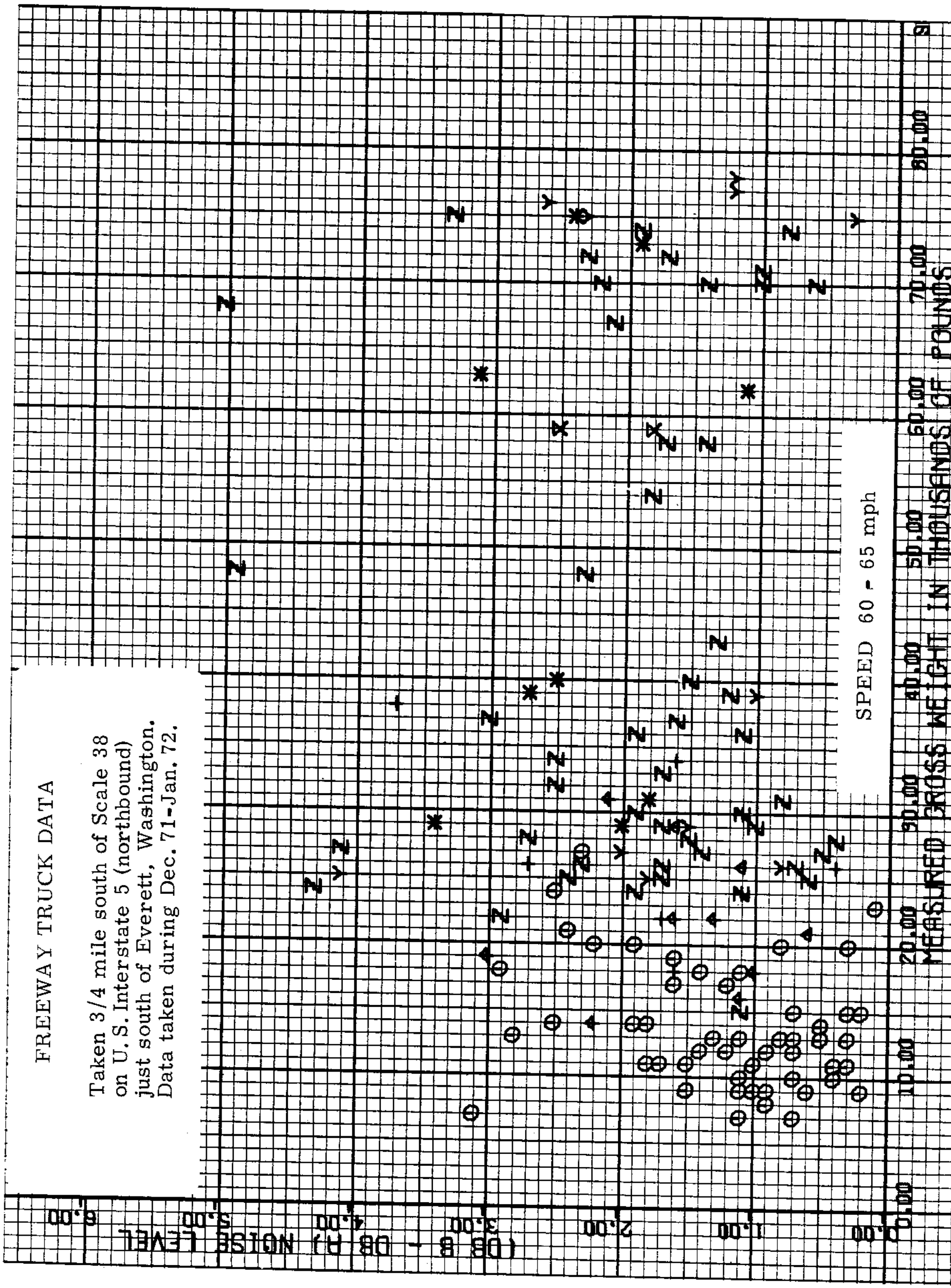

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
DB B NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
75.00
78.00
81.00
84.00
87.00
90.00
93.00
96.00
99.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

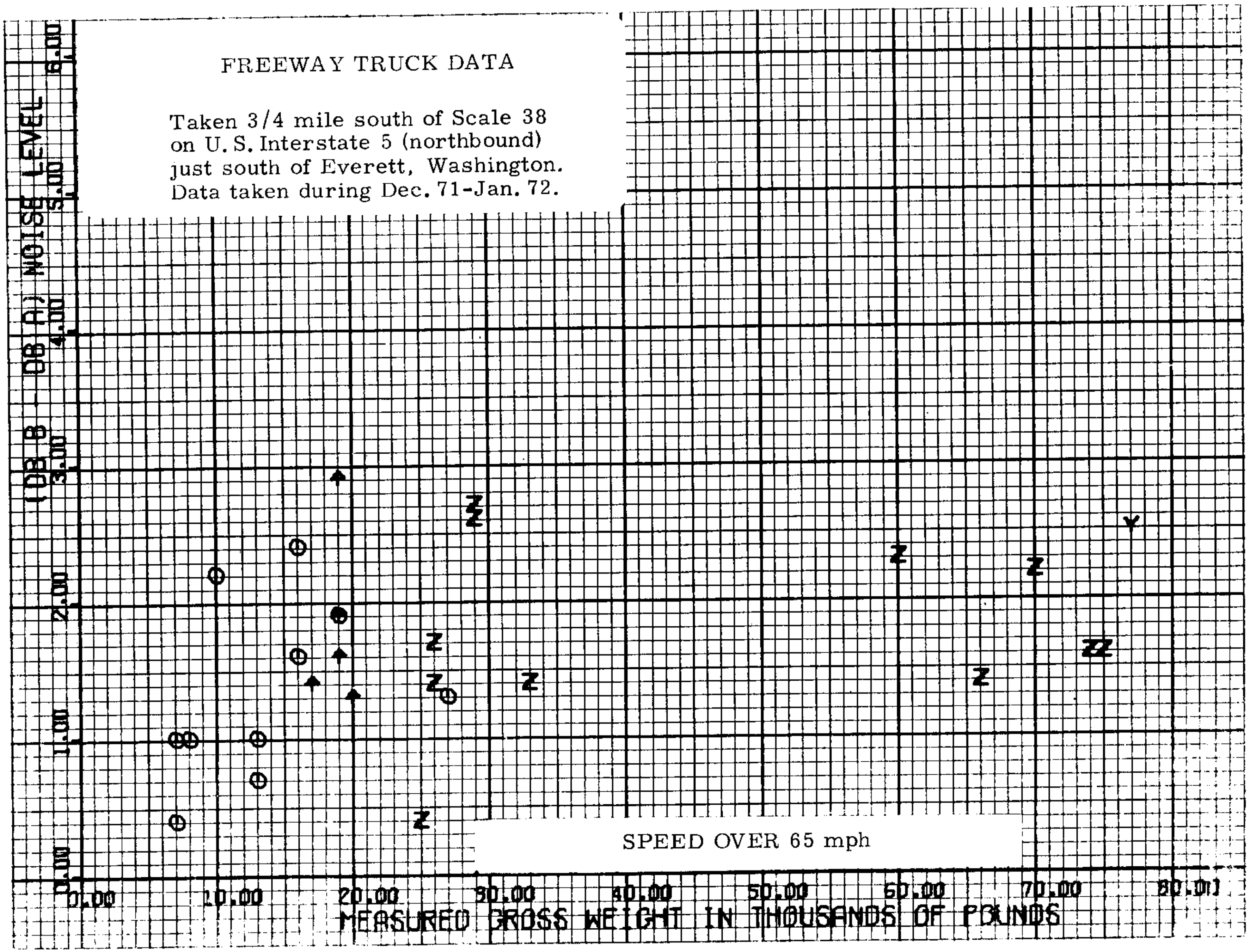

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
(DB B - DB A) NOISE LEVEL
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
(DB B - DB A) NOISE LEVEL
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
SPEED LESS THAN 50 mph


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72
SPEED 50 - 55 mph
(DB B - DB A) NOISE LEVEL
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS

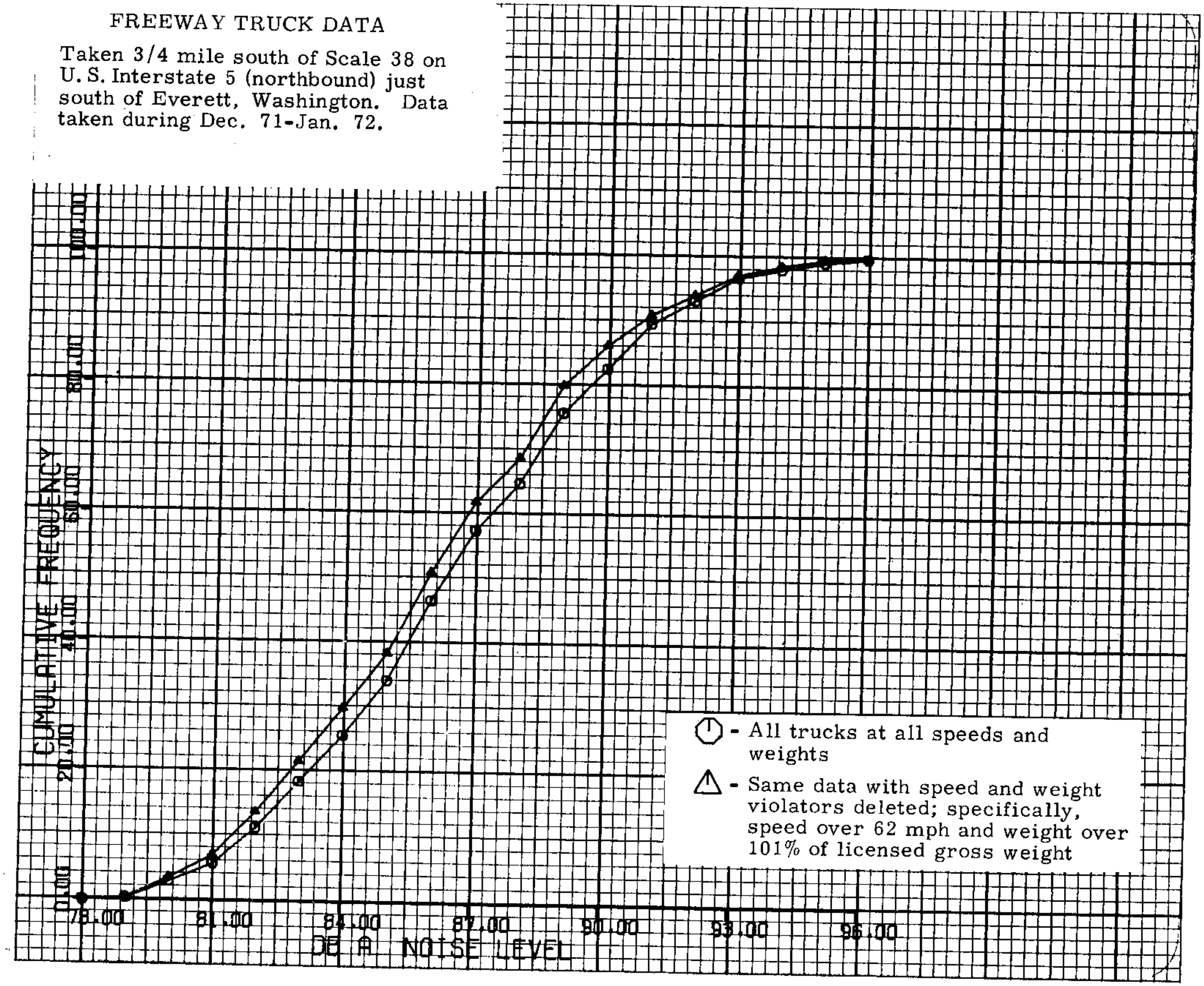

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72
SPEED 55 - 60 mph
(DB B - DB A) NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
1.00
2.00
3.00
4.00
5.00
6.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
SPEED 60 - 65 mph
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
(DB B - DB A) NOISE LEVEL
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
1.00
2.00
3.00
4.00
5.00
6.00


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
SPEED OVER 65 mph
(DB B - DB A) NOISE LEVEL
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS

FREEWAY TRUCK DATA

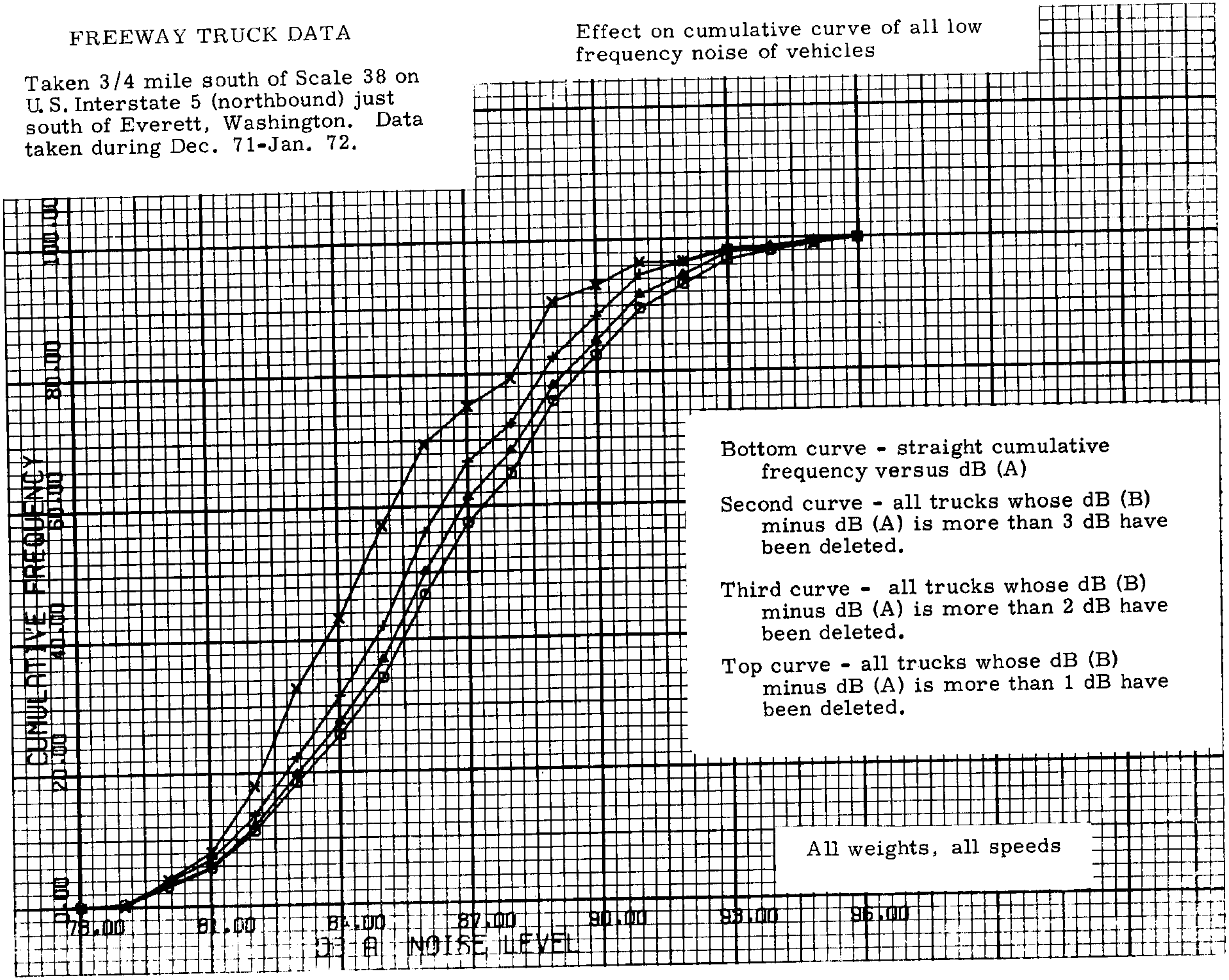
Taken 3/4 mile south of Scale 38 on U. S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.

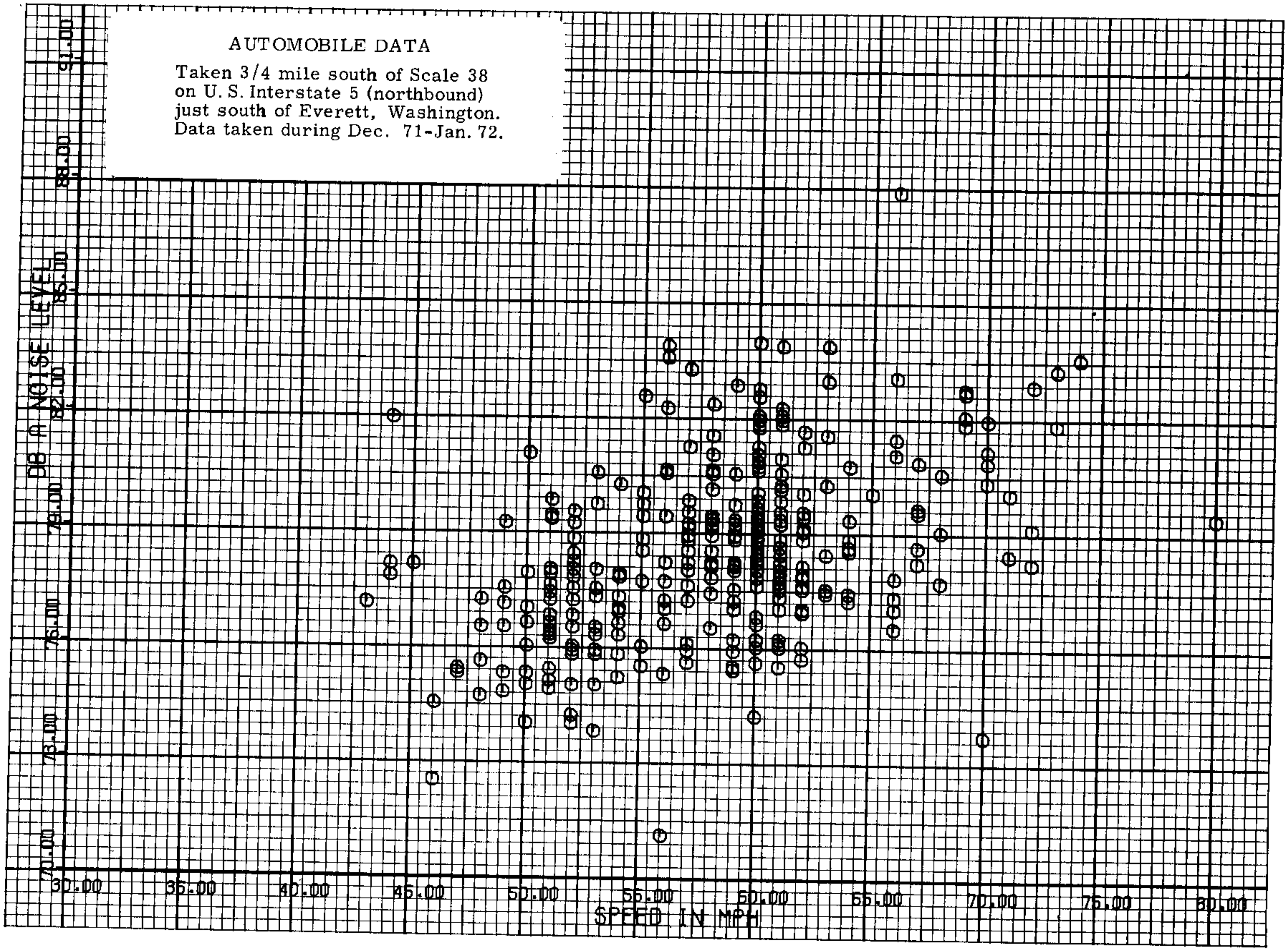


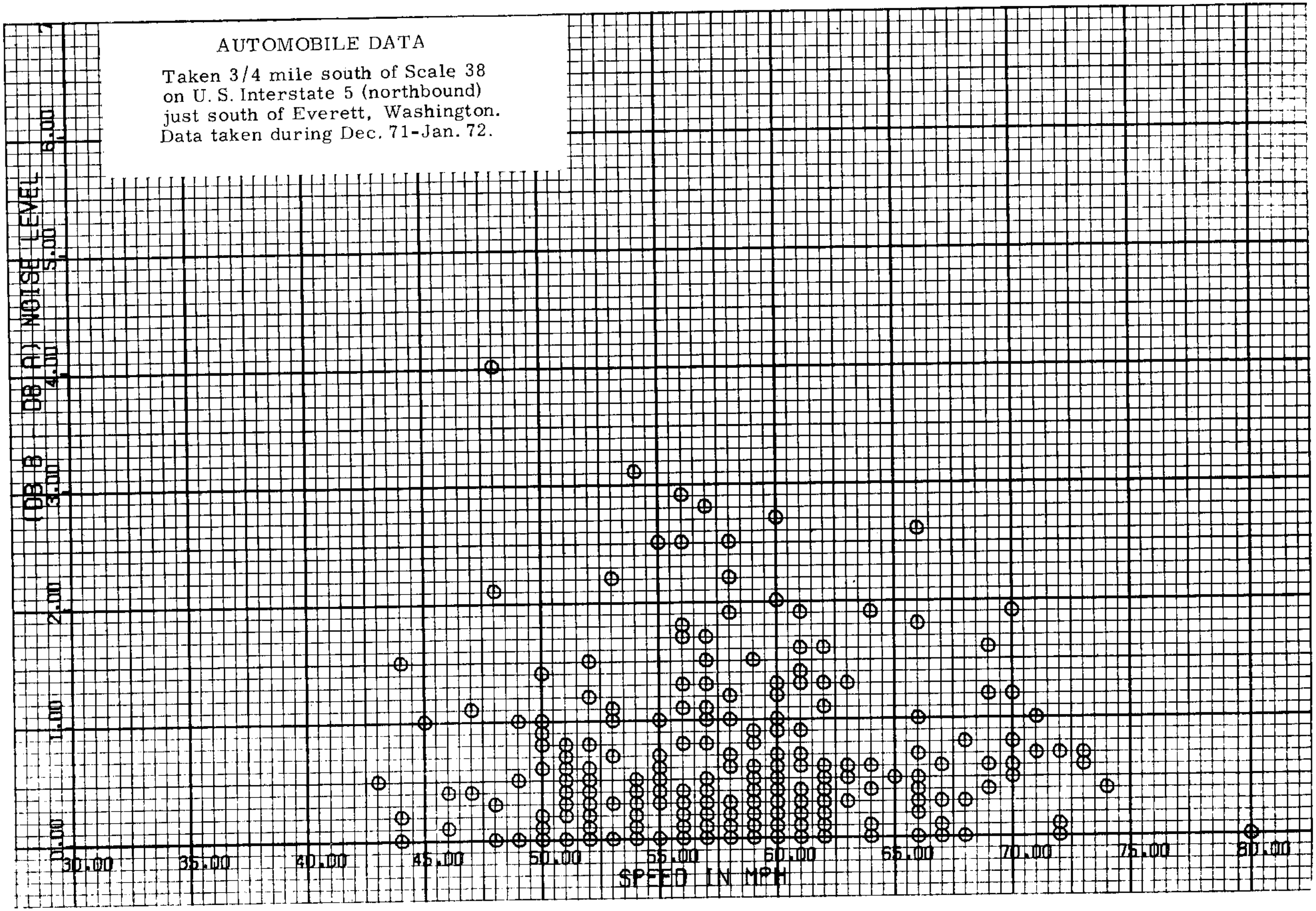
FREEWAY TRUCK DATA

Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.

Effect on cumulative curve of all low frequency noise of vehicles




AUTOMOBILE DATA
Taken 3/4 mile south of Scale 38
on U. S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
DB A NOISE LEVEL
91.00
88.00
85.00
82.00
79.00
76.00
73.00
70.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
SPEED IN MPH


AUTOMOBILE DATA
Taken 3/4 mile south of Scale 38
on U.S. Interstate 5 (northbound)
just south of Everett, Washington.
Data taken during Dec. 71-Jan. 72.
(DB B - DB A) NOISE LEVEL
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7
SPEED IN MPH
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00

APPENDIX B

DATA TAKEN MARCH 9, 1972, 1/2 MILE SOUTH OF SCALE 26 ON U.S. INTERSTATE 5 (NORTHBOUND) EAST OF FIFE, WASHINGTON.

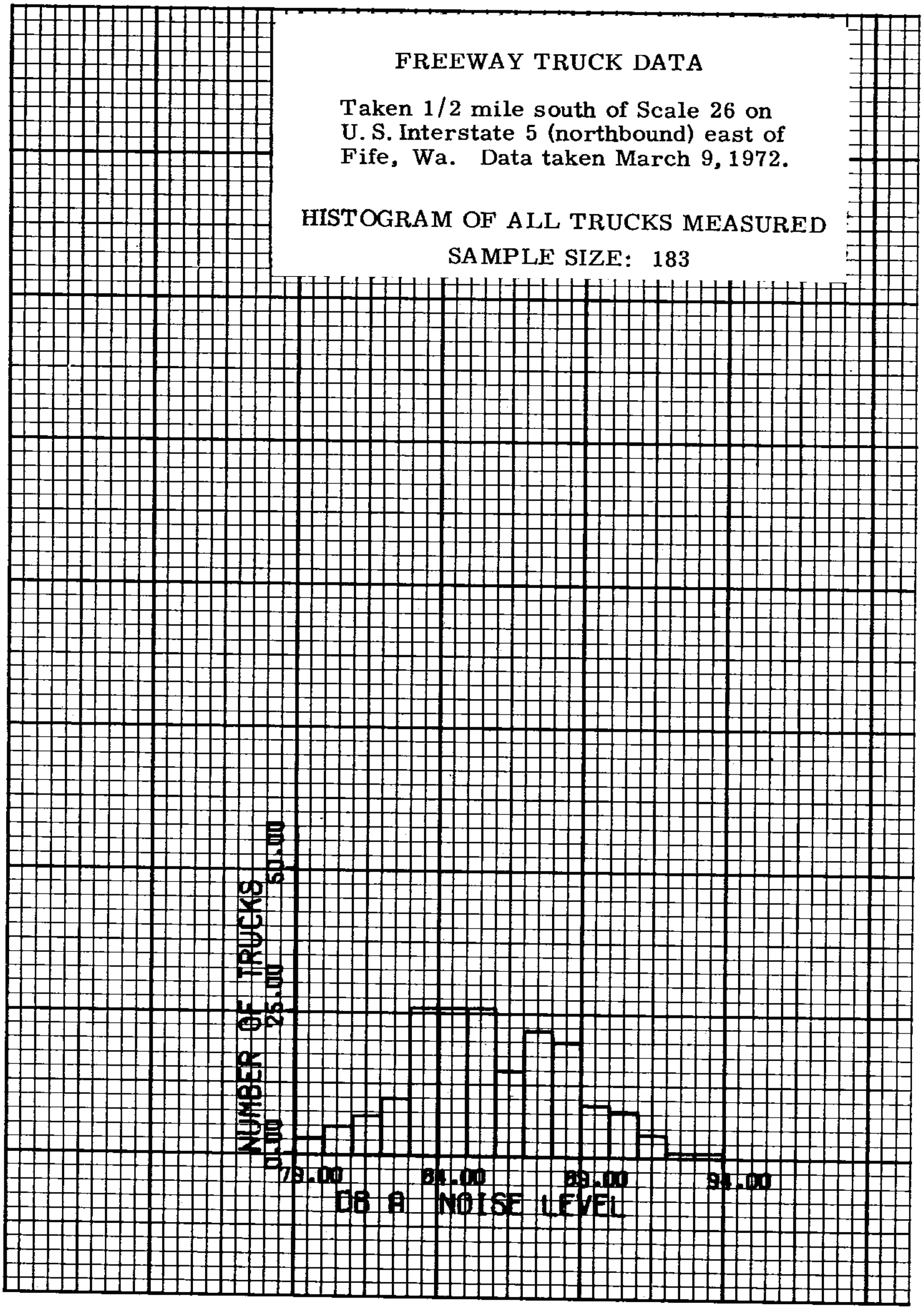
(See Figure 17 in main text for key to symbols representing each class of truck.)

FREEWAY TRUCK DATA

Taken 1/2 mile south of Scale 26 on
U. S. Interstate 5 (northbound) east of
Fife, Wa. Data taken March 9, 1972.

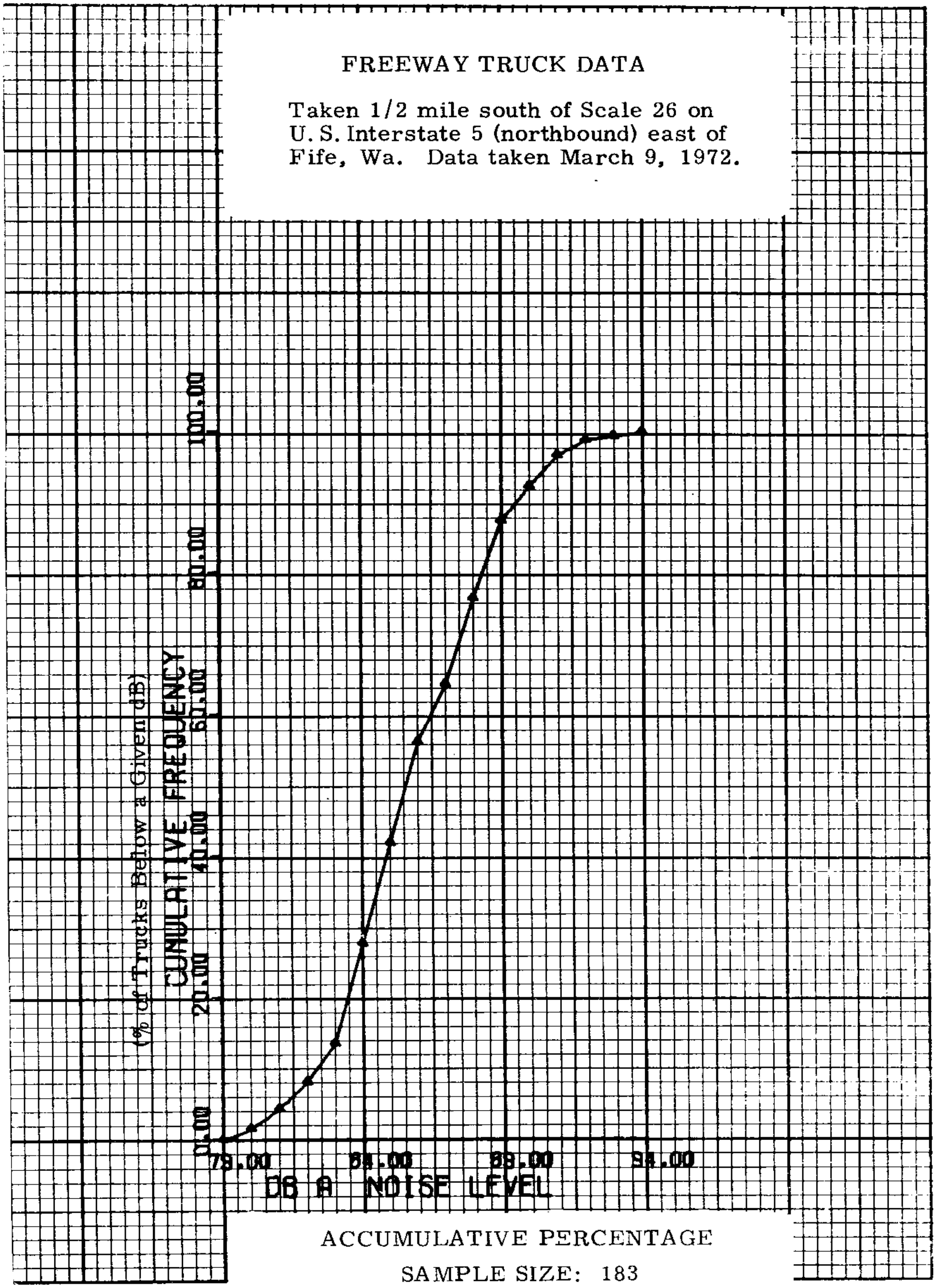
HISTOGRAM OF ALL TRUCKS MEASURED

SAMPLE SIZE: 183



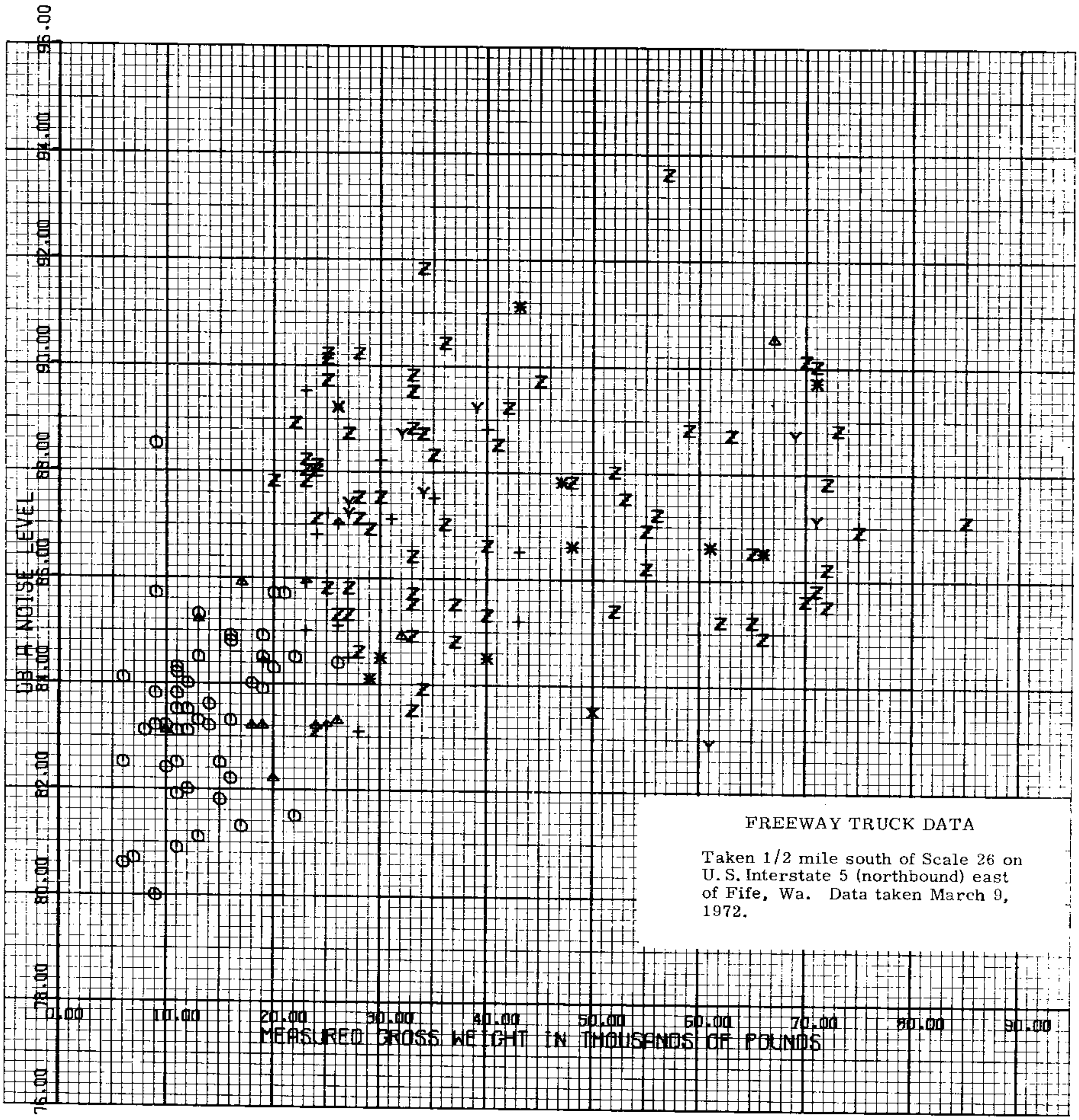
FREEWAY TRUCK DATA

Taken 1/2 mile south of Scale 26 on U.S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.



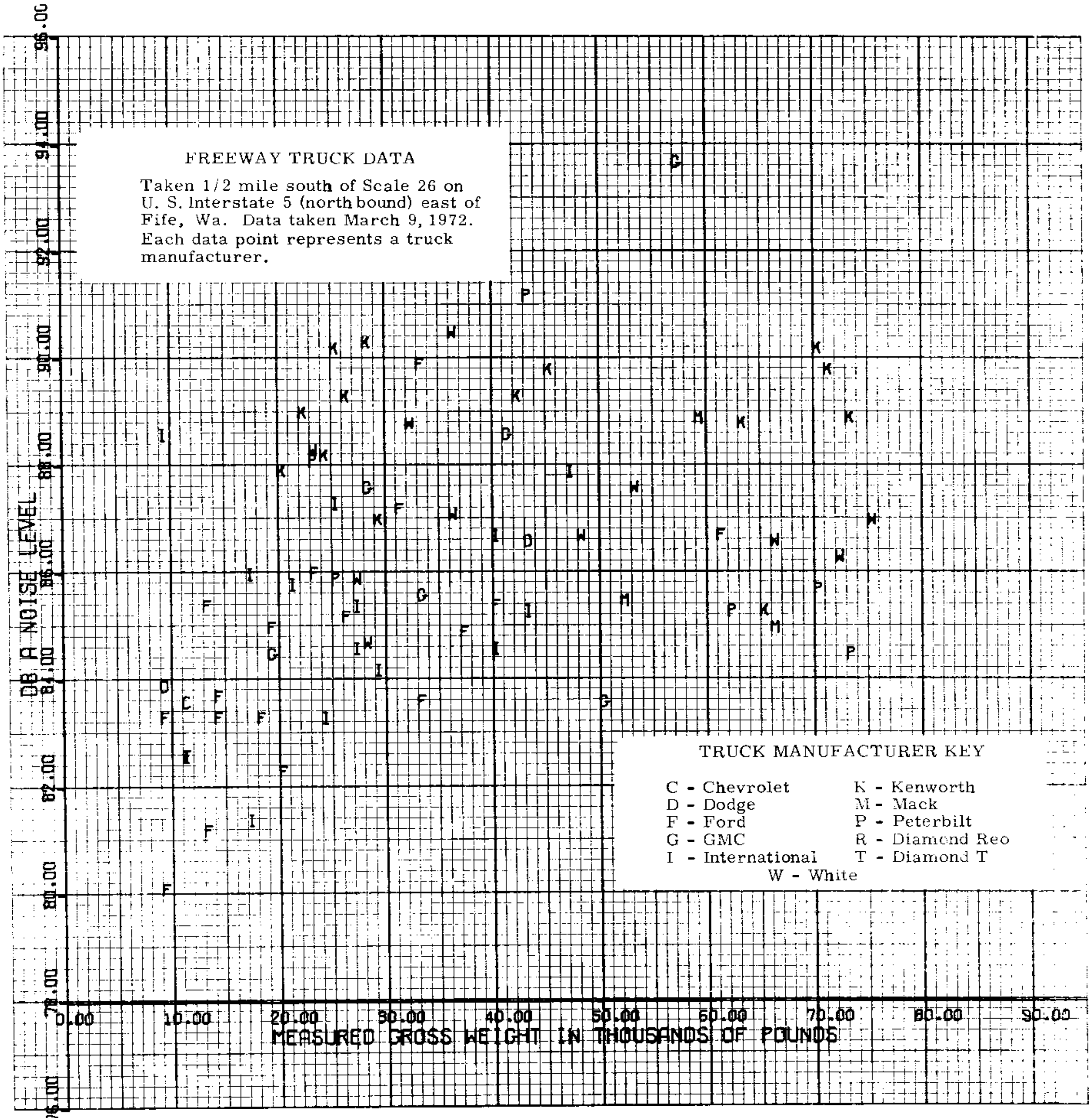
ACCUMULATIVE PERCENTAGE

SAMPLE SIZE: 183

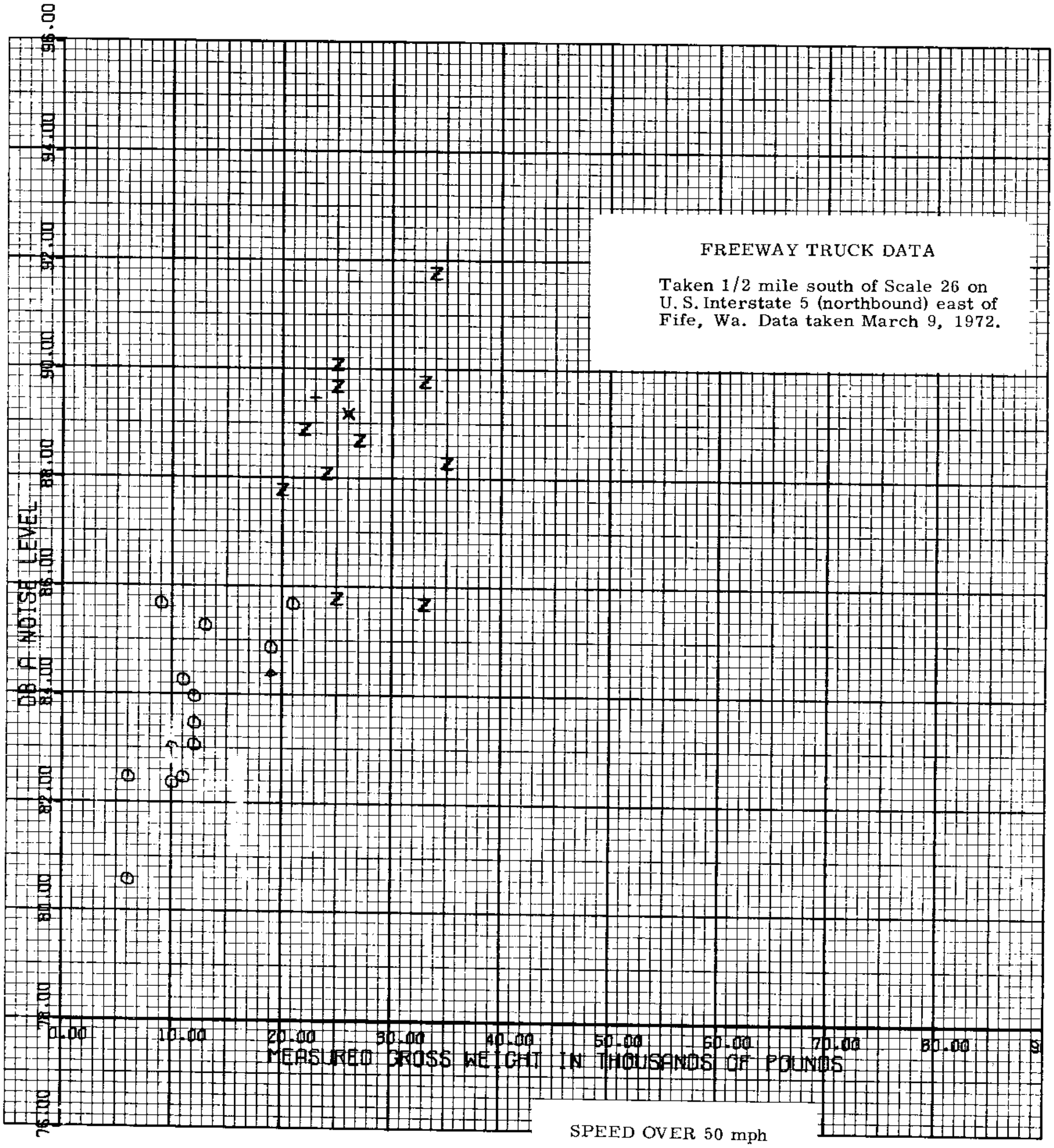


FREEWAY TRUCK DATA

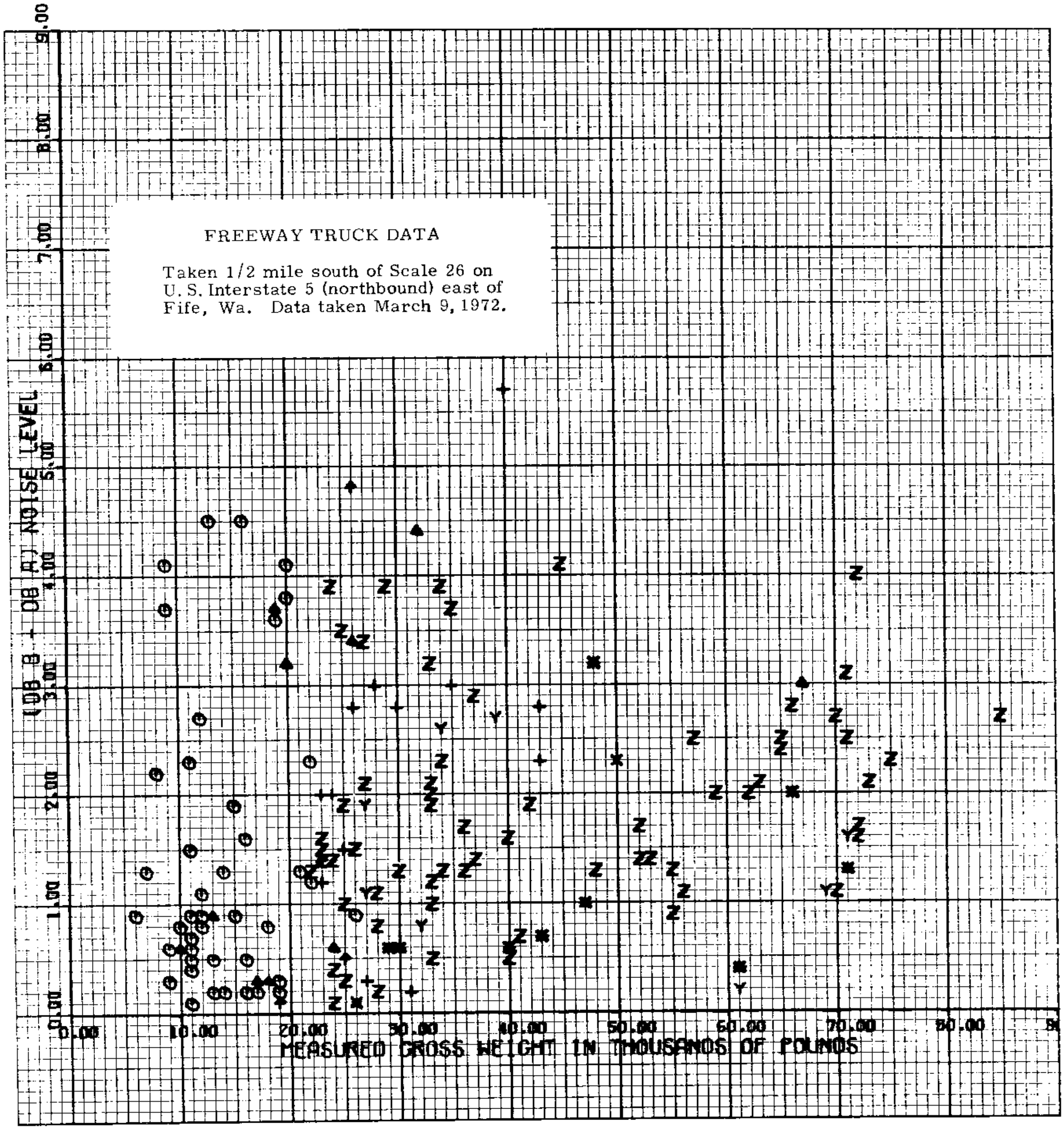
Taken 1/2 mile south of Scale 26 on U. S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.

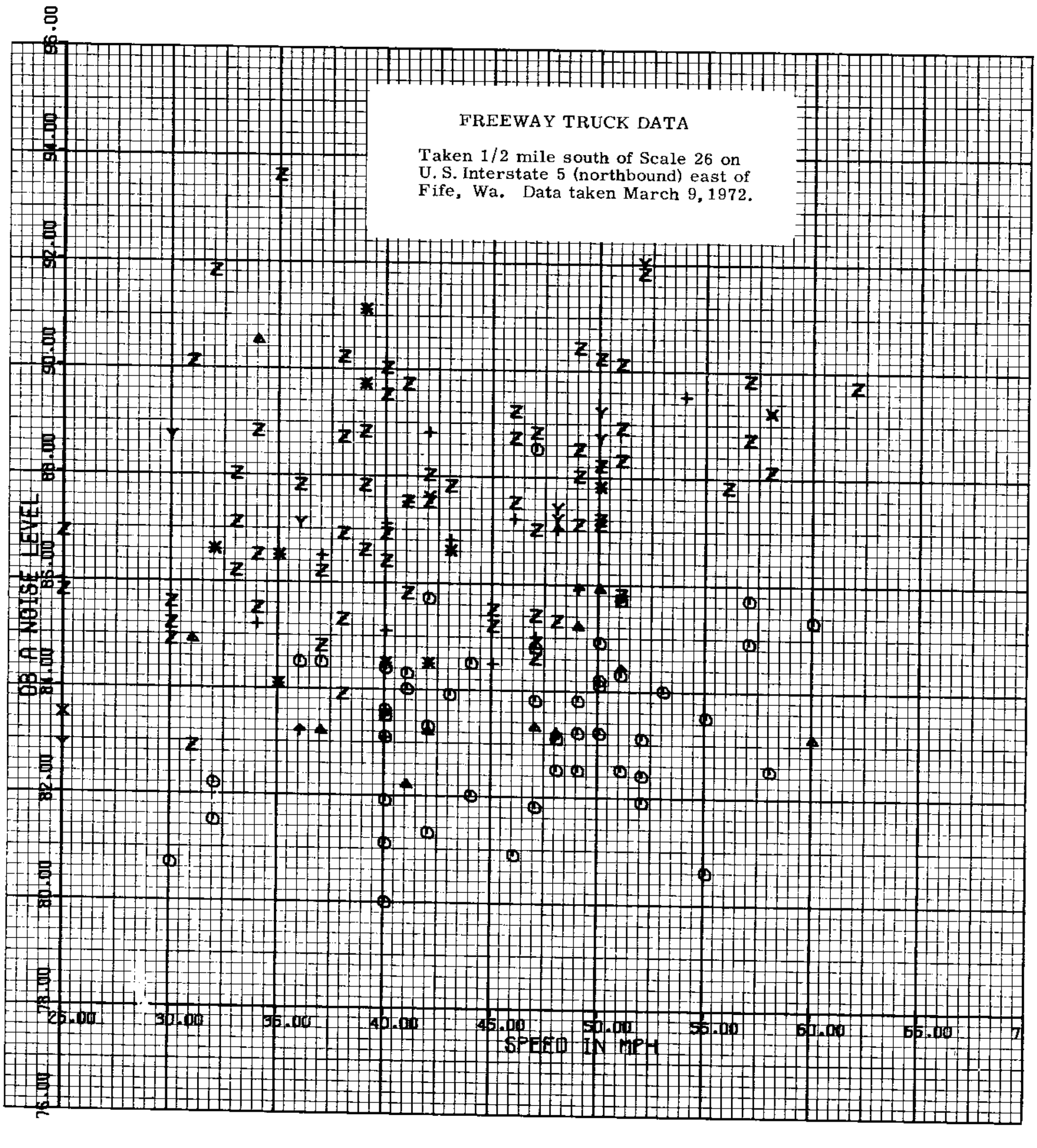


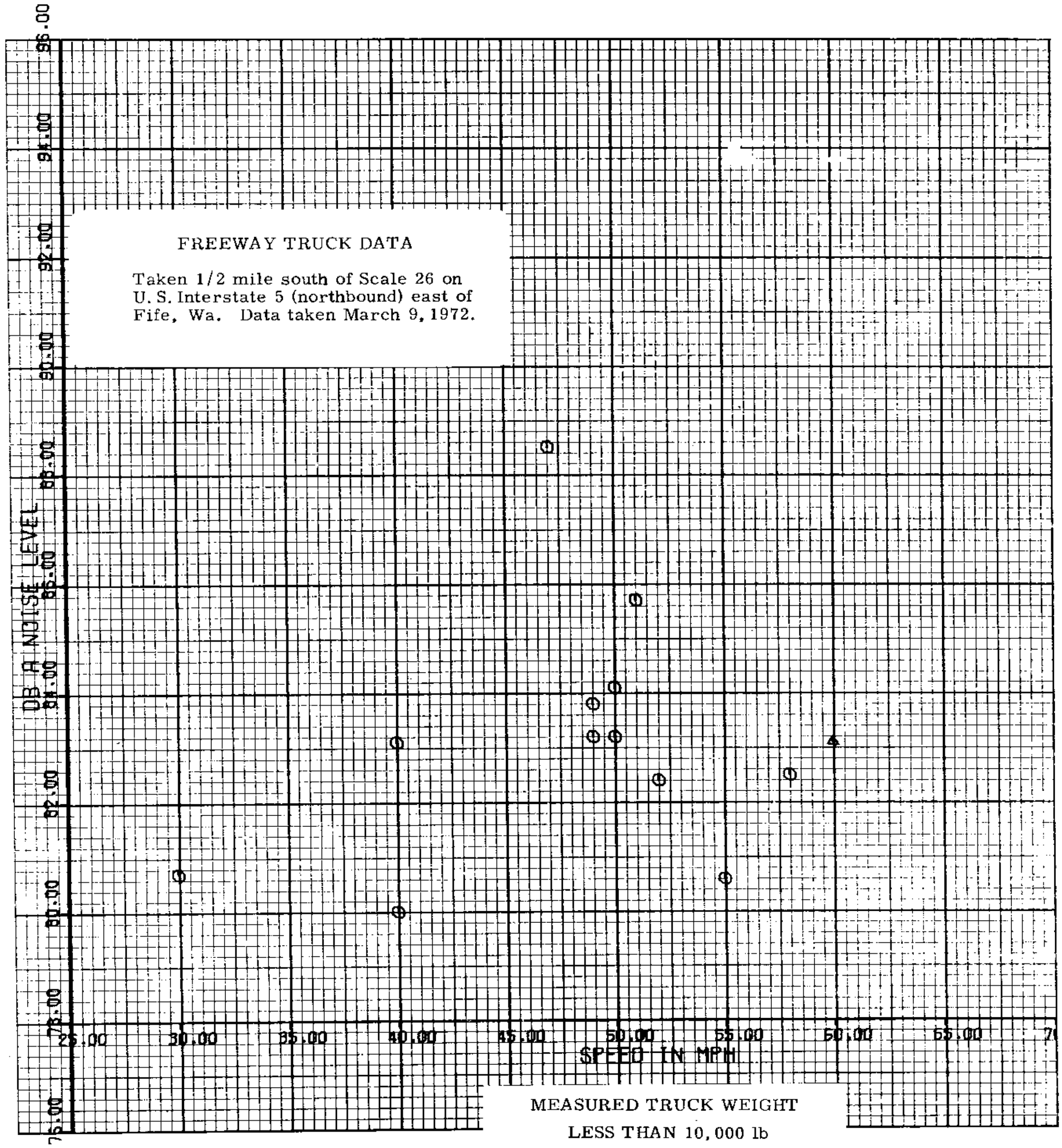
FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U. S. Interstate 5 (north bound) east of Fife, Wa. Data taken March 9, 1972. Each data point represents a truck manufacturer.
TRUCK MANUFACTURER KEY
C - Chevrolet
D - Dodge
F - Ford
G - GMC
I - International
K - Kenworth
M - Mack
P - Peterbilt
R - Diamond Reo
T - Diamond T
W - White
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00
94.00
96.00

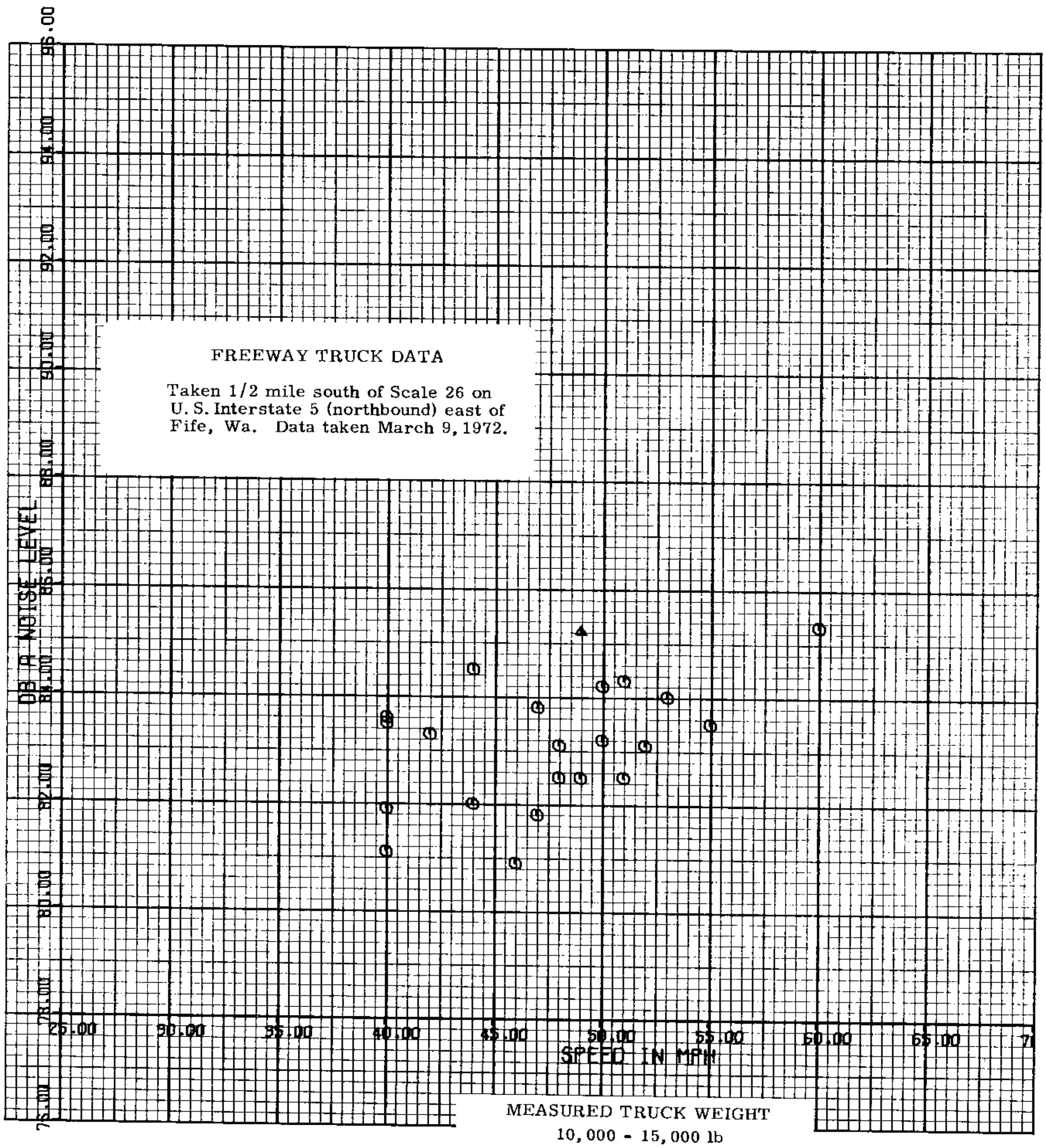


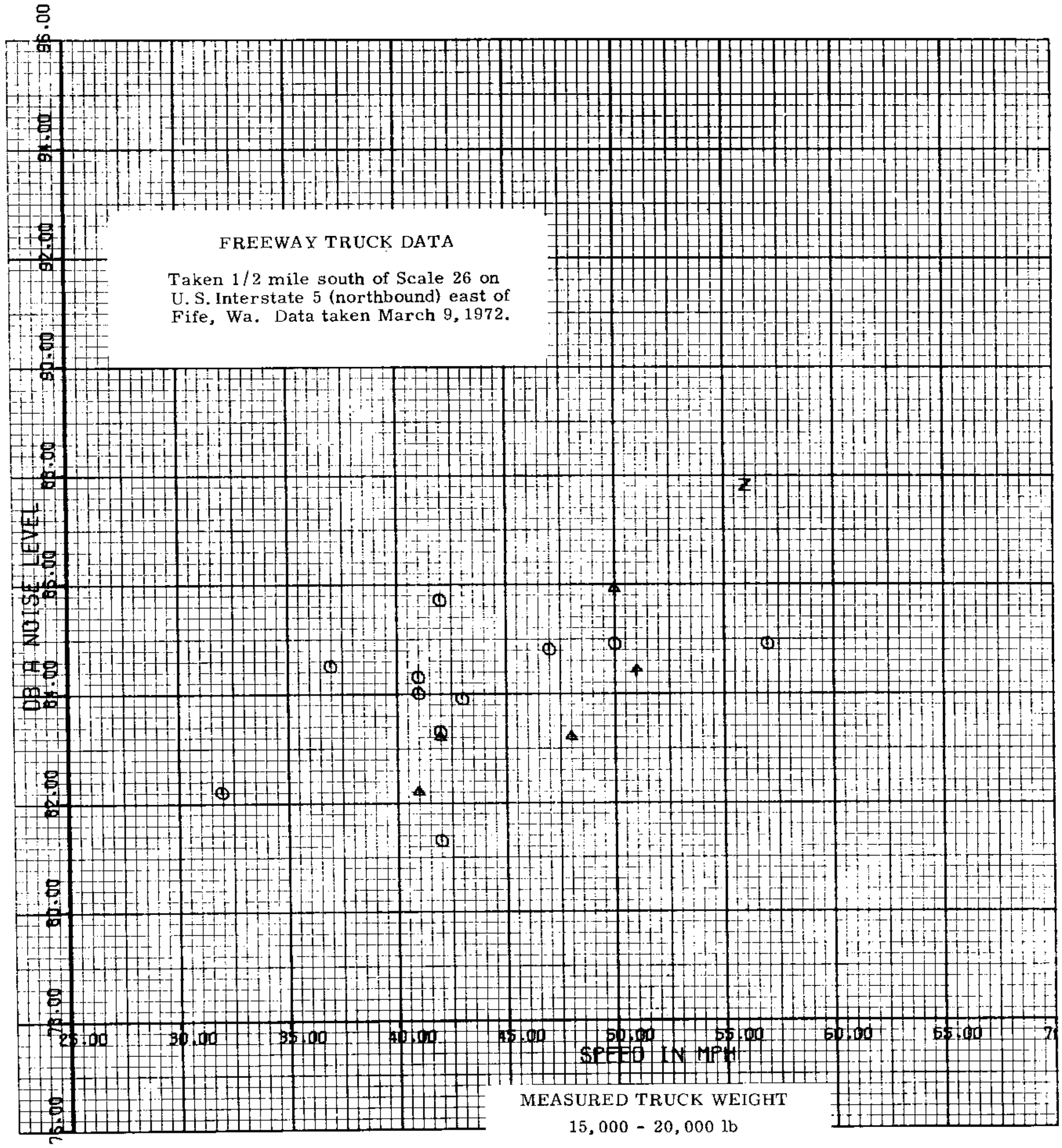
FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U. S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.
DB A NOISE LEVEL
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
SPEED OVER 50 mph

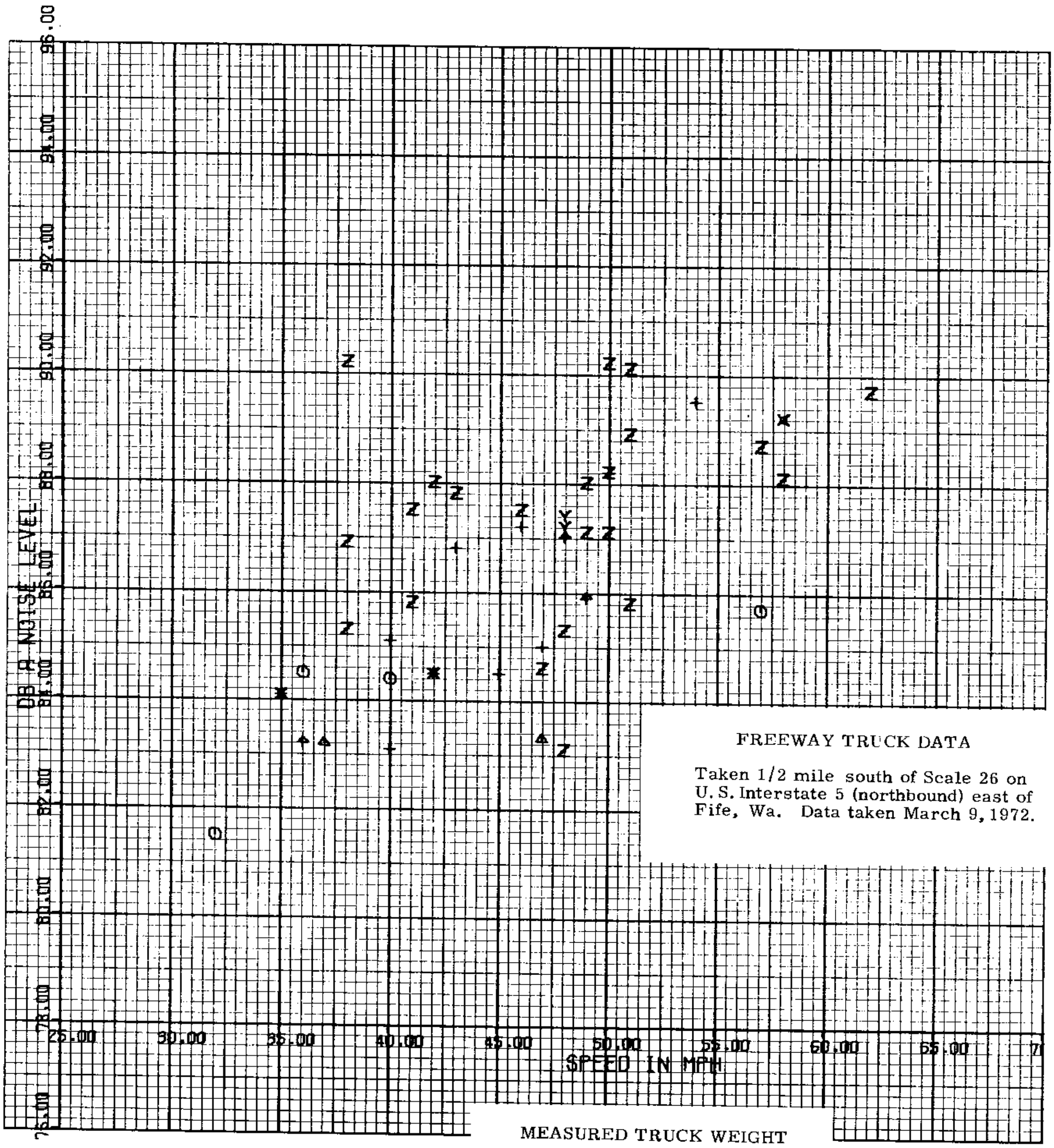

FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U. S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.
(DB B - DB A) NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00


FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U. S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.
DB A NOISE LEVEL
SPEED IN MPH
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00

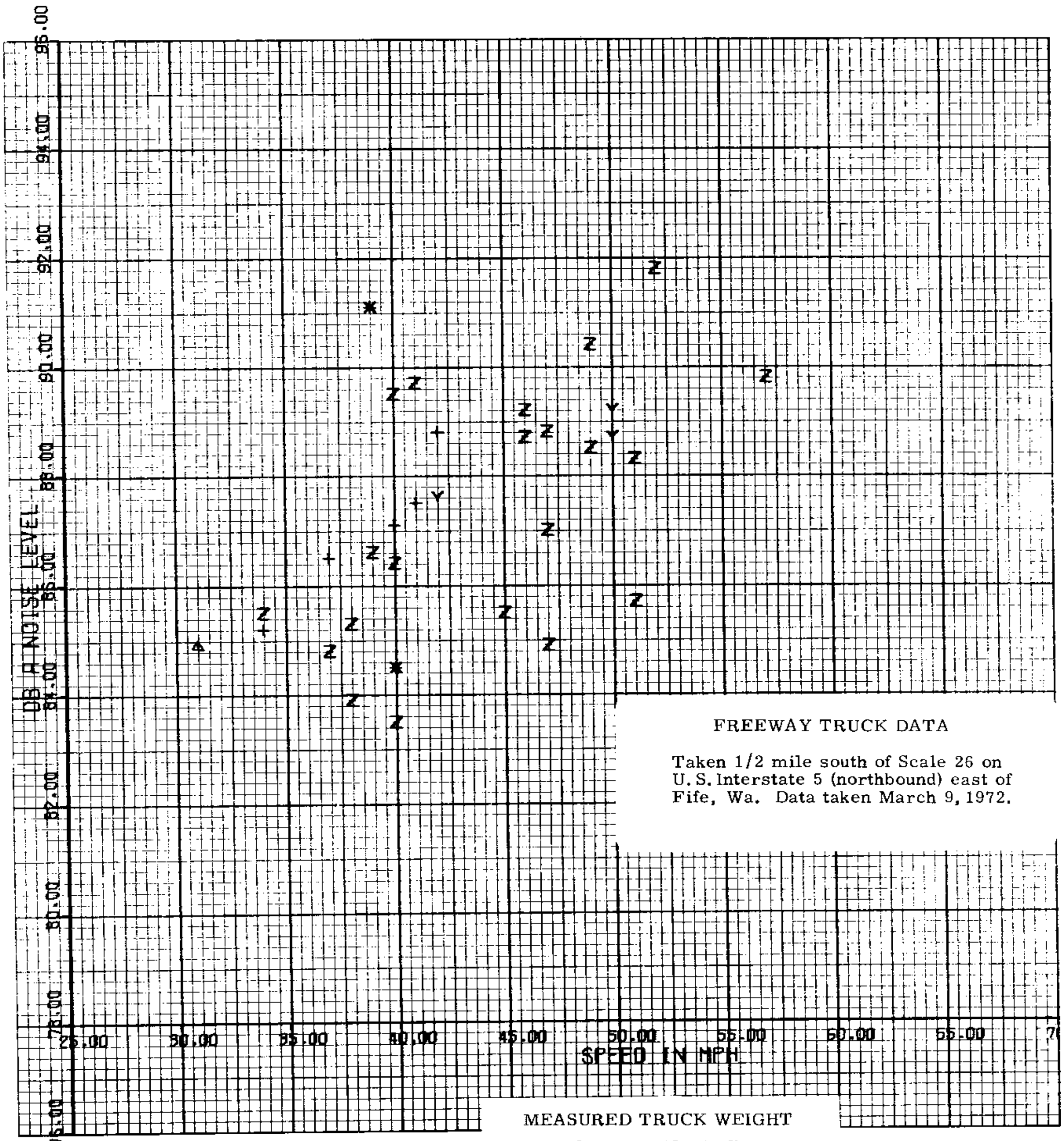

FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U. S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.
DB A NOISE LEVEL
SPEED IN MPH
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
MEASURED TRUCK WEIGHT
LESS THAN 10,000 lb


FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U.S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.
DB A NOISE LEVEL
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
SPEED IN MPH
MEASURED TRUCK WEIGHT
10,000 - 15,000 lb


FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U. S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.
DB A NOISE LEVEL
SPEED IN MPH
MEASURED TRUCK WEIGHT
15,000 - 20,000 lb



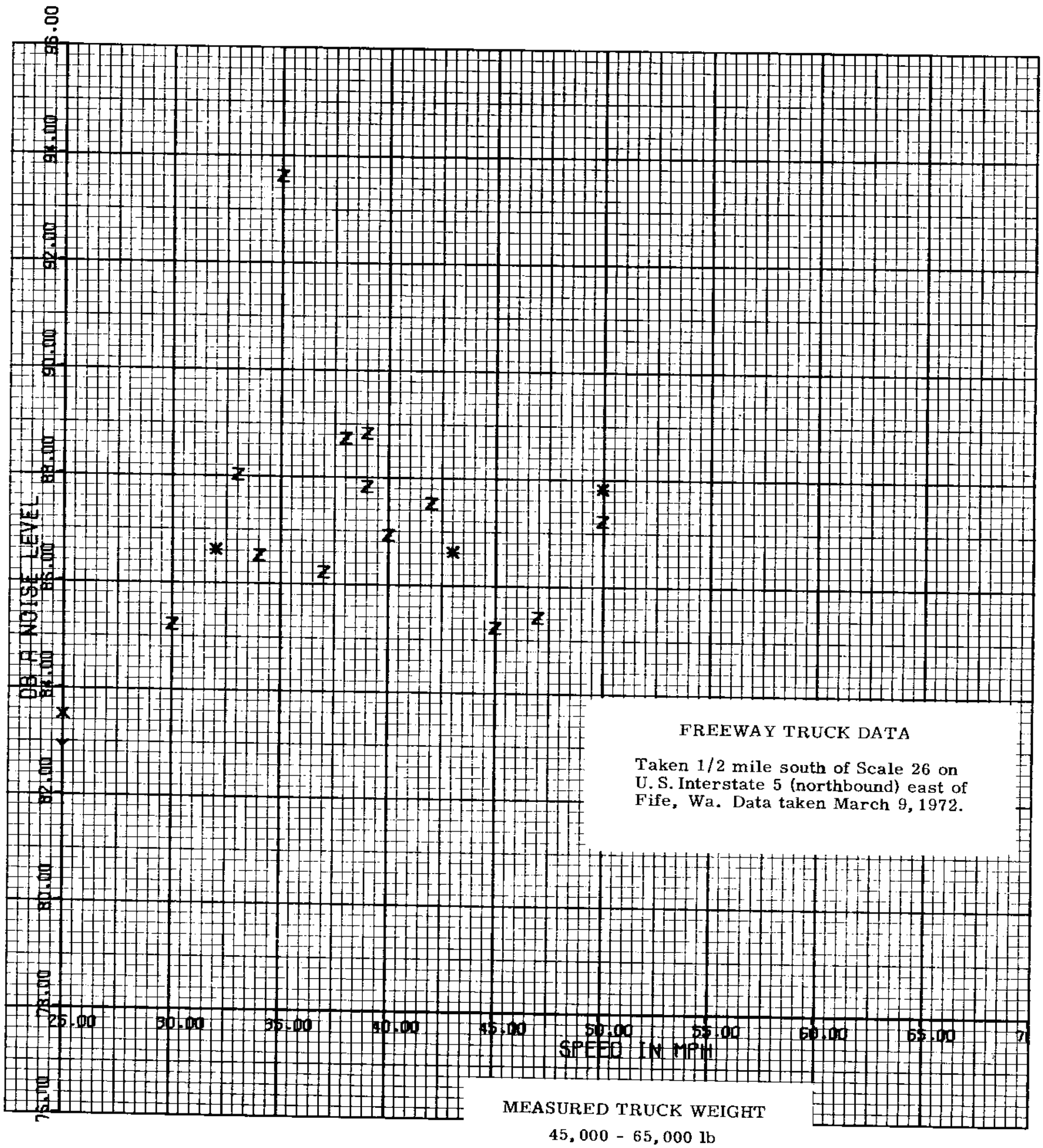
MEASURED TRUCK WEIGHT
20,000 - 30,000 lb

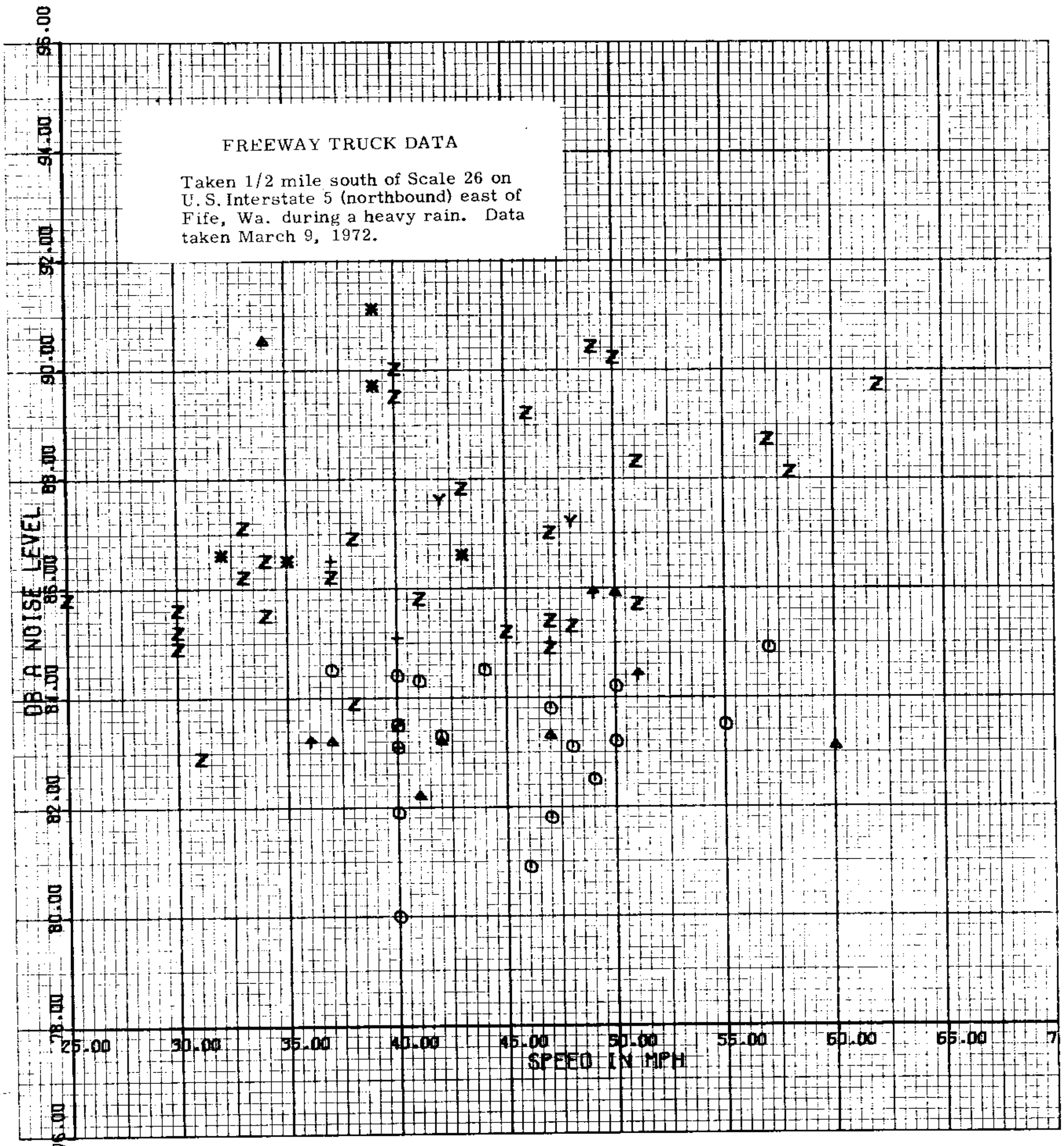


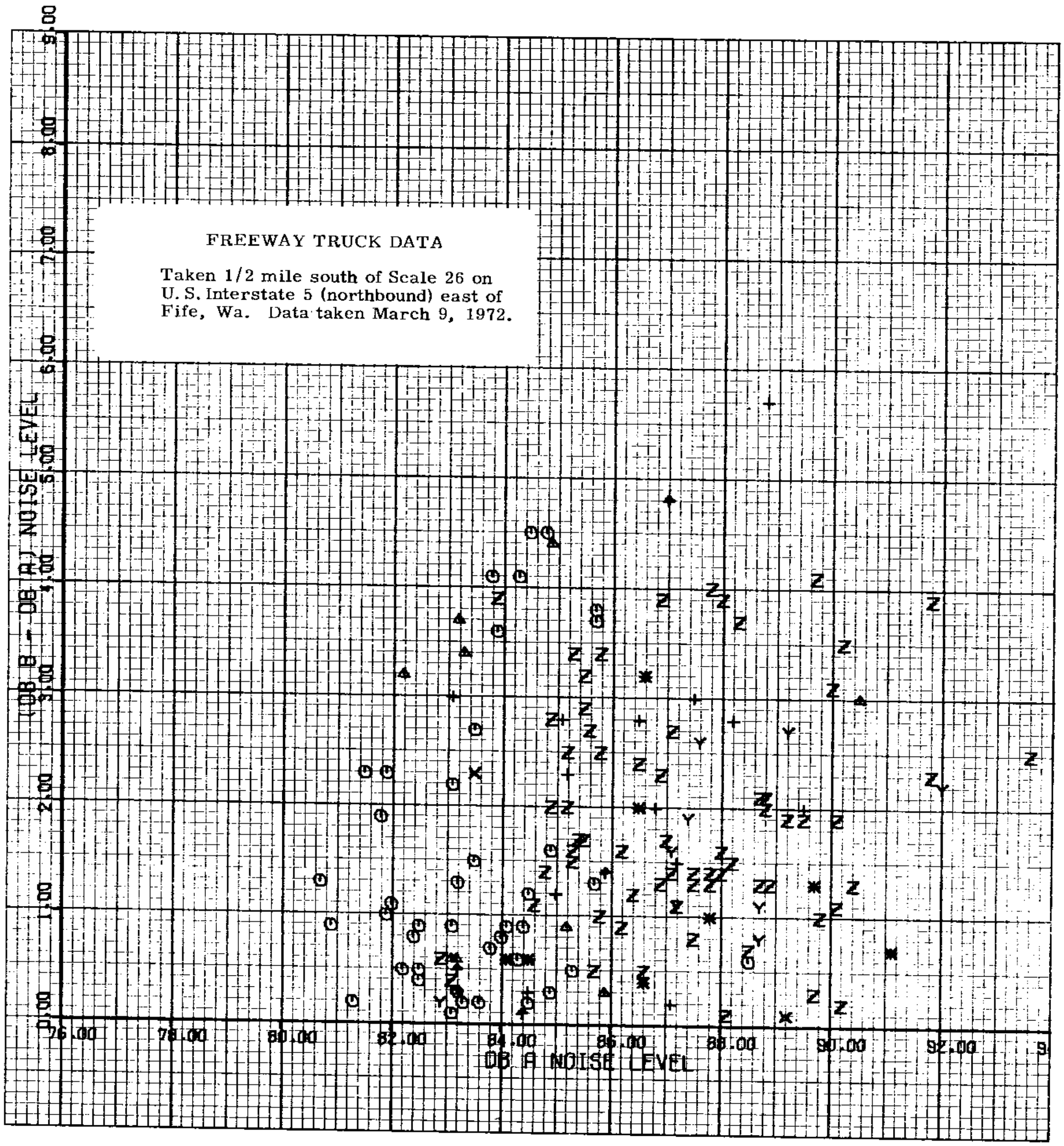
FREEWAY TRUCK DATA

Taken 1/2 mile south of Scale 26 on U.S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.

MEASURED TRUCK WEIGHT
30,000 - 45,000 lb


DB A NOISE LEVEL
SPEED IN MPH
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U.S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.
MEASURED TRUCK WEIGHT
45,000 - 65,000 lb

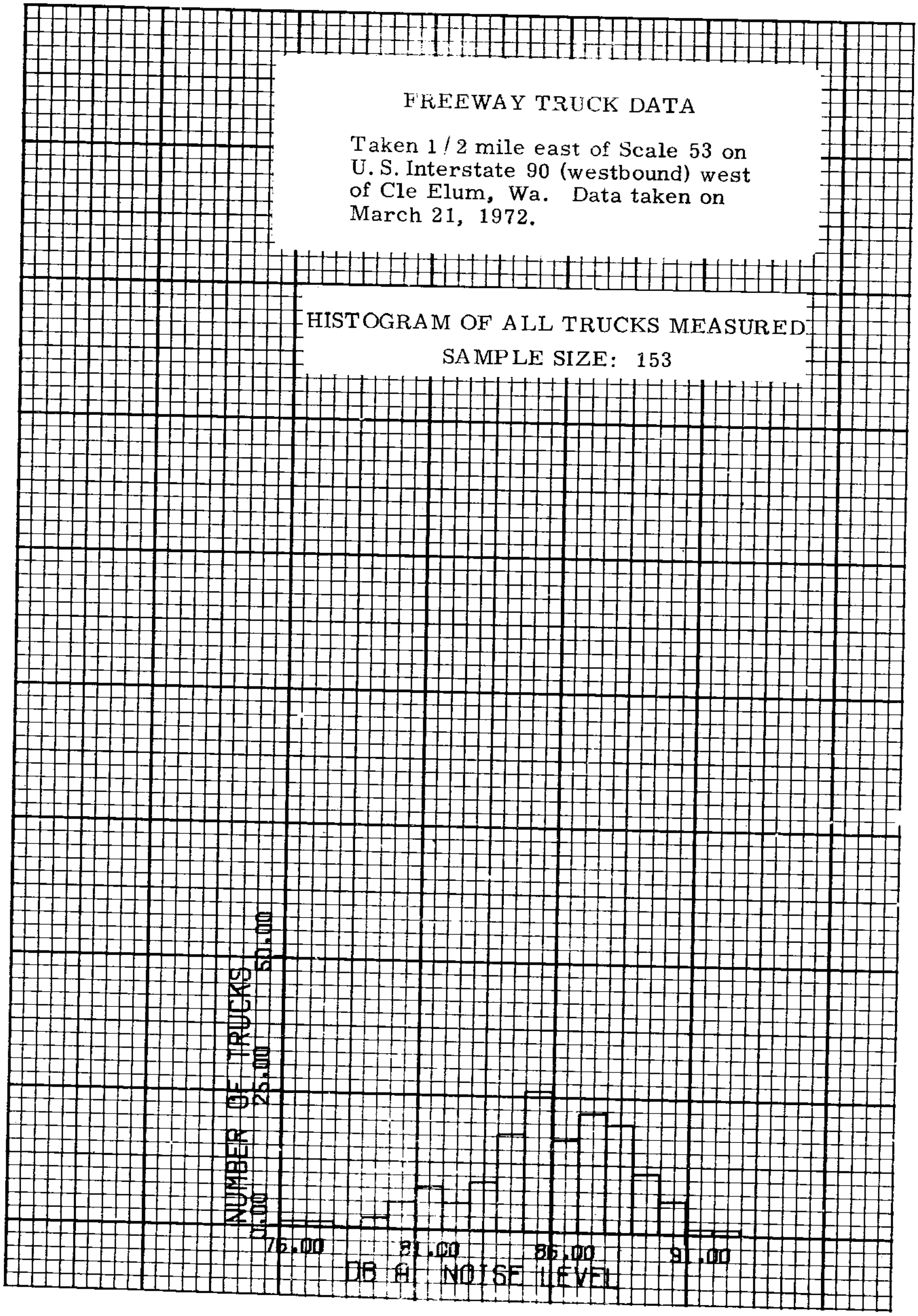

FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U.S. Interstate 5 (northbound) east of Fife, Wa. during a heavy rain. Data taken March 9, 1972.
DB A NOISE LEVEL
SPEED IN MPH
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00

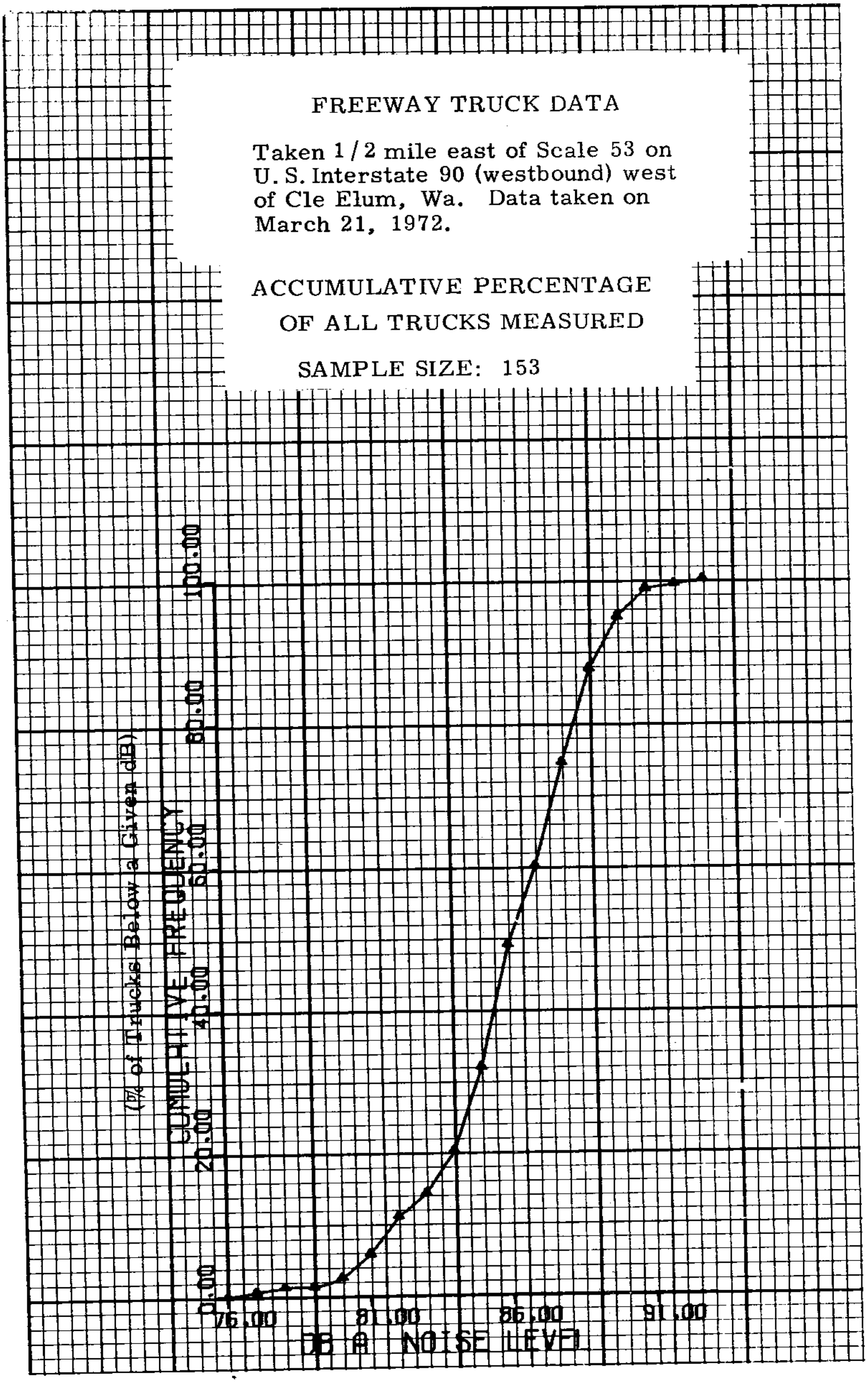

FREEWAY TRUCK DATA
Taken 1/2 mile south of Scale 26 on U. S. Interstate 5 (northbound) east of Fife, Wa. Data taken March 9, 1972.
(DB B - DB A) NOISE LEVEL
DB A NOISE LEVEL
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00

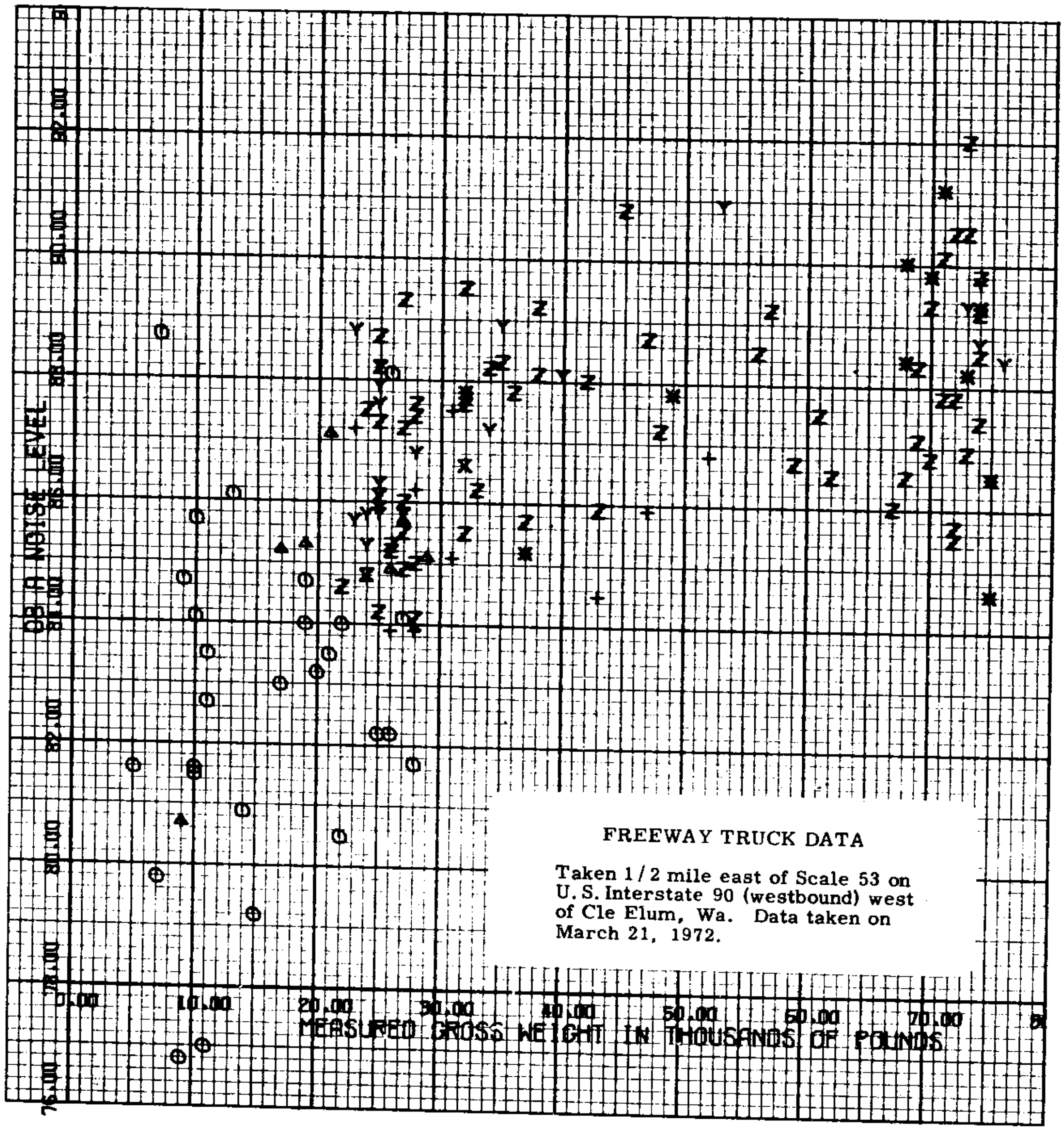
APPENDIX C

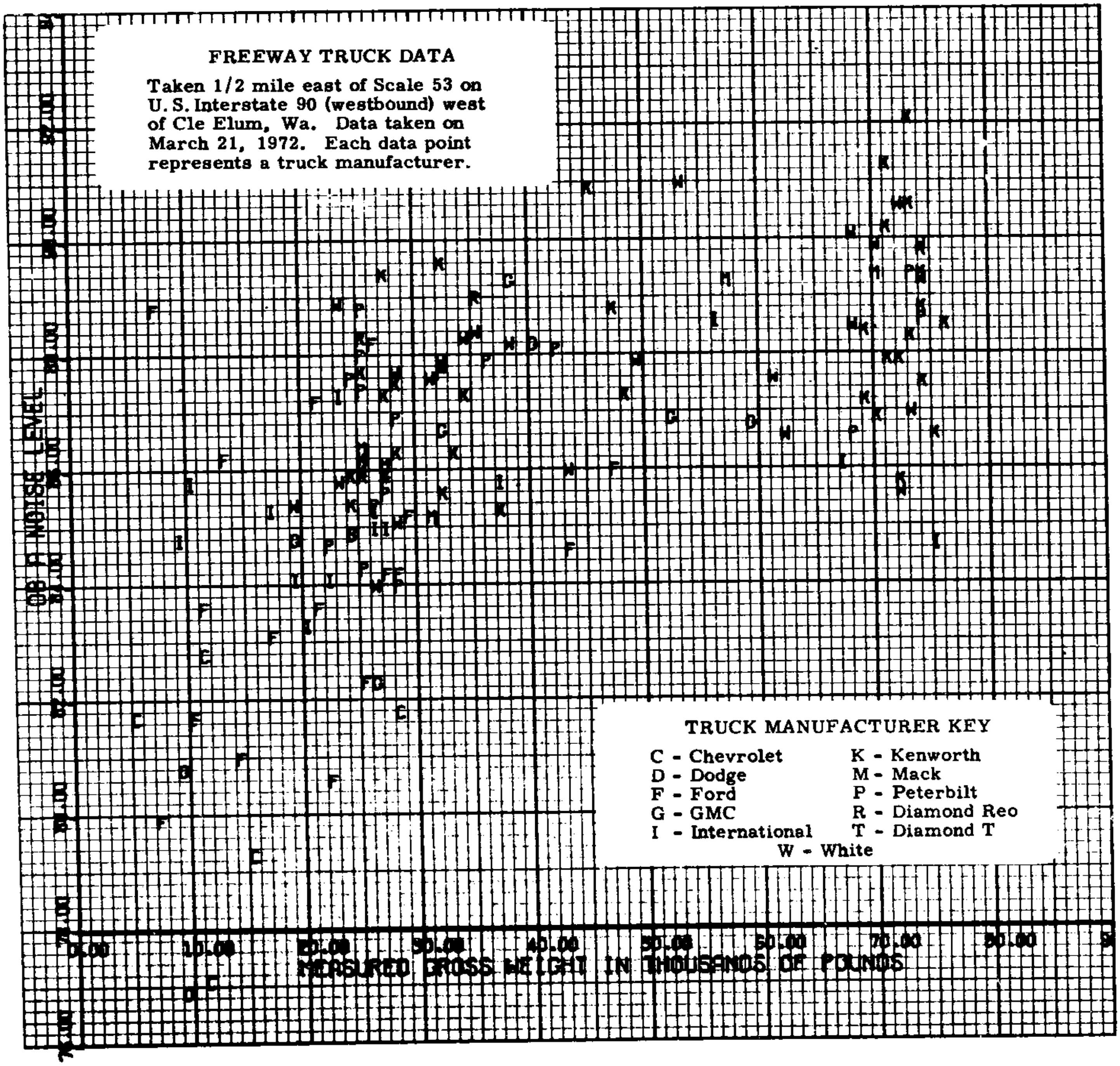
DATA TAKEN MARCH 21, 1972, 1/2 MILE EAST OF SCALE 53 ON U.S. INTERSTATE 90 (WESTBOUND) WEST OF CLE ELUM, WASHINGTON.

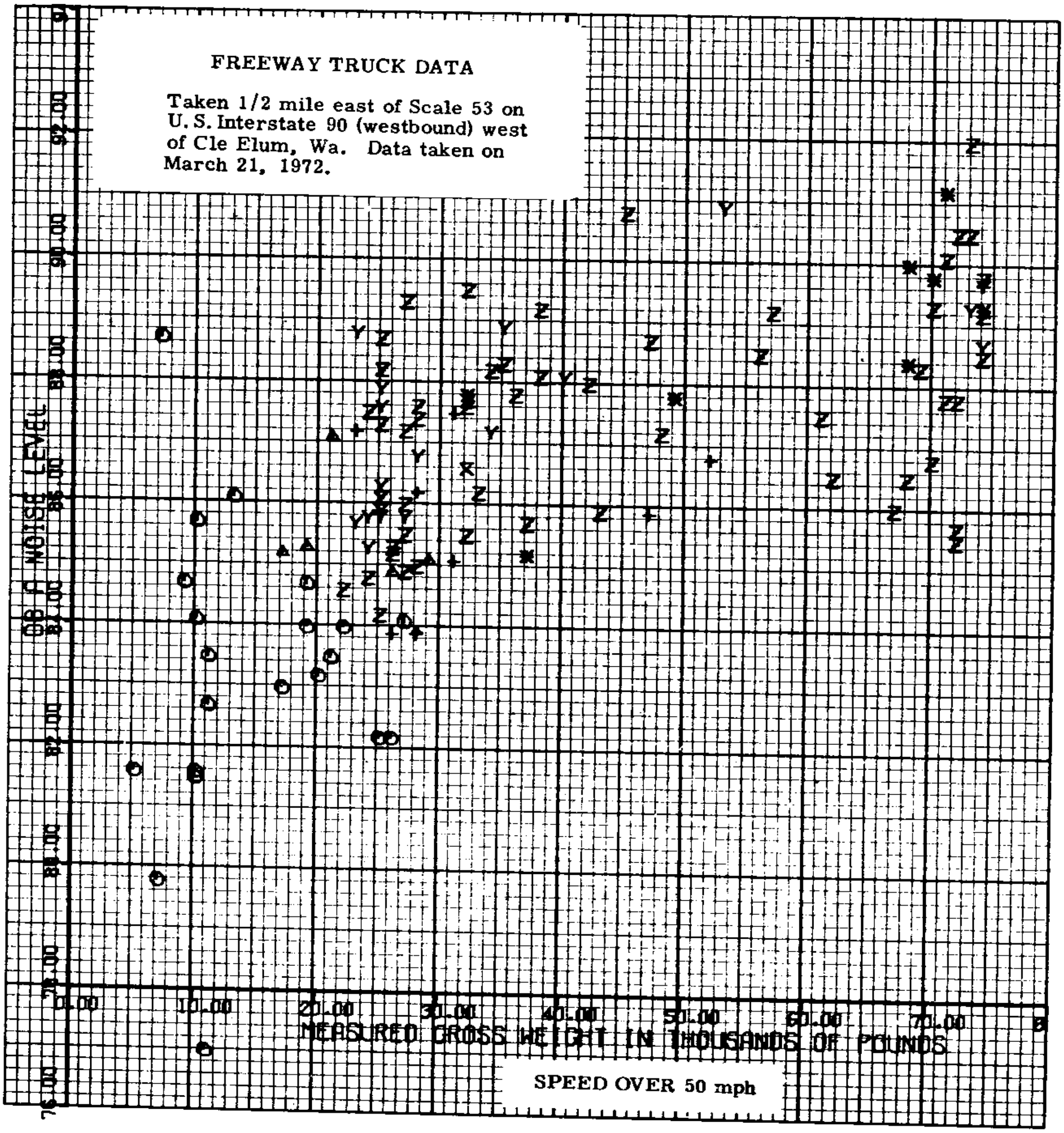
(See Figure 17 in main text for key to symbols representing each class of truck.)


FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U.S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
HISTOGRAM OF ALL TRUCKS MEASURED
SAMPLE SIZE: 153
NUMBER OF TRUCKS
0.00
25.00
50.00
76.00
81.00
86.00
91.00
DB A NOISE LEVEL

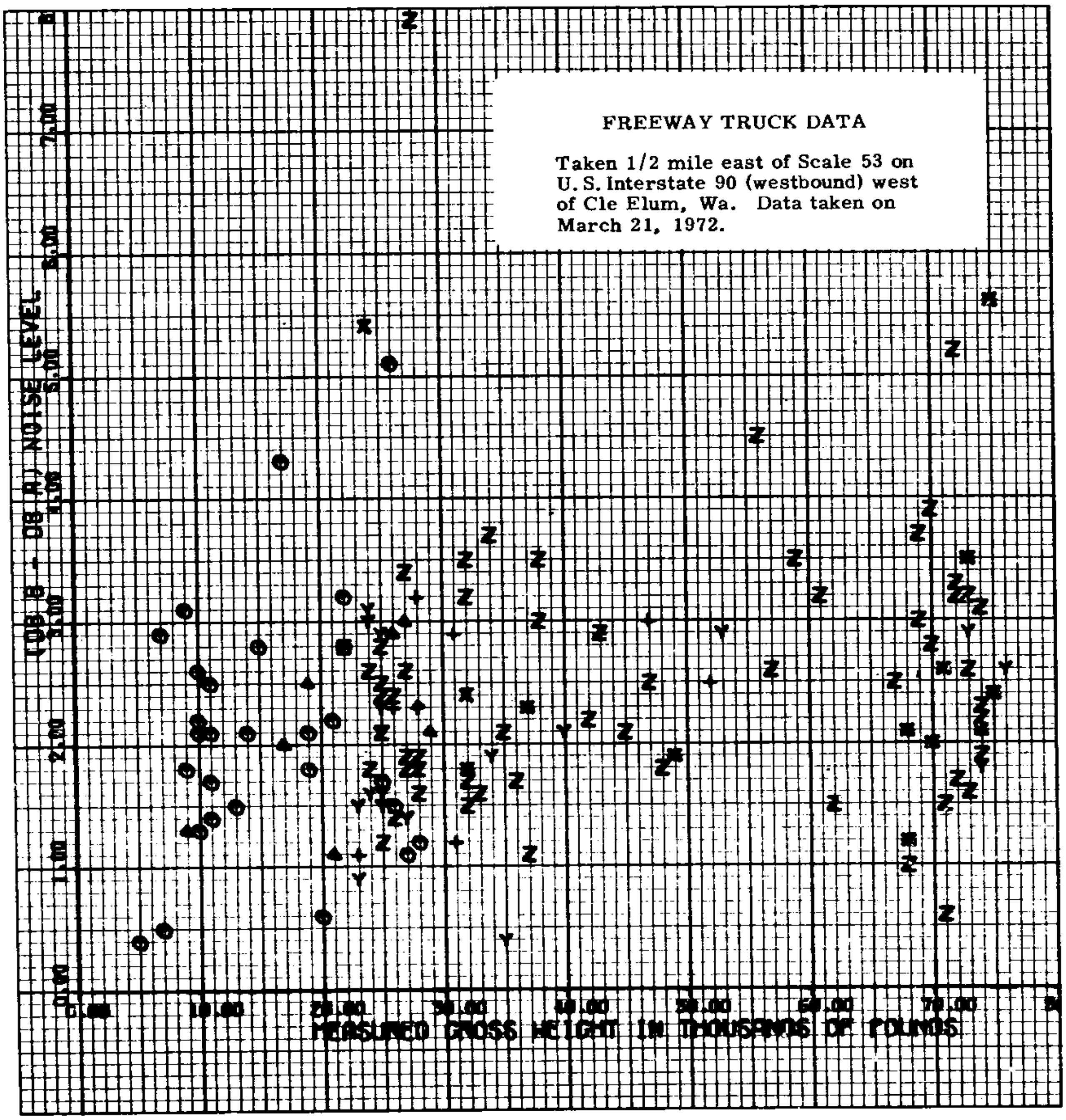

FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U. S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
ACCUMULATIVE PERCENTAGE OF ALL TRUCKS MEASURED
SAMPLE SIZE: 153
(% of Trucks Below a Given dB)
CUMULATIVE FREQUENCY
0.00
20.00
40.00
60.00
80.00
100.00
76.00
81.00
86.00
91.00
DB A NOISE LEVEL

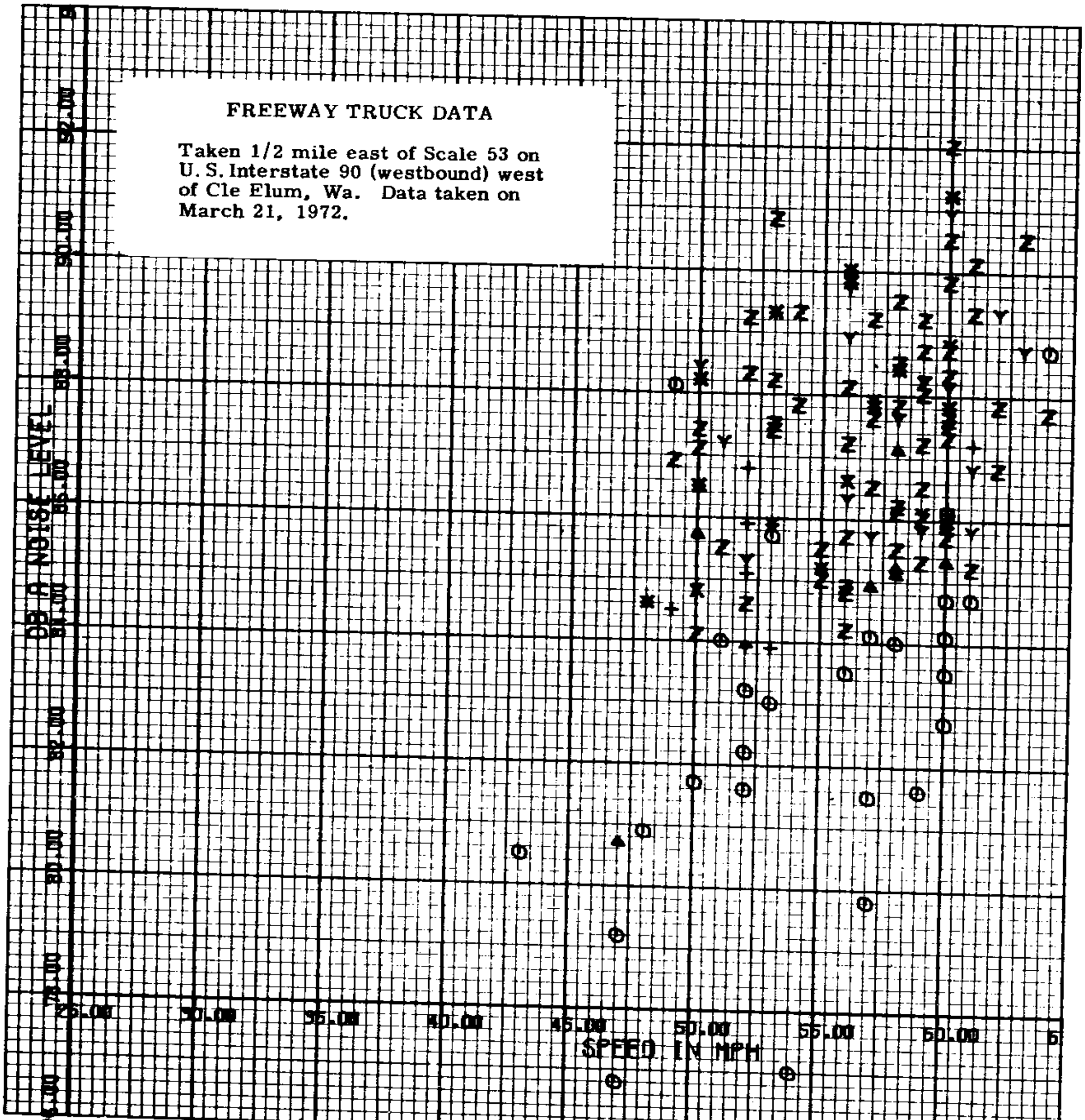

DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00
FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U. S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.

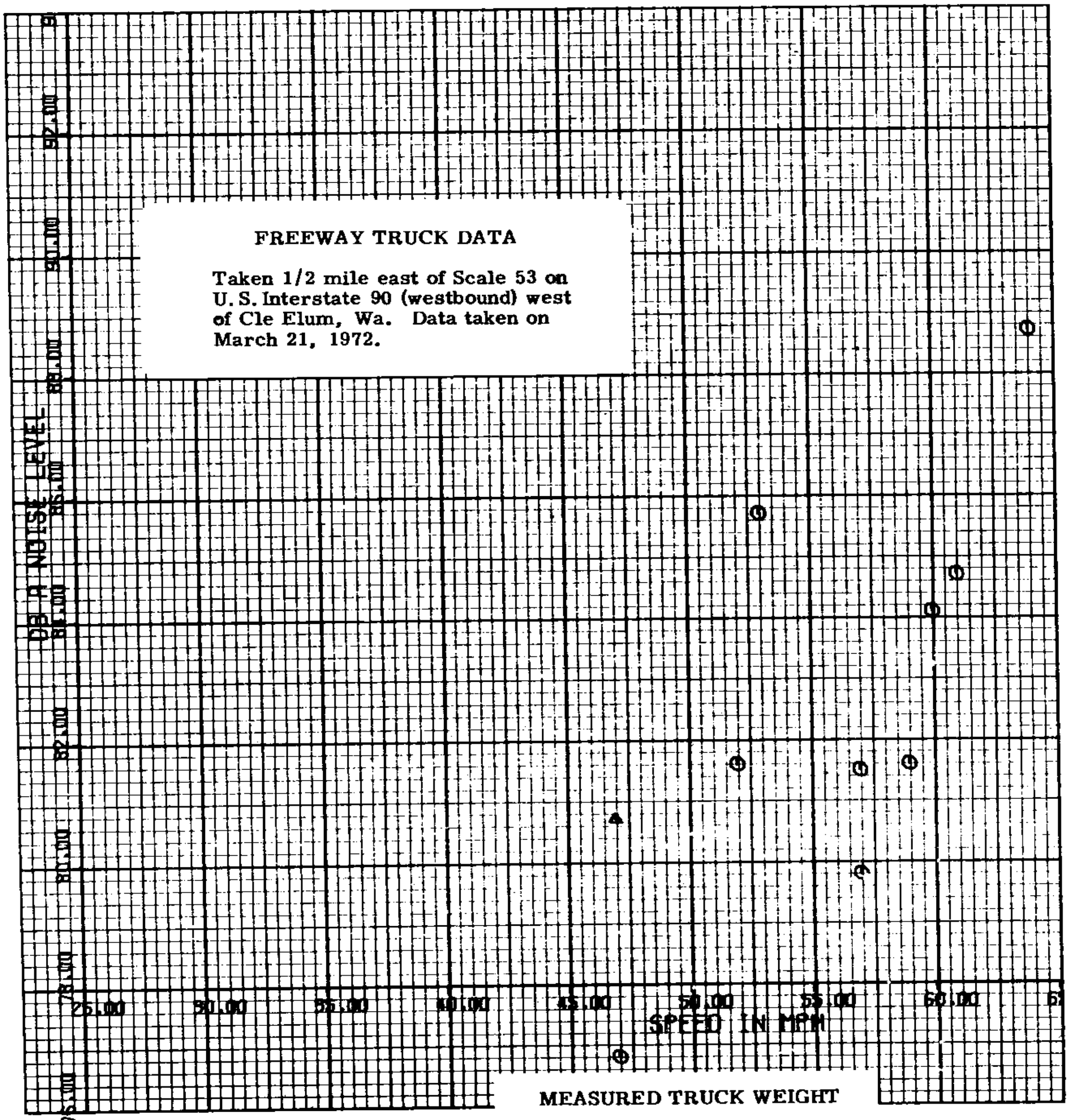

FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U. S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972. Each data point represents a truck manufacturer.
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
TRUCK MANUFACTURER KEY
C - Chevrolet
D - Dodge
F - Ford
G - GMC
I - International
K - Kenworth
M - Mack
P - Peterbilt
R - Diamond Reo
T - Diamond T
W - White



FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U.S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
SPEED OVER 50 mph

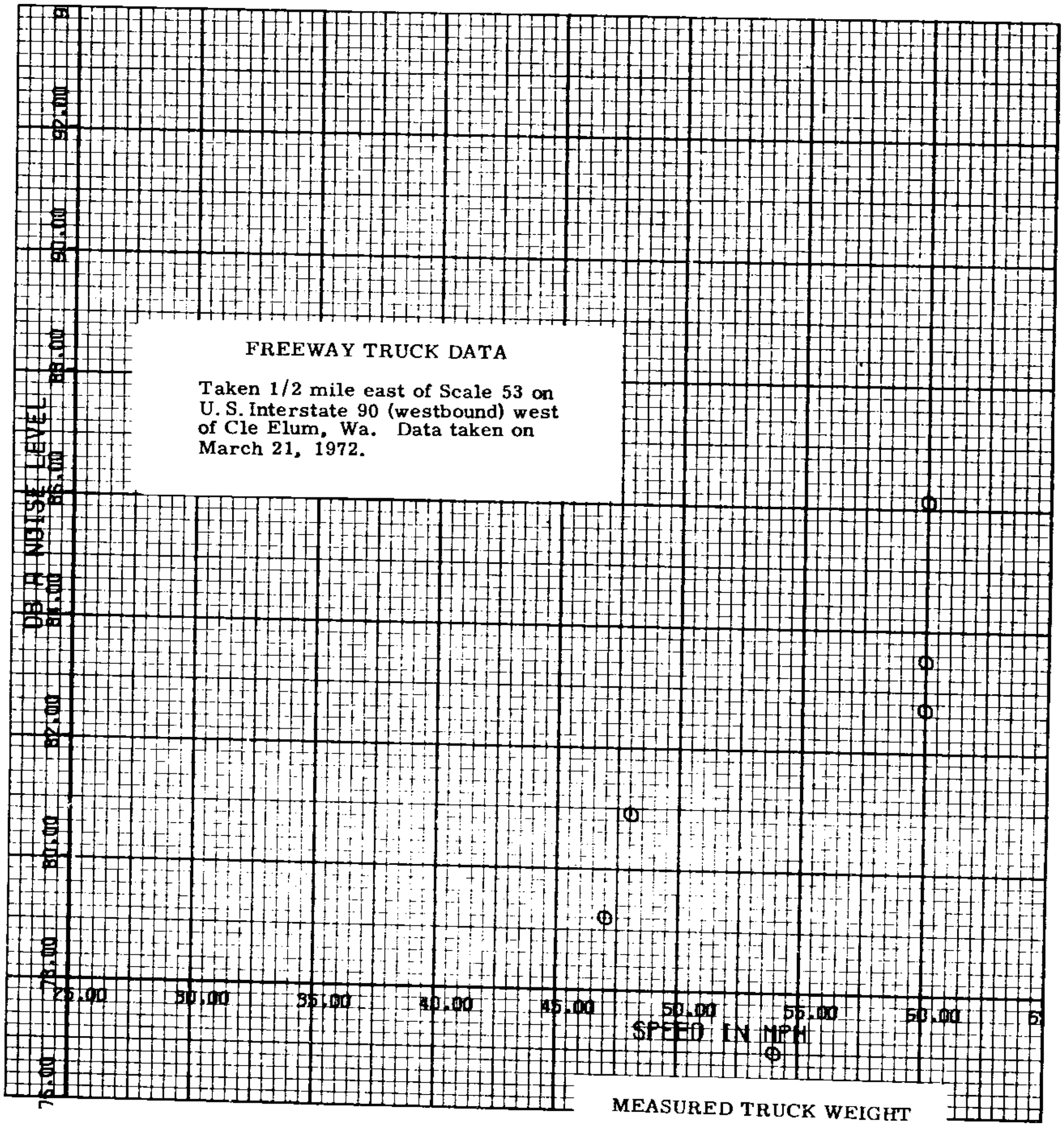

FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U. S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
(DB B - DB A) NOISE LEVEL


FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on
U. S. Interstate 90 (westbound) west
of Cle Elum, Wa. Data taken on
March 21, 1972.
DB A NOISE LEVEL
SPEED IN MPH



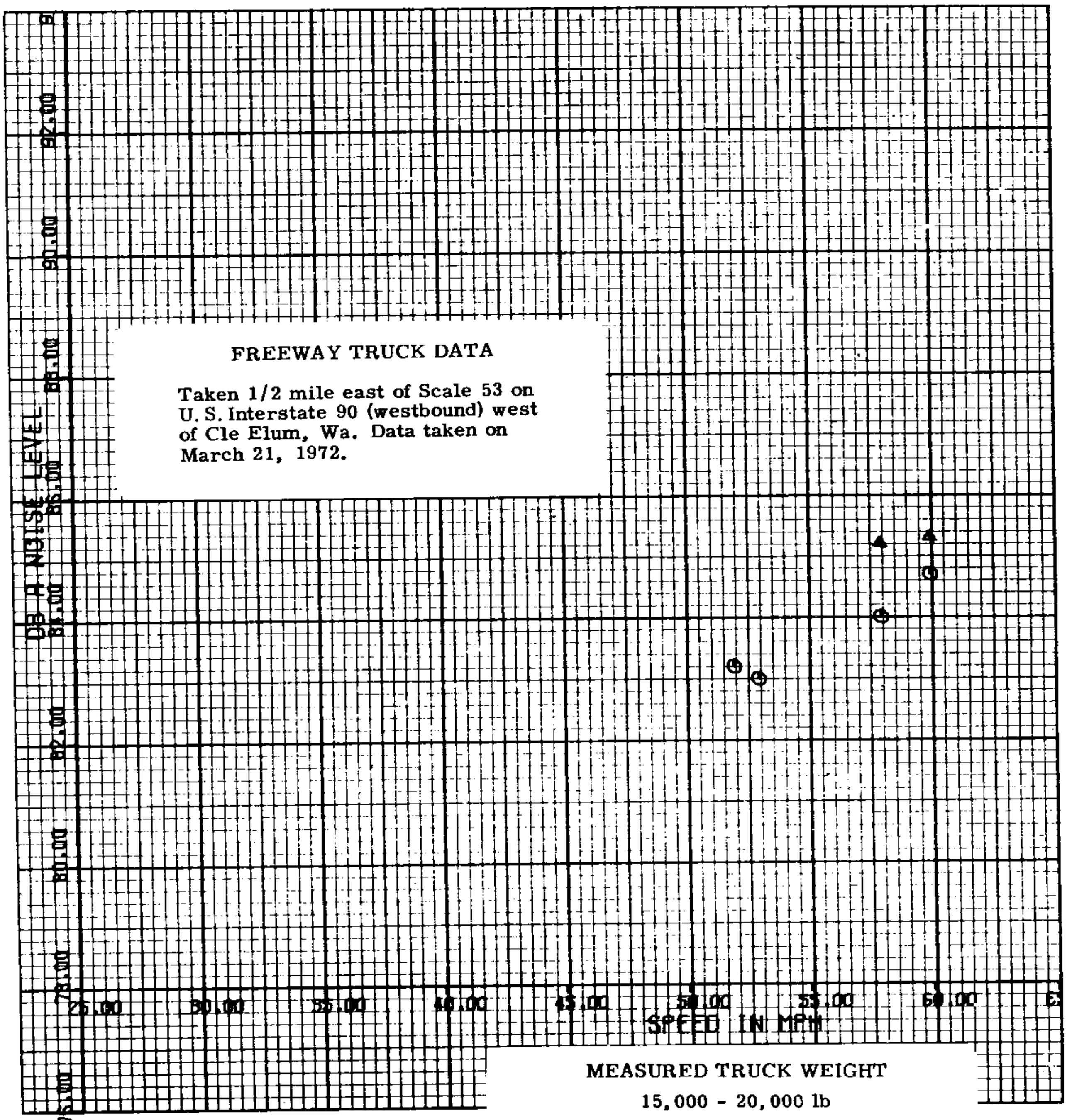
MEASURED TRUCK WEIGHT

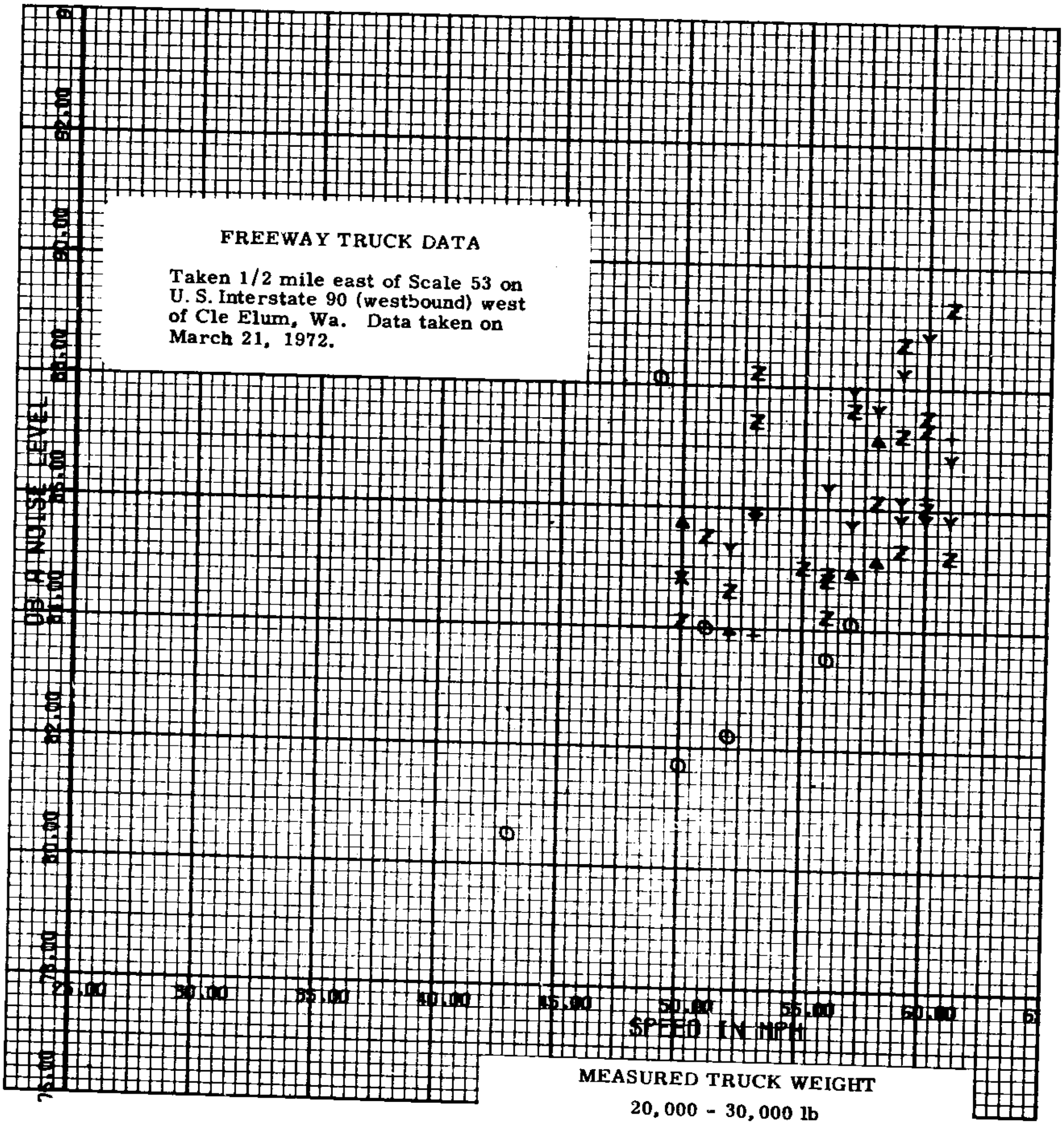
LESS THAN 10,000 lb

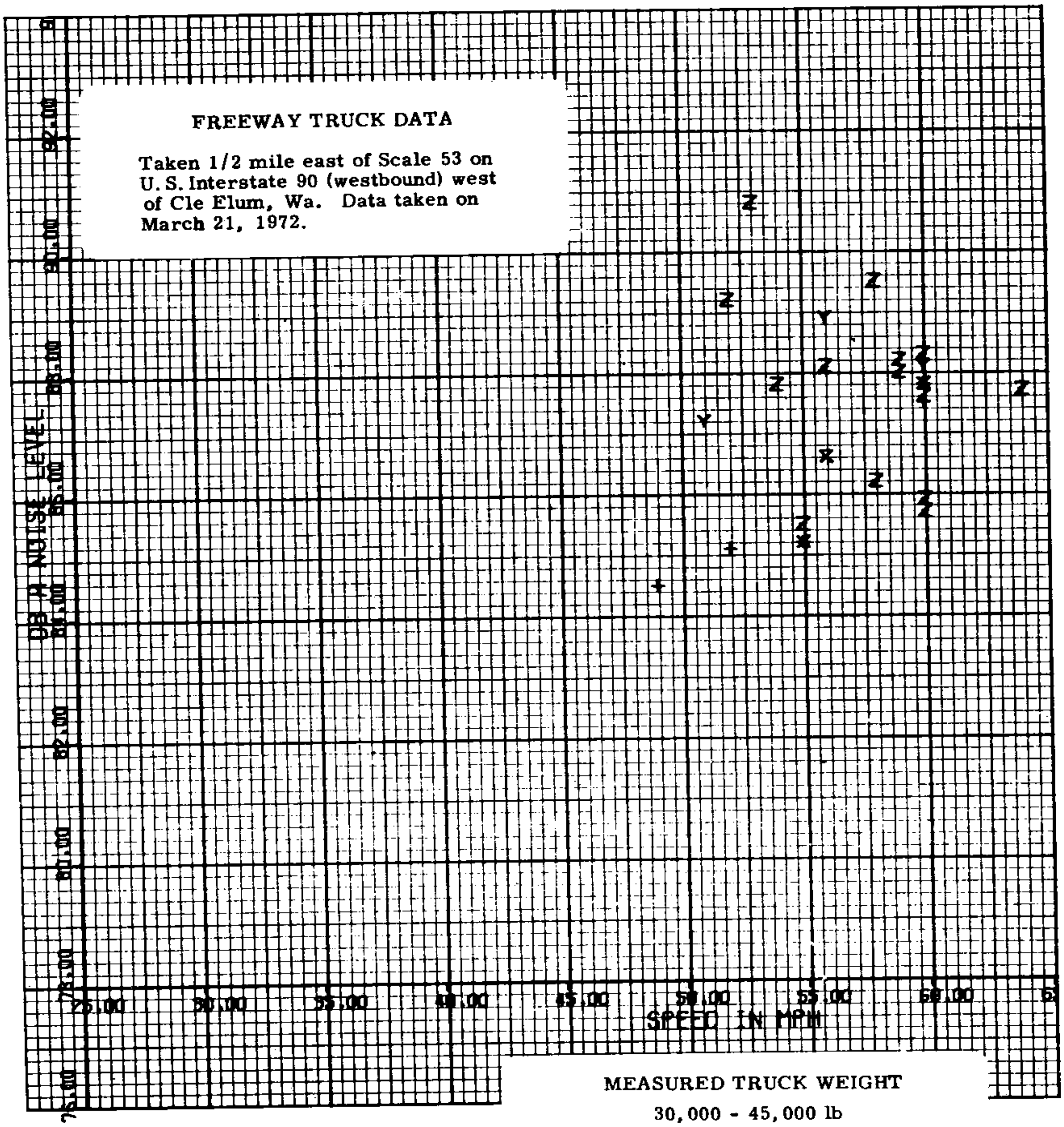


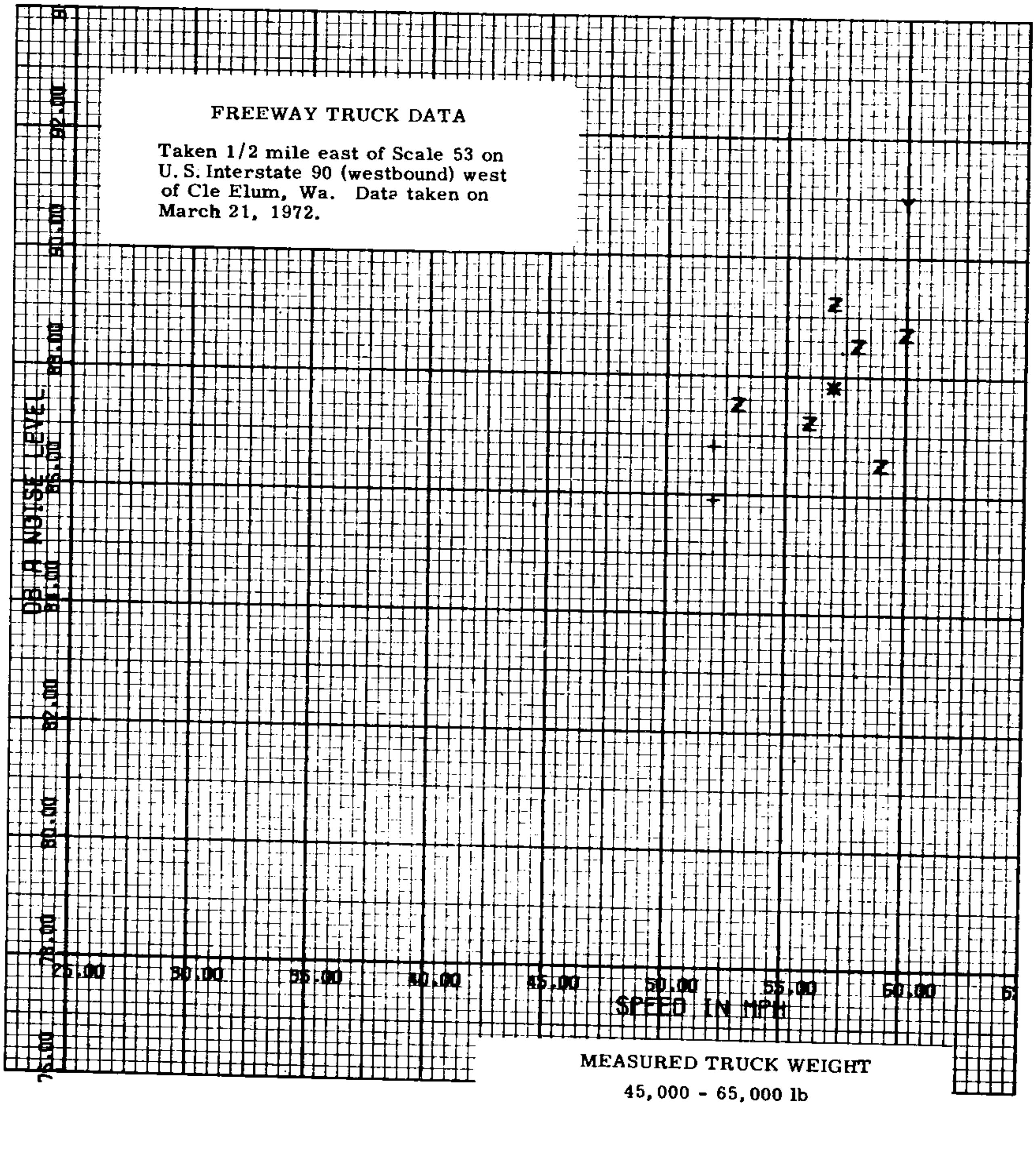
MEASURED TRUCK WEIGHT

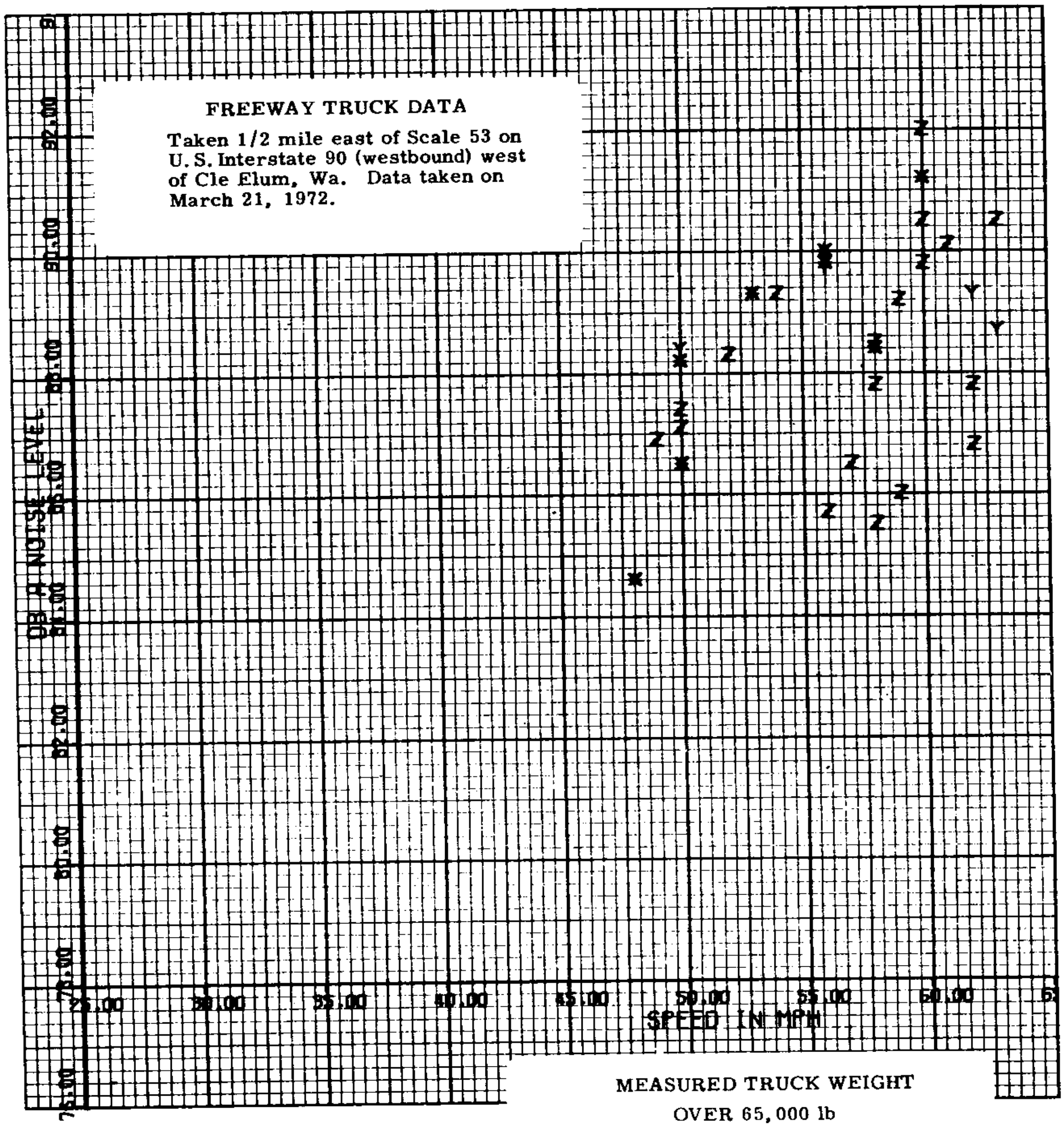
10,000 - 15,000 lb

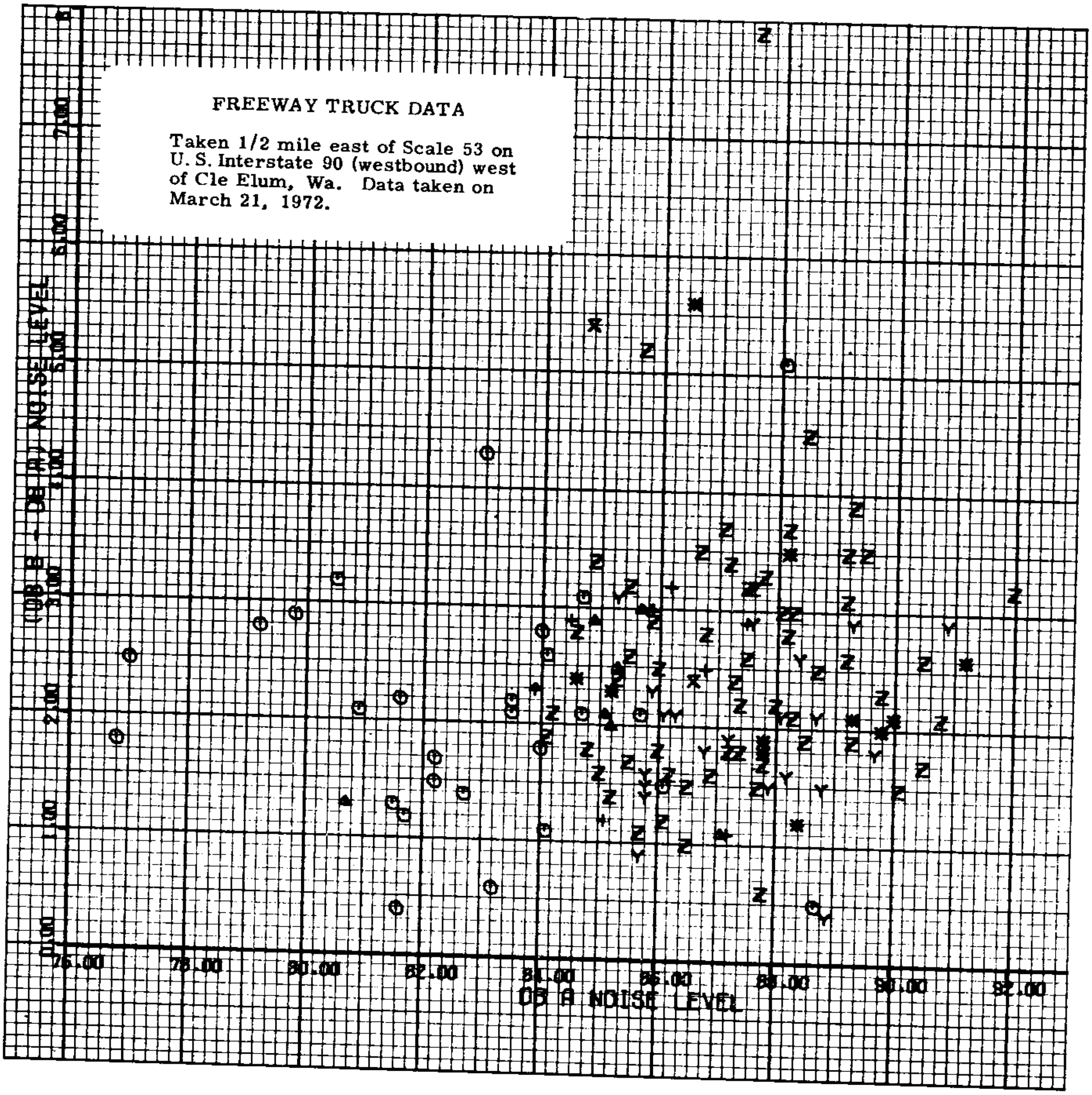

DB A NOISE LEVEL
SPEED IN MPH
FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U. S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
MEASURED TRUCK WEIGHT
15,000 - 20,000 lb


FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U. S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
DB A NOISE LEVEL
SPEED IN MPH
MEASURED TRUCK WEIGHT
20,000 - 30,000 lb


FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U. S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
DB A NOISE LEVEL
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
SPEED IN MPH
MEASURED TRUCK WEIGHT
30,000 - 45,000 lb


FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U. S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
DB A NOISE LEVEL
SPEED IN MPH
MEASURED TRUCK WEIGHT
45,000 - 65,000 lb


FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U.S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
DB A NOISE LEVEL
SPEED IN MPH
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
MEASURED TRUCK WEIGHT
OVER 65,000 lb


FREEWAY TRUCK DATA
Taken 1/2 mile east of Scale 53 on U. S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
(DB B - DB A) NOISE LEVEL
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00
DB A NOISE LEVEL

APPENDIX D

DATA TAKEN MARCH 23, 1972, 3/4 MILE SOUTH OF SCALE 38 ON U.S. INTERSTATE 5 (NORTHBOUND) JUST SOUTH OF EVERETT, WASHINGTON.

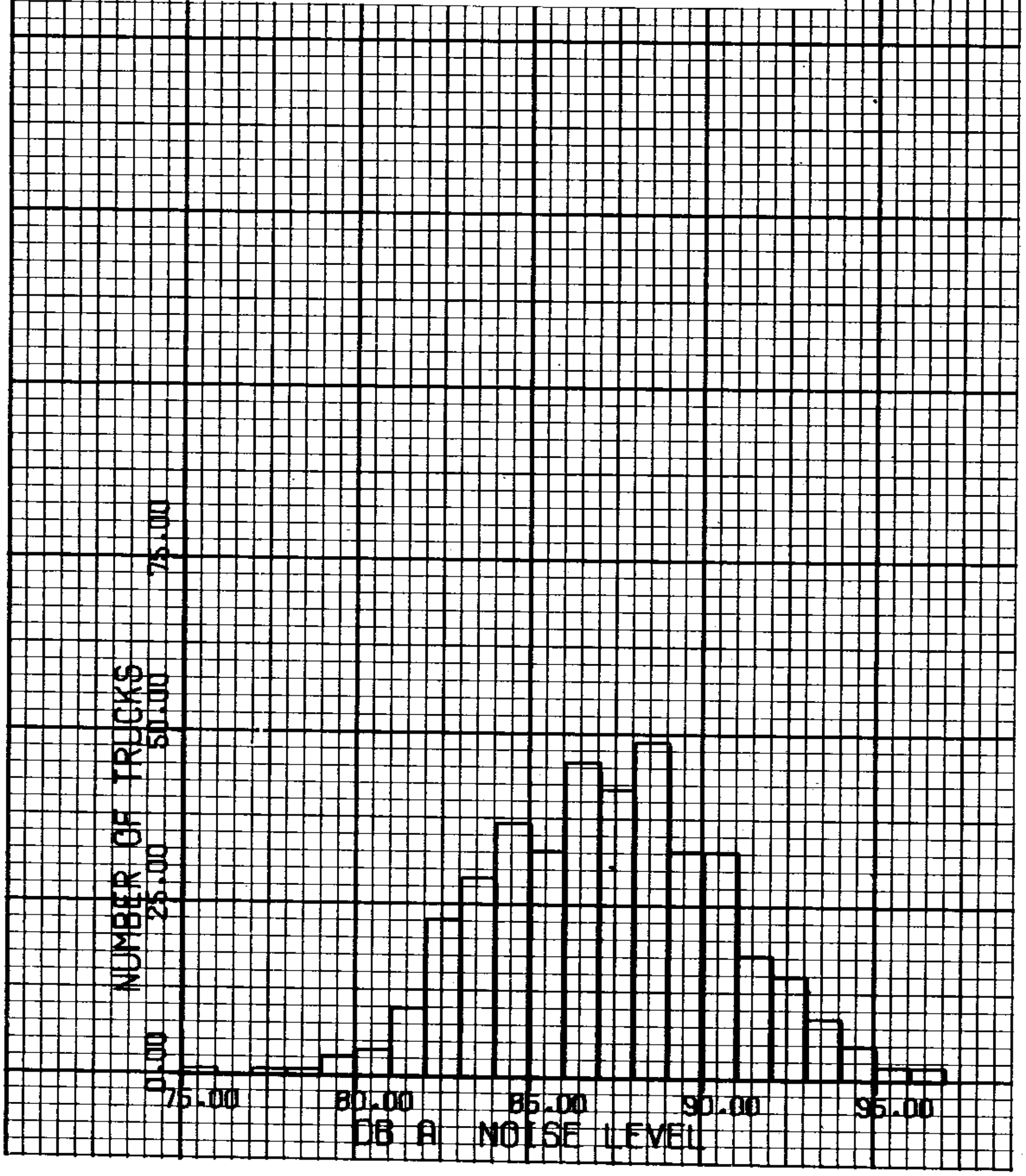
(See Figure 17 in main text for key to symbols representing each class of truck.)

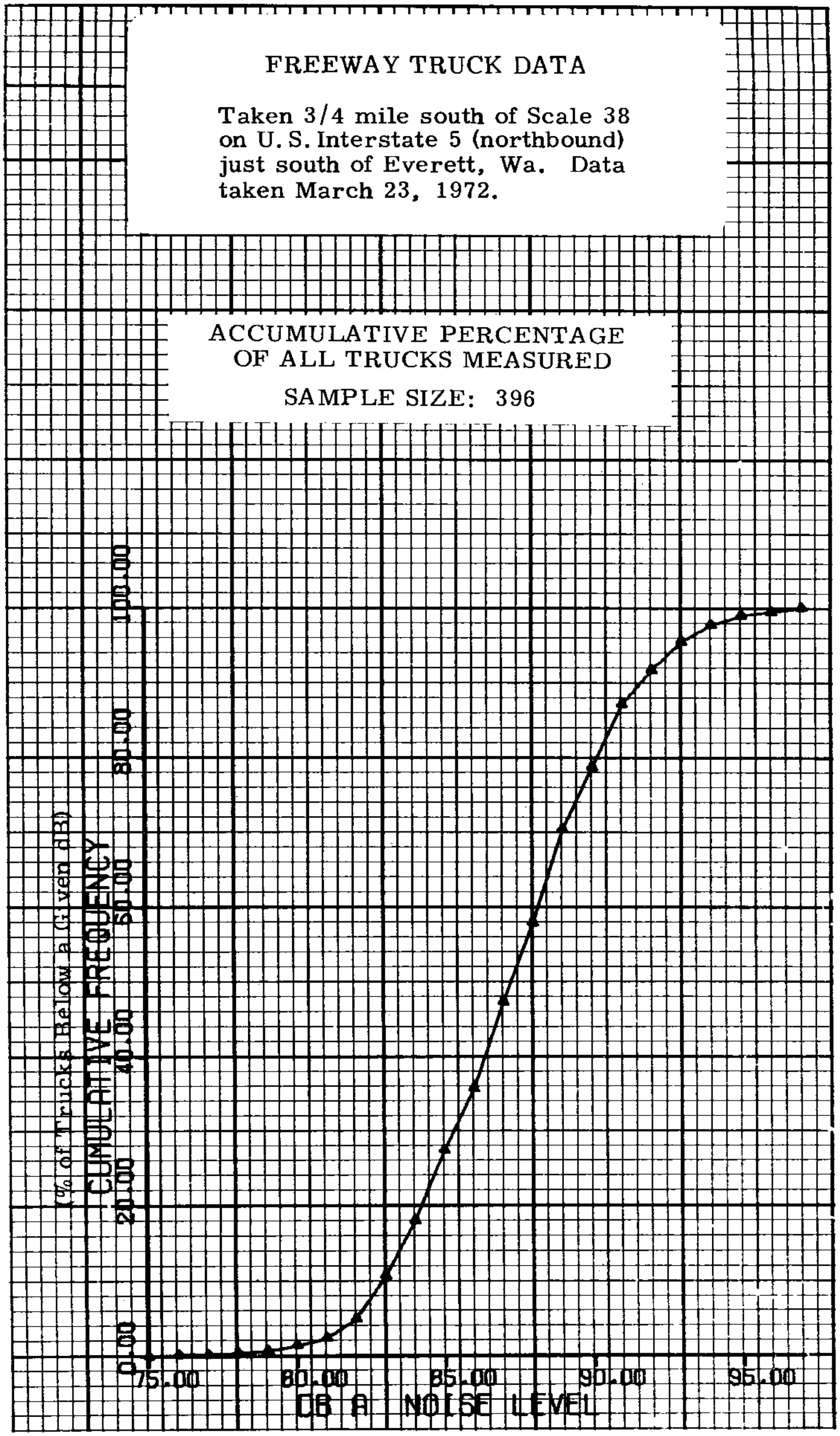
FREEWAY TRUCK DATA

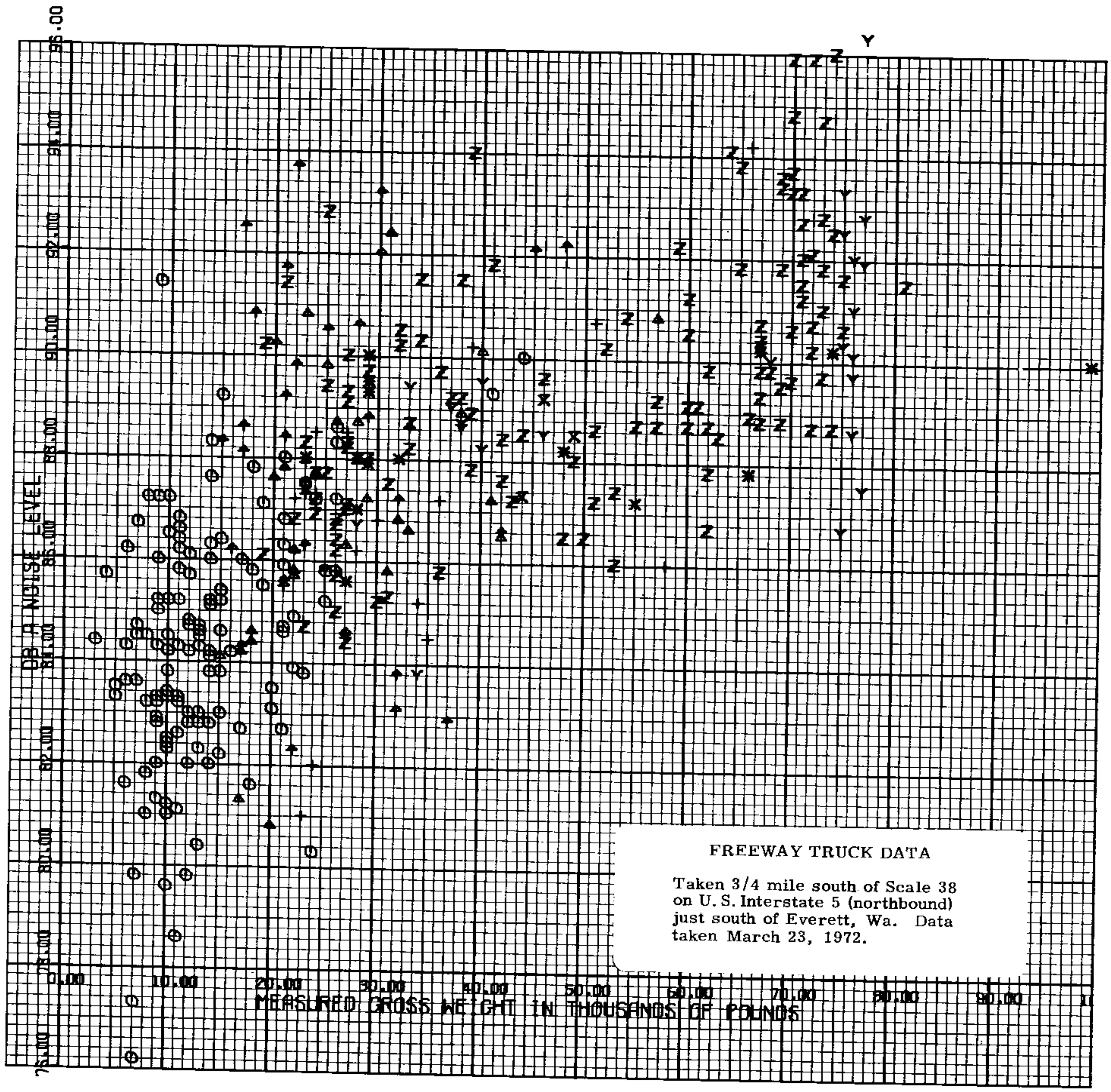
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.

HISTOGRAM OF ALL TRUCKS MEASURED

SAMPLE SIZE: 396

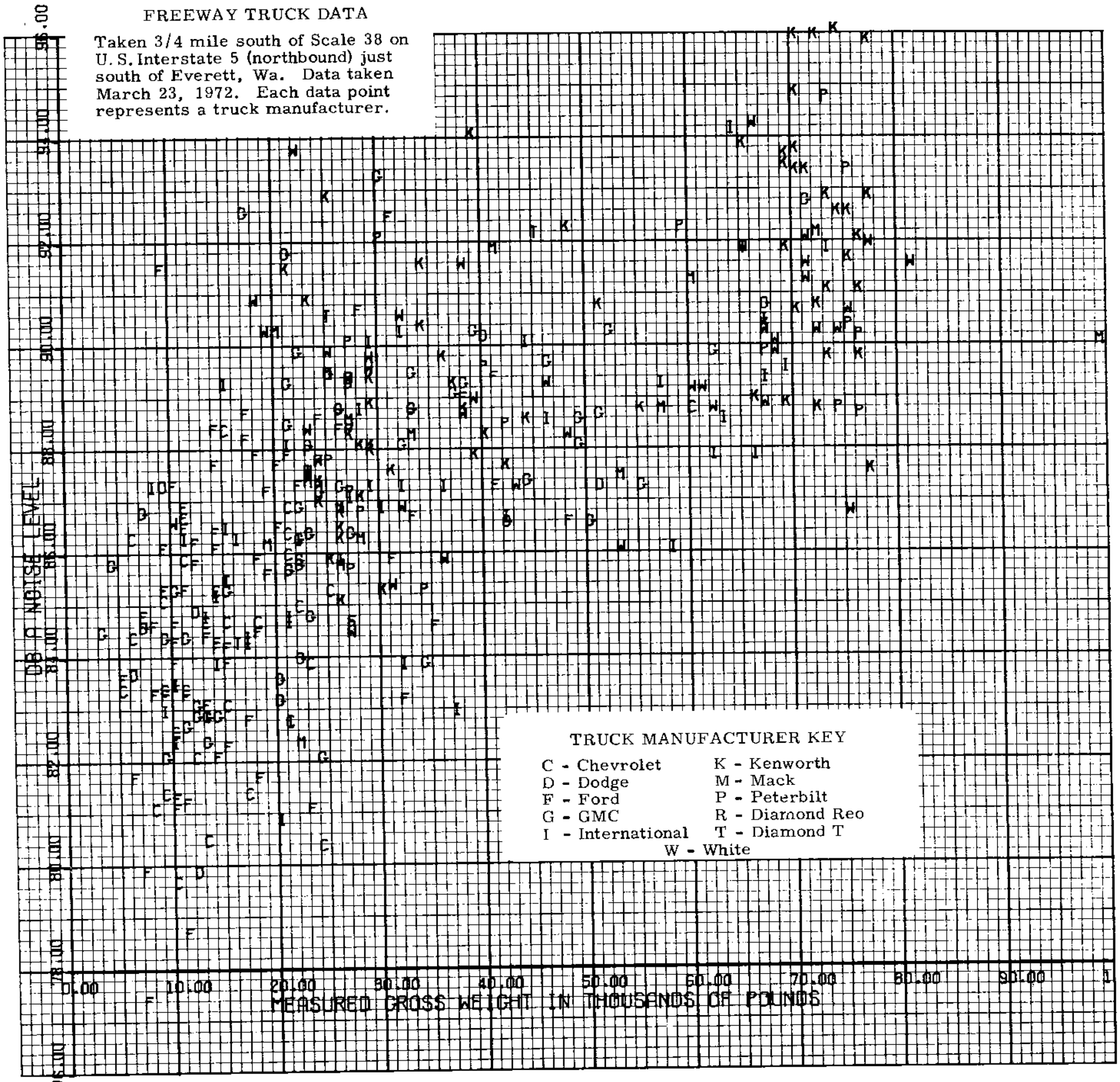


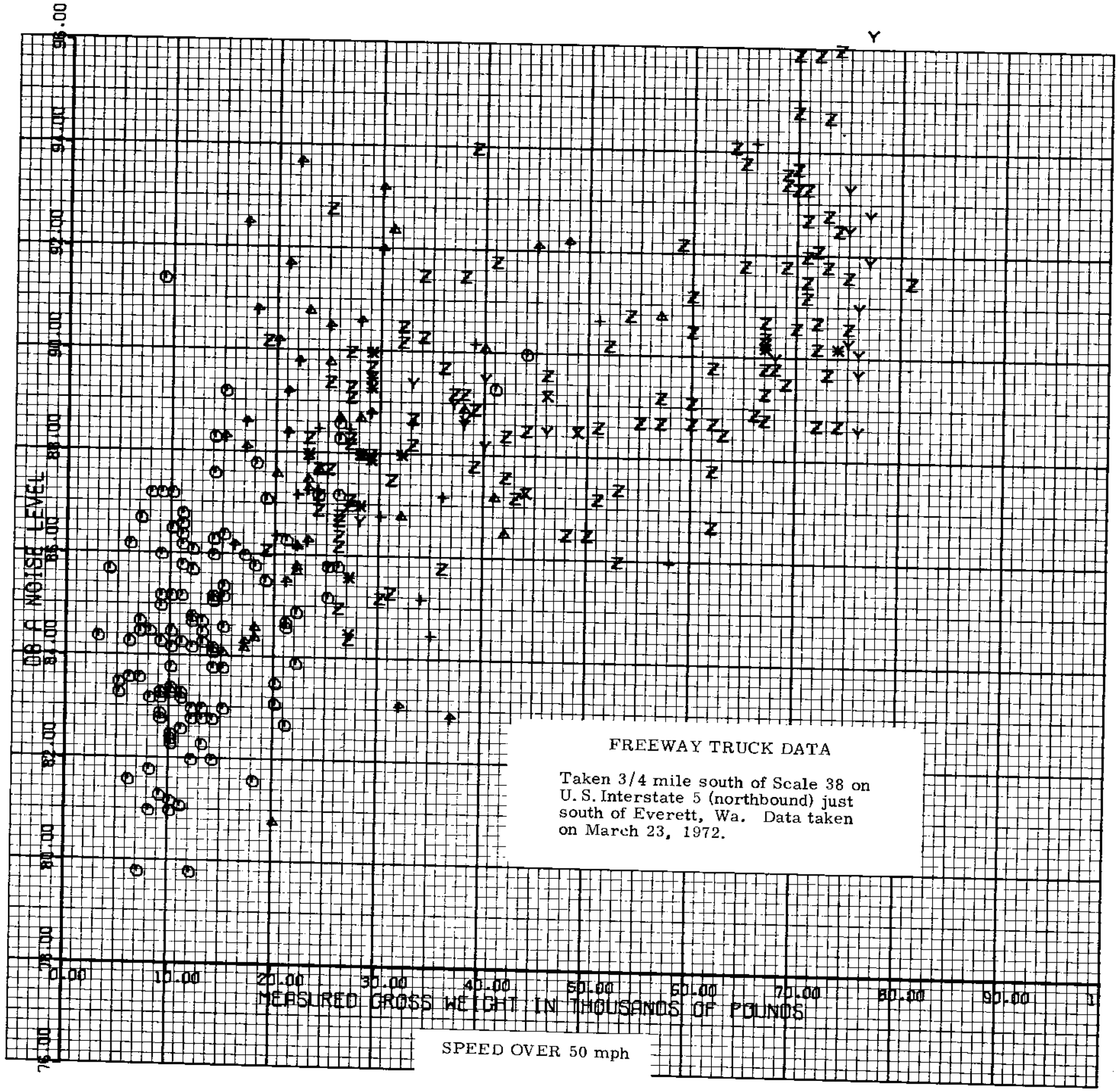

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.
ACCUMULATIVE PERCENTAGE OF ALL TRUCKS MEASURED
SAMPLE SIZE: 396
CUMULATIVE FREQUENCY
(% of Trucks Below a Given dB)
0.00
20.00
40.00
60.00
80.00
100.00
75.00
80.00
85.00
90.00
95.00
DB A NOISE LEVEL

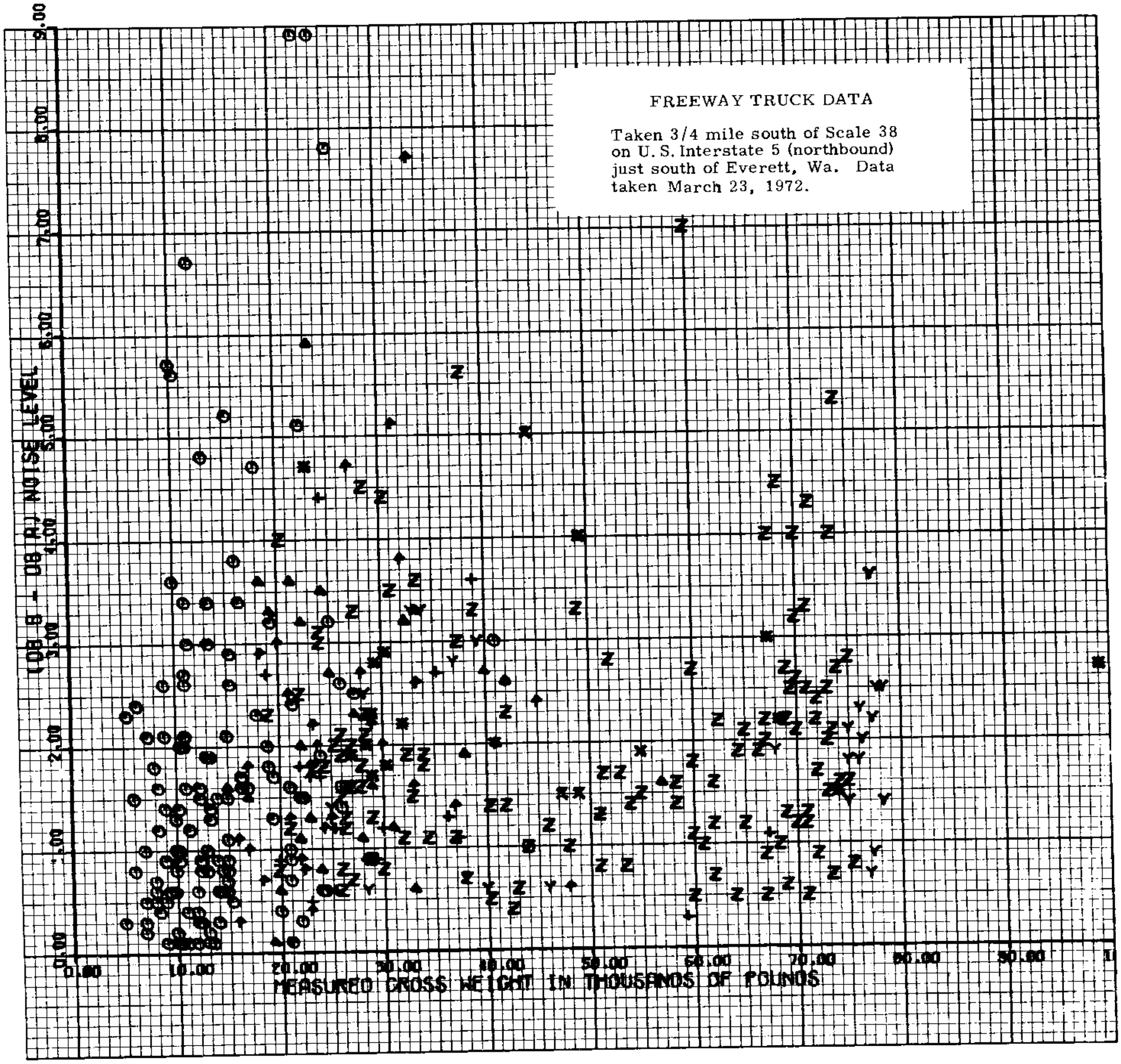


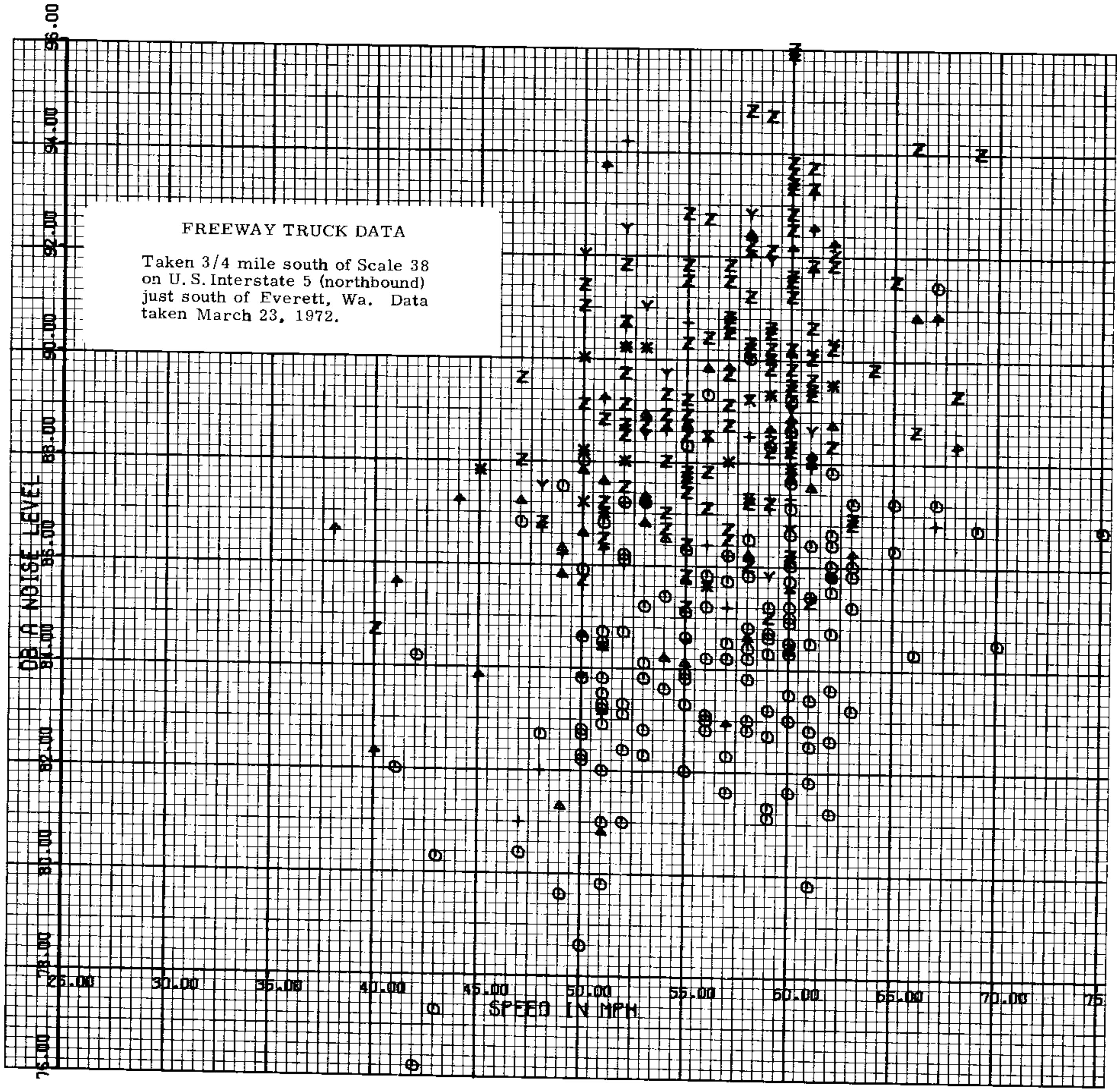
FREEWAY TRUCK DATA

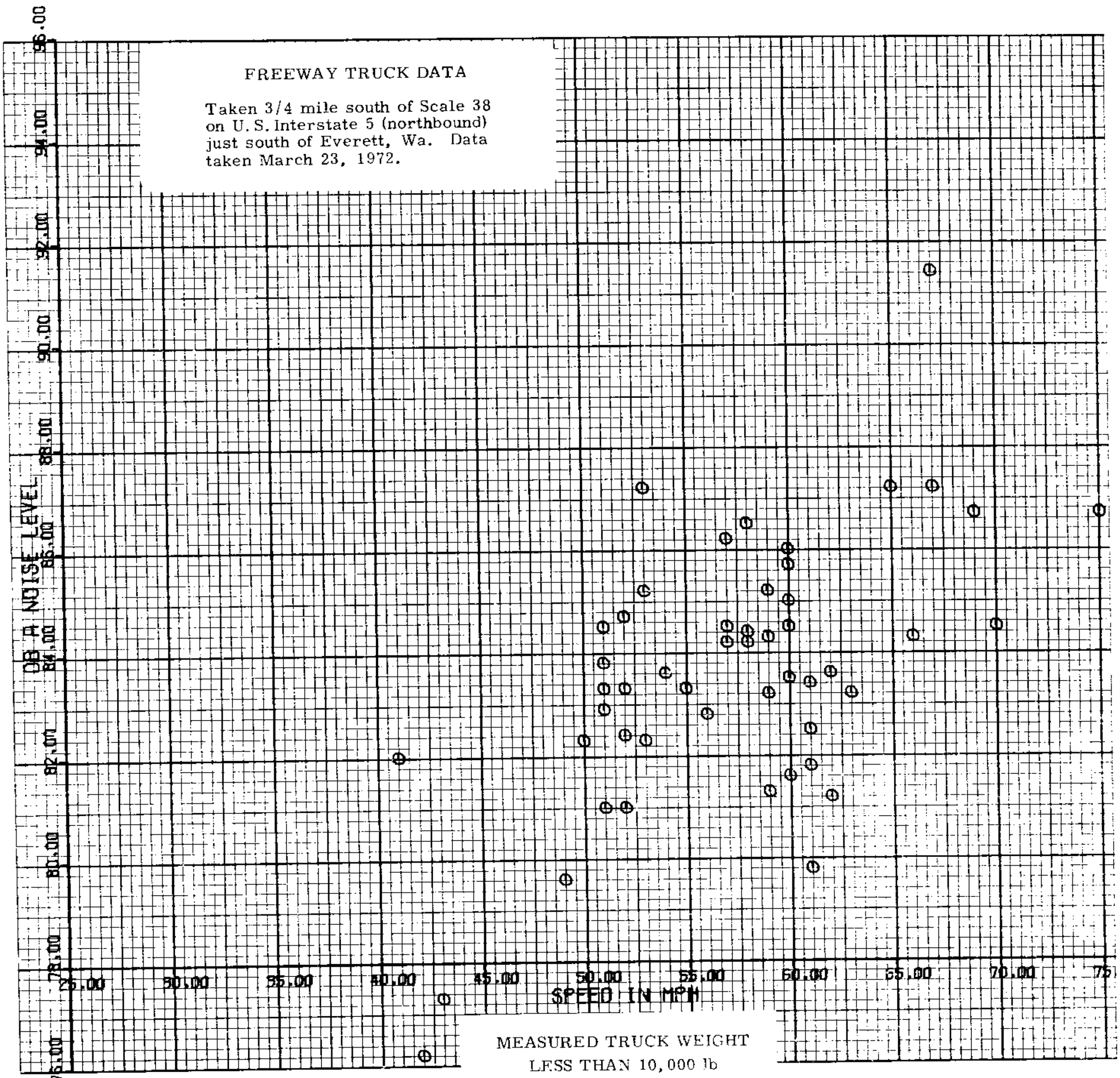
Taken 3/4 mile south of Scale 38 on U. S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.

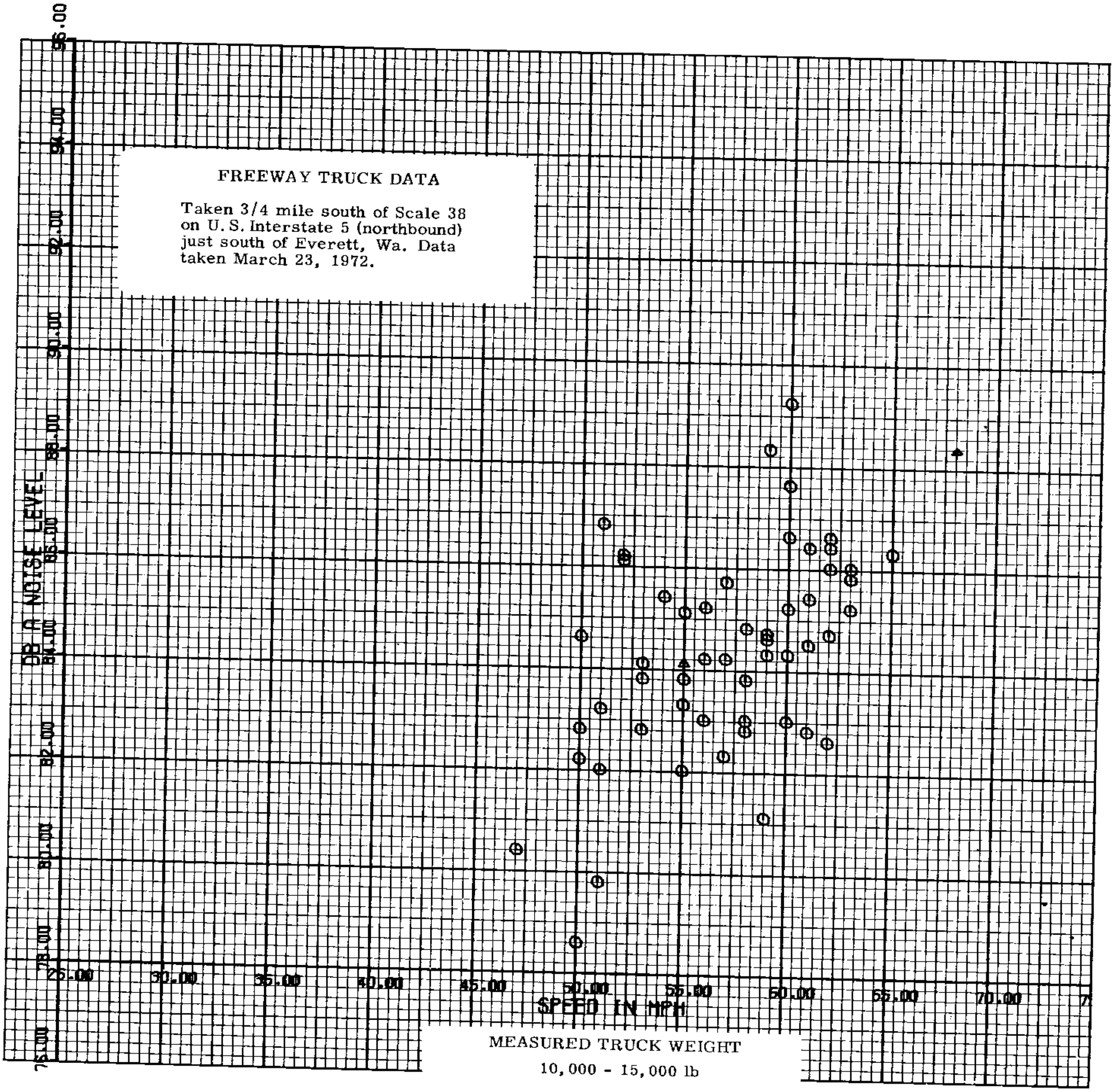

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972. Each data point represents a truck manufacturer.
TRUCK MANUFACTURER KEY
C - Chevrolet
D - Dodge
F - Ford
G - GMC
I - International
K - Kenworth
M - Mack
P - Peterbilt
R - Diamond Reo
T - Diamond T
W - White
DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS

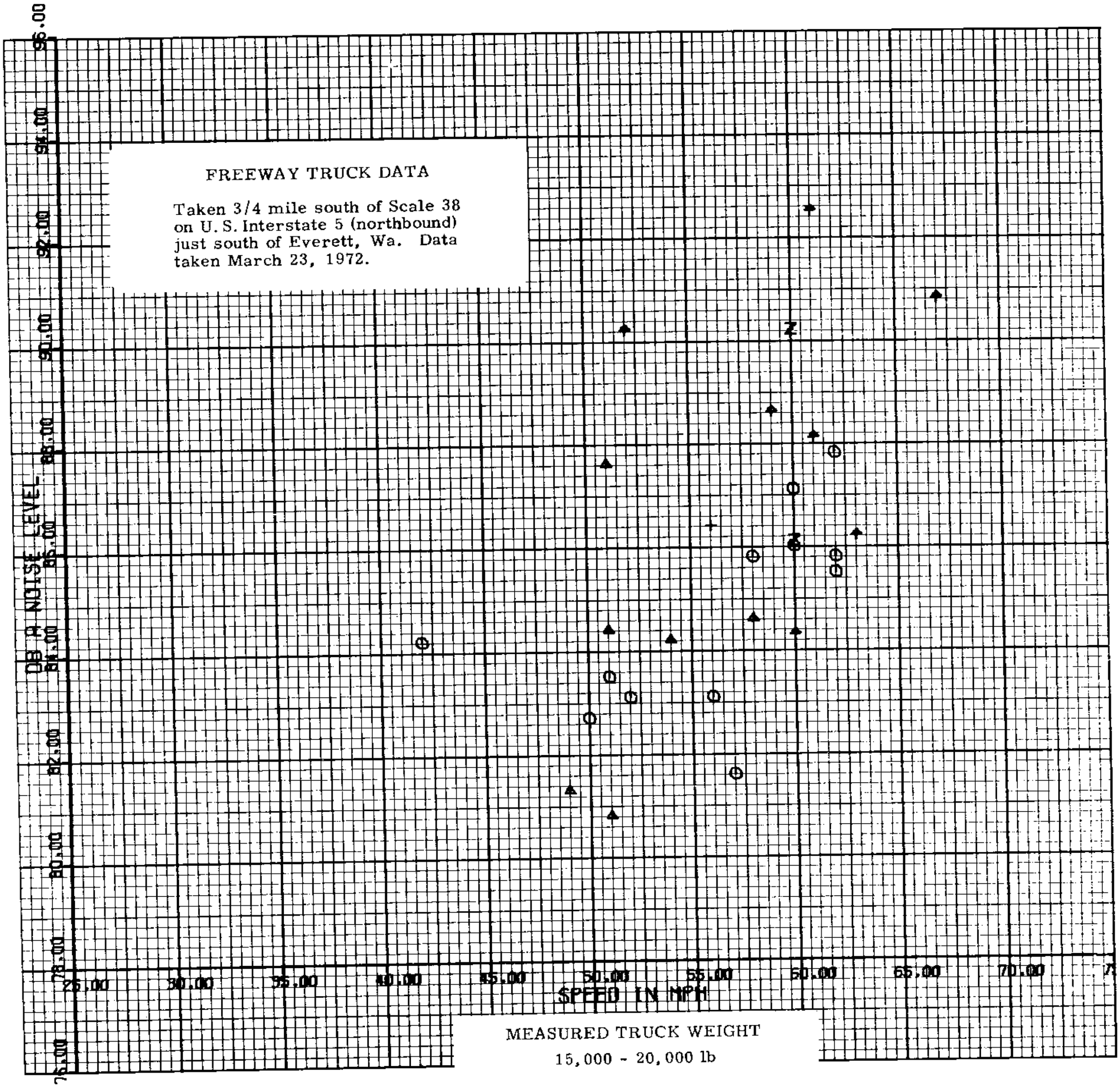

DB A NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken on March 23, 1972.
SPEED OVER 50 mph

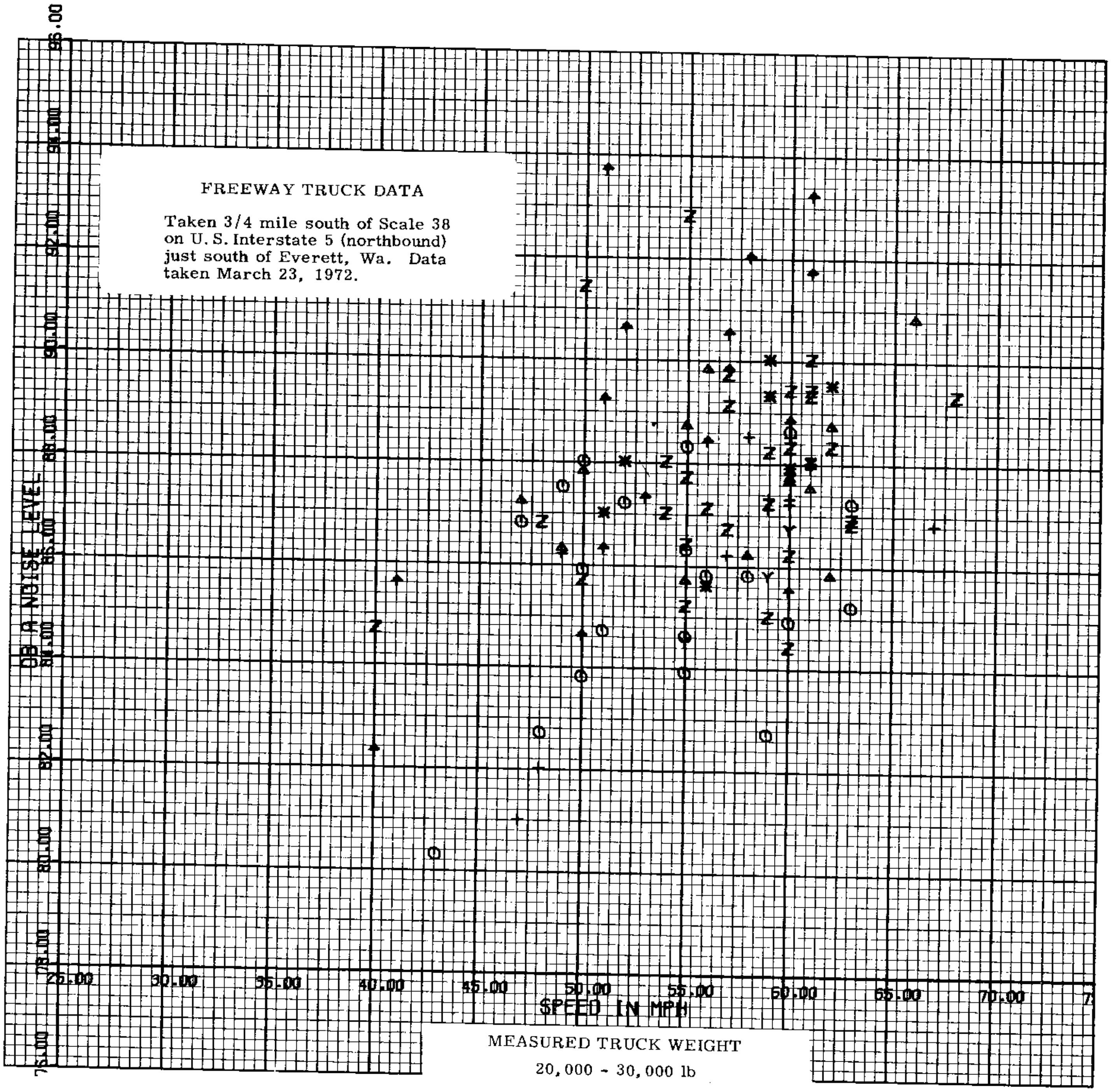

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.
(DB B - DB RJ NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00

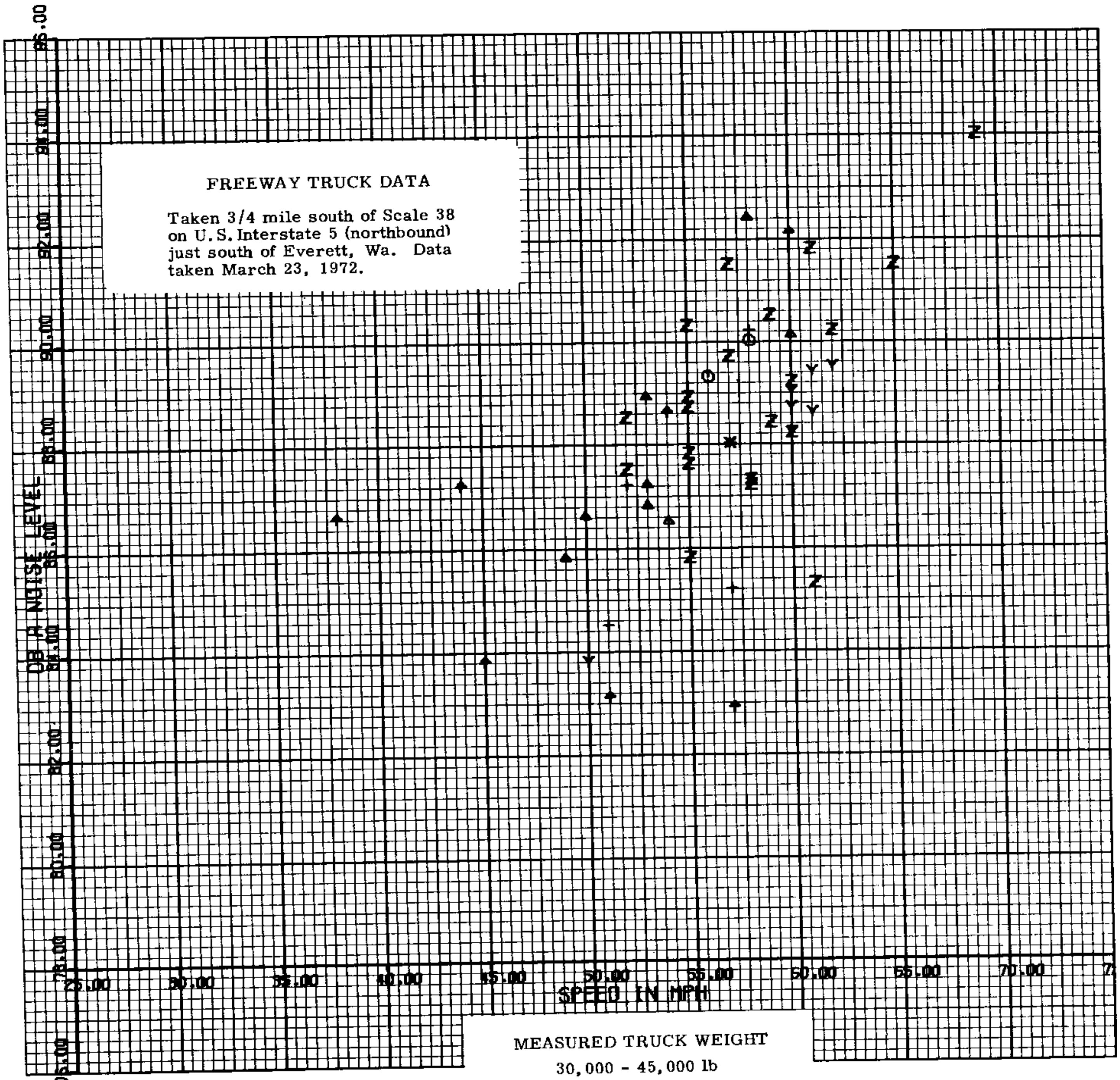

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.
DB A NOISE LEVEL
SPEED IN MPH
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00
94.00
96.00

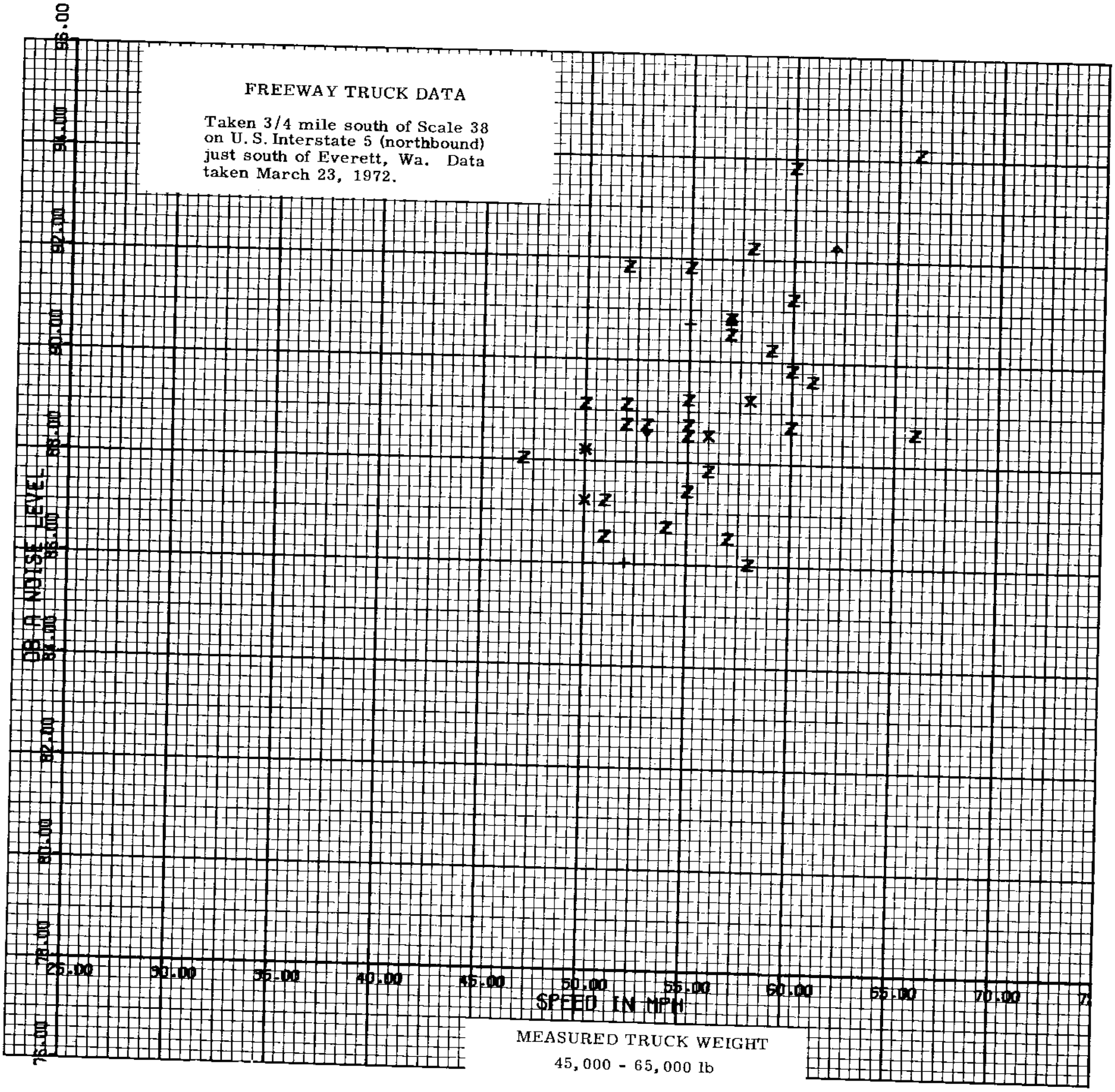

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.
DB A NOISE LEVEL
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75
SPEED IN MPH
MEASURED TRUCK WEIGHT
LESS THAN 10,000 lb

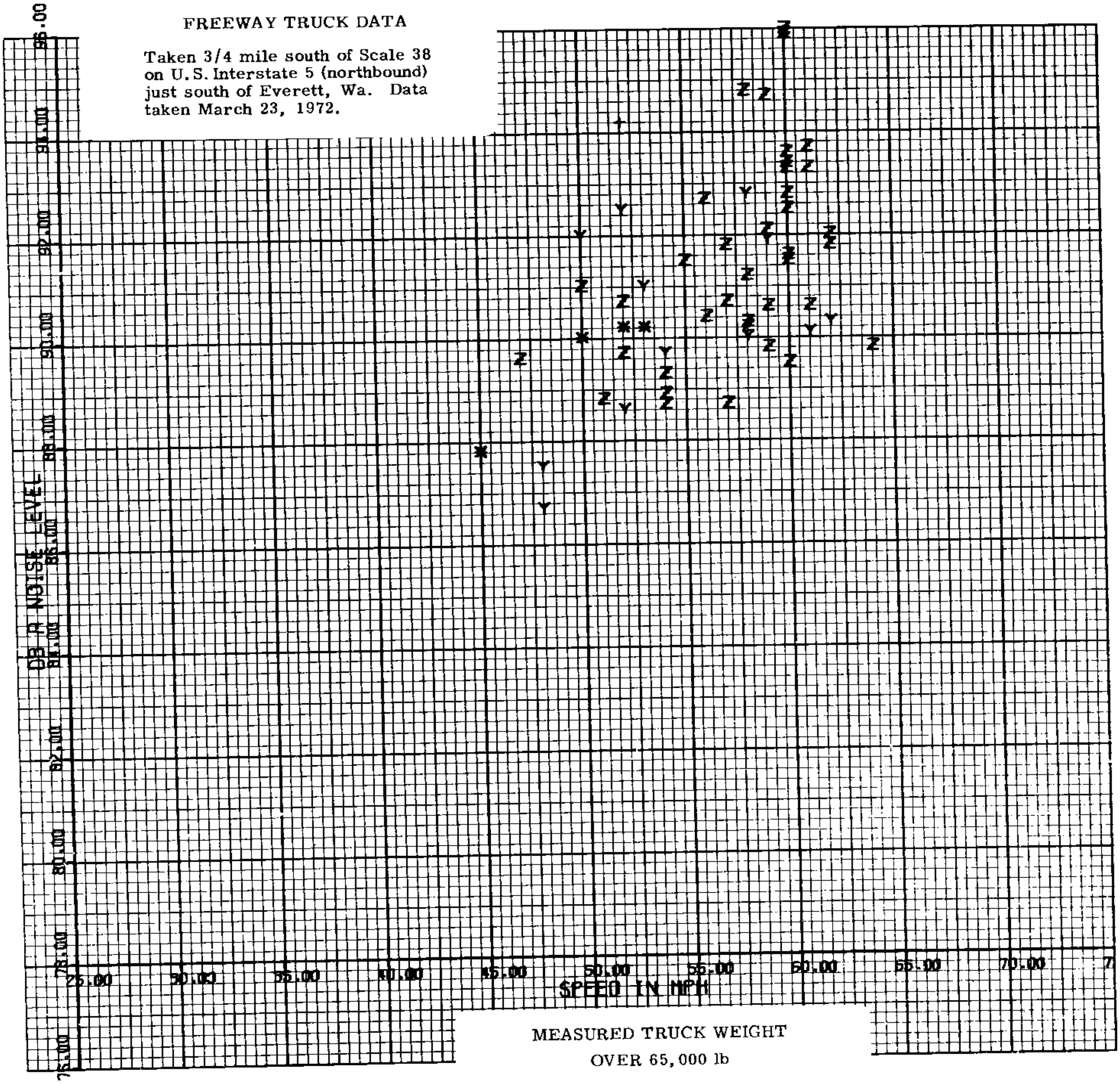

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.
DB A NOISE LEVEL
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
SPEED IN MPH
MEASURED TRUCK WEIGHT
10,000 - 15,000 lb

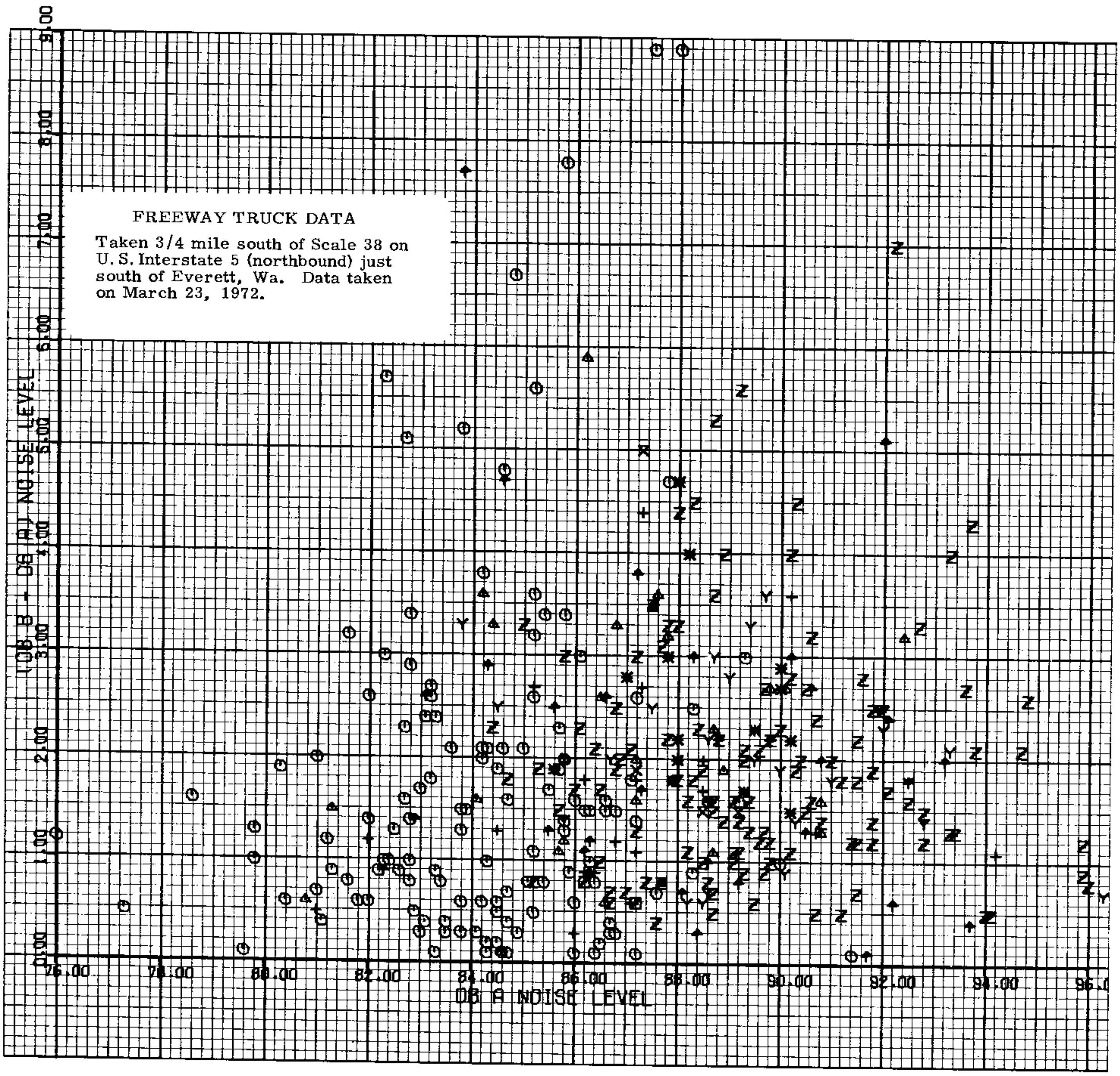

FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.
DB A NOISE LEVEL
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
SPEED IN MPH
MEASURED TRUCK WEIGHT
15,000 - 20,000 lb


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.
DB A NOISE LEVEL
SPEED IN MPH
MEASURED TRUCK WEIGHT
20,000 - 30,000 lb


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.
DB A NOISE LEVEL
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
SPEED IN MPH
MEASURED TRUCK WEIGHT
30,000 - 45,000 lb


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.
DB A NOISE LEVEL
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
SPEED IN MPH
MEASURED TRUCK WEIGHT
45,000 - 65,000 lb


FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972.
DB A NOISE LEVEL
SPEED IN MPH
MEASURED TRUCK WEIGHT
OVER 65,000 lb



FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U. S. Interstate 5 (northbound) just south of Everett, Wa. Data taken on March 23, 1972.
(DB B - DB A) NOISE LEVEL
DB A NOISE LEVEL
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
76.00
78.00
80.00
82.00
84.00
86.00
88.00
90.00
92.00
94.00

APPENDIX E

DATA TAKEN APRIL 11, 1972, BELOW THE N. MERIDIAN ROAD OVERPASS ON U.S. INTERSTATE 5 (SOUTHBOUND) NEAR NISQUALLY, WASHINGTON.

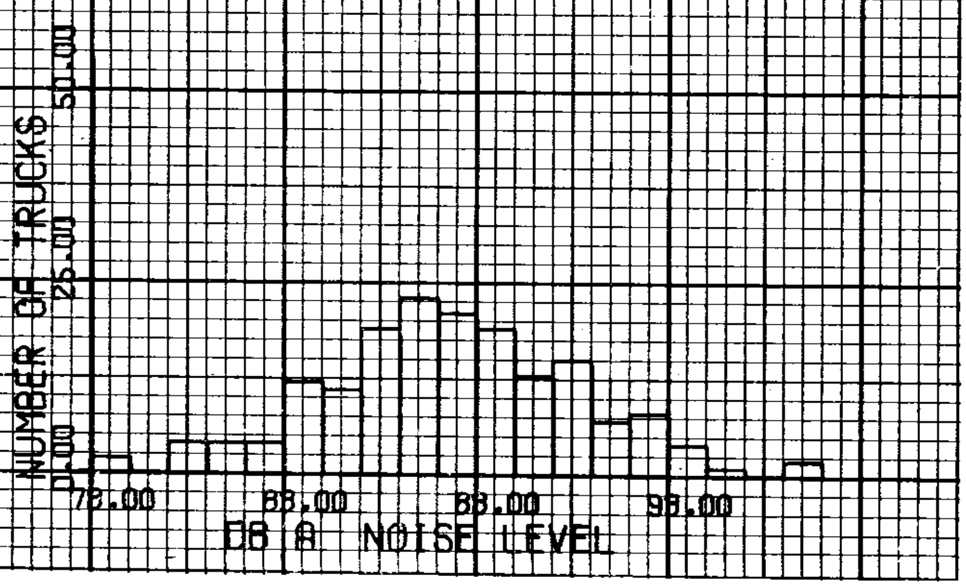
(See Figure 17 in main text for key to symbols representing each class of truck.)

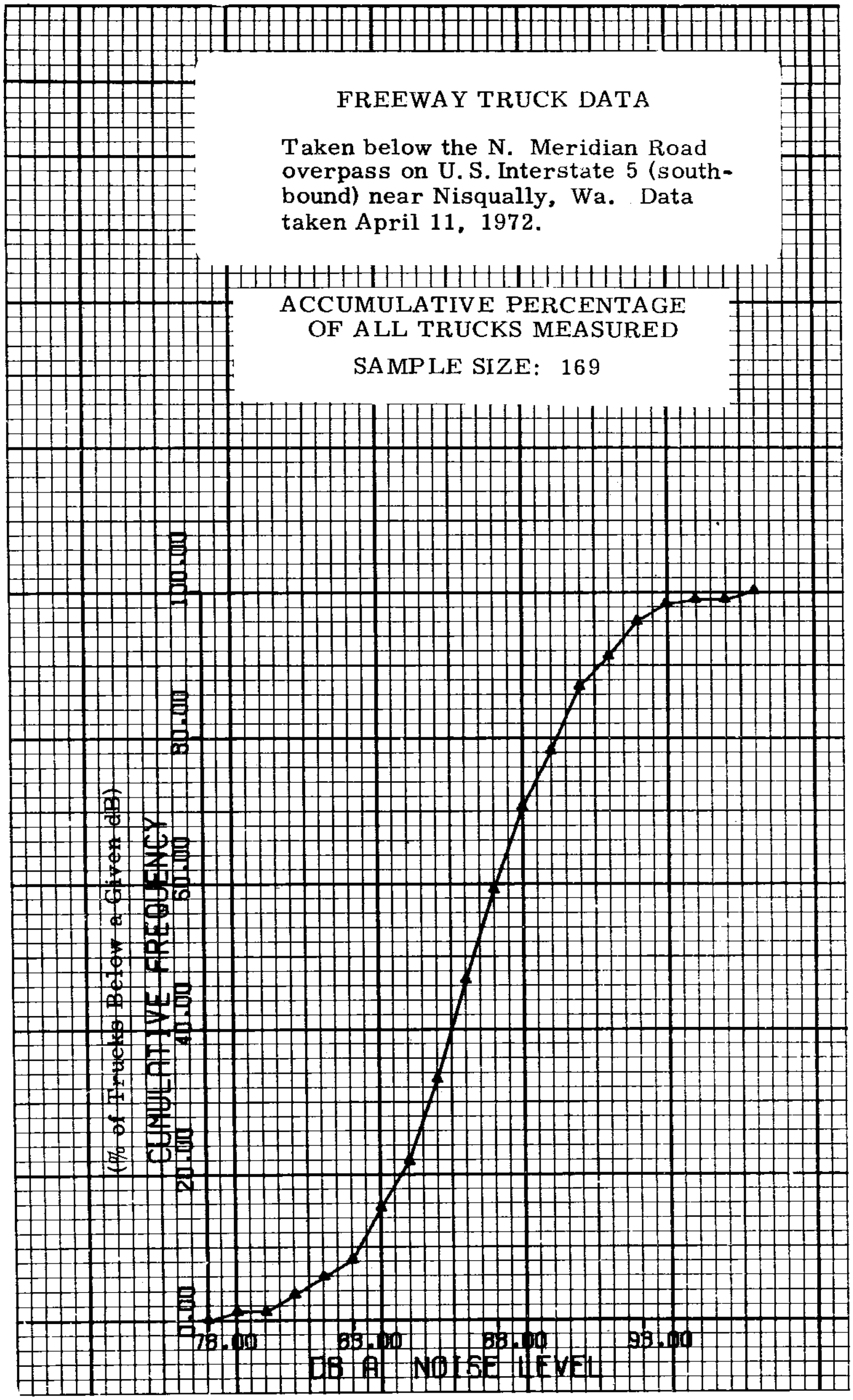
FREEWAY TRUCK DATA

Taken below the N. Meridian Road overpass on U. S. Interstate 5 (southbound) near Nisqually, Wa. Data taken April 11, 1972.

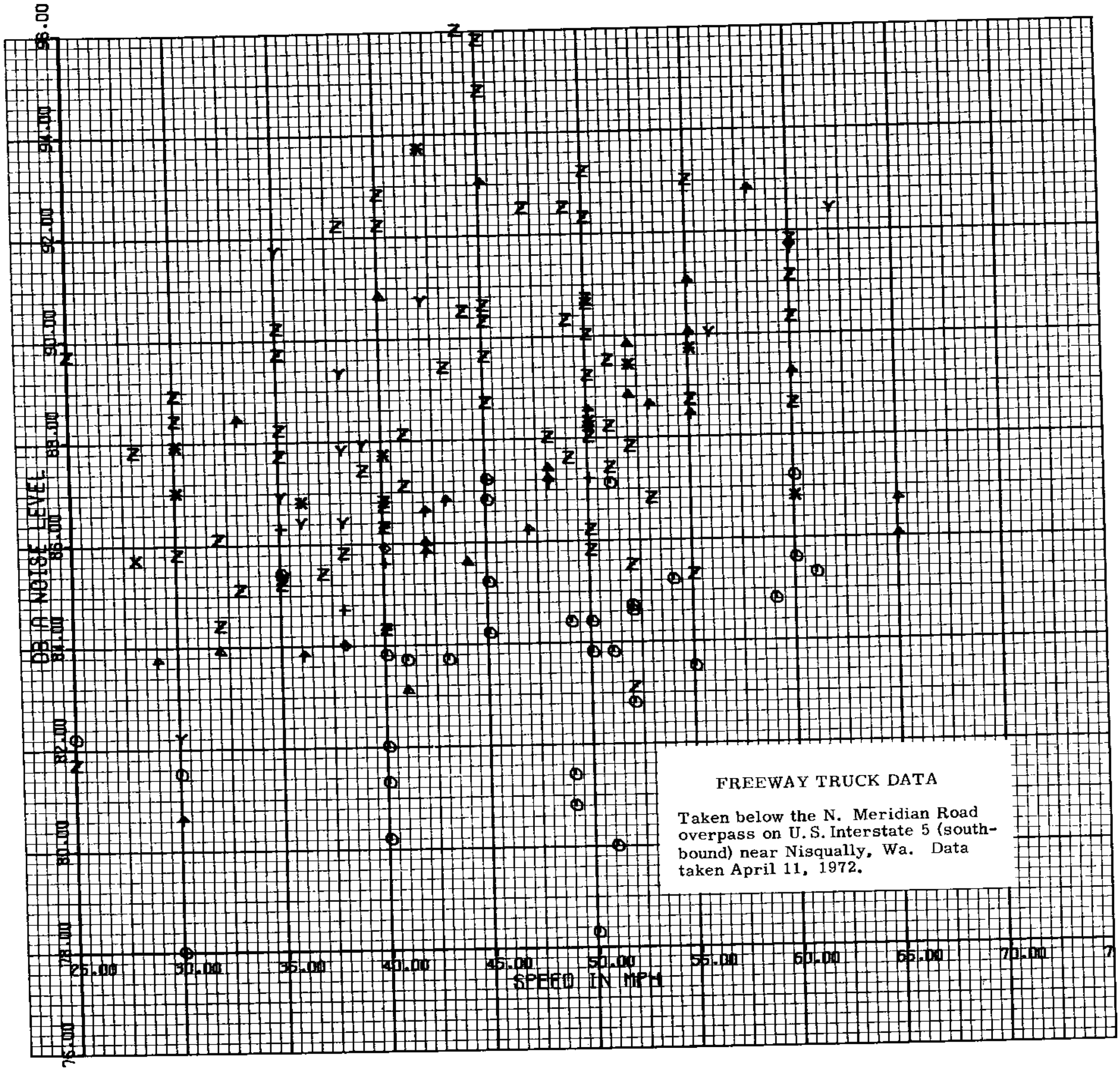
HISTOGRAM OF ALL TRUCKS MEASURED

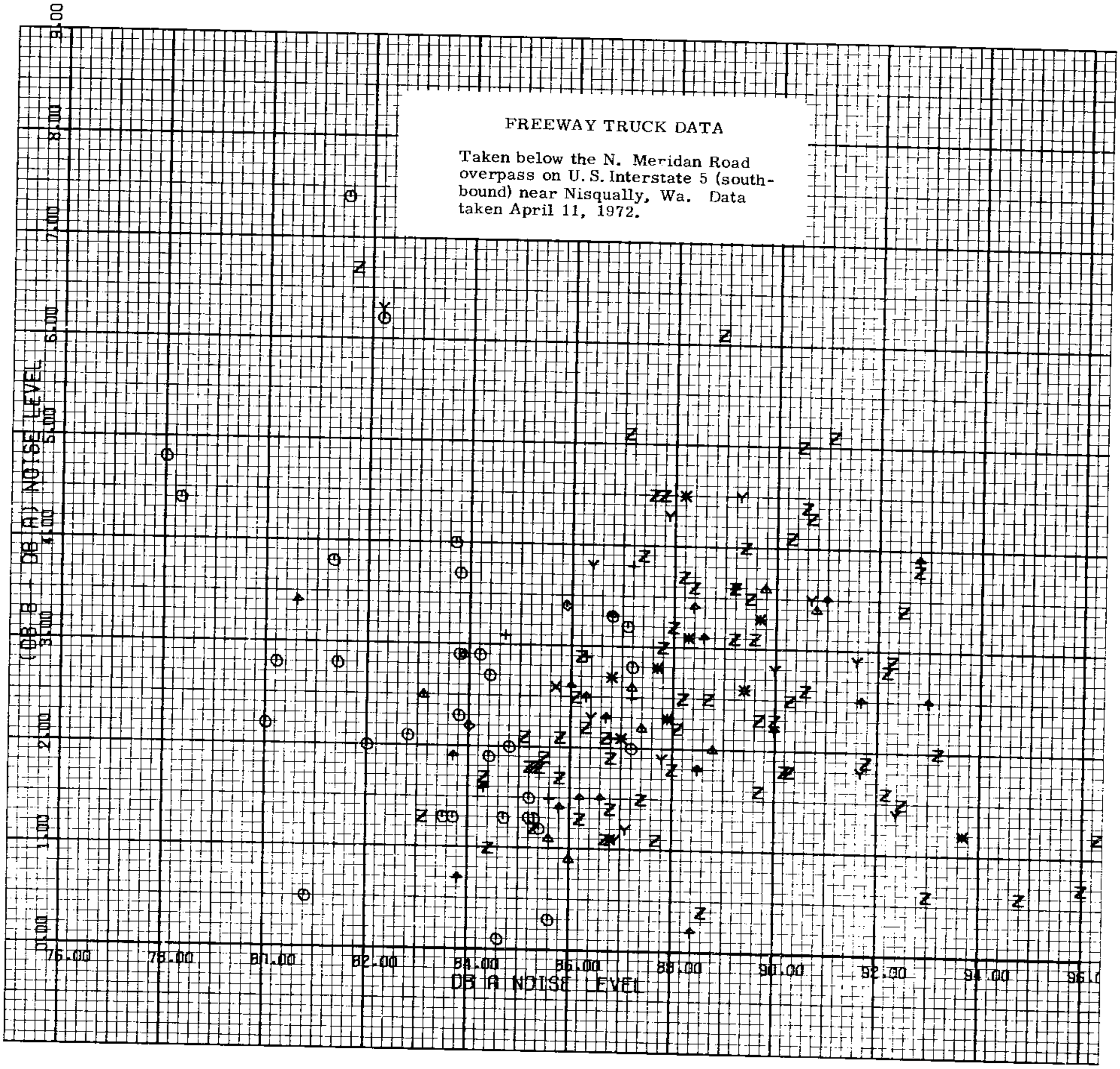
SAMPLE SIZE: 169





FREEWAY TRUCK DATA
Taken below the N. Meridian Road overpass on U. S. Interstate 5 (south-bound) near Nisqually, Wa. Data taken April 11, 1972.
ACCUMULATIVE PERCENTAGE OF ALL TRUCKS MEASURED
SAMPLE SIZE: 169
(% of Trucks Below a Given dB)
CUMULATIVE FREQUENCY
0.00
20.00
40.00
60.00
80.00
100.00
78.00
83.00
88.00
93.00
DB A NOISE LEVEL


DB A NOISE LEVEL
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
SPEED IN MPH
FREEWAY TRUCK DATA
Taken below the N. Meridian Road overpass on U.S. Interstate 5 (southbound) near Nisqually, Wa. Data taken April 11, 1972.



FREEWAY TRUCK DATA
Taken below the N. Meridan Road overpass on U.S. Interstate 5 (southbound) near Nisqually, Wa. Data taken April 11, 1972.
(DB B - DB A) NOISE LEVEL
DB A NOISE LEVEL

APPENDIX F

SURVEY OF EXISTING (1971) VEHICLE NOISE CONTROL LEGISLATION FOR CONTINENTAL U.S. AND CANADIAN PROVINCES

Continental United States*

Alabama

No enacted or proposed law.

Arizona

No law which sets a specific dB noise level for motor vehicles; however, every motor vehicle is required to be equipped with a muffler to prevent excessive noise.

Arkansas

No enacted or proposed law which sets a specific dB noise level for motor vehicles; however, every motor vehicle is required to be equipped with a muffler to prevent excessive or unusual noise.

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* No information was solicited from Hawaii or Alaska

California

(Excerpts from Amended* California Vehicle Code)

23130. (a) No person shall operate either a motor vehicle or combination of vehicles of a type subject to registration at any time or under any condition of grade, load, acceleration or deceleration in such a manner as to exceed the following noise limit for the category of motor vehicle within the speed limits specified in this section:

	Speed Limit of 35 mph or less	Speed Limit of more than 35 mph
(1) Any motor vehicle with a manufacturer's gross vehicle weight rating of 6,000 pounds or more and any combination of vehicles towed by such motor vehicle:		
(A) Before January 1, 1973	88 dB (A)	90 dB (A)
(B) On and after January 1, 1973	86 dB (A)	90 dB (A)
(2) Any motorcycle other than a motor-driven cycle	82 dB (A)	86 dB (A)
(3) Any other motor vehicle and any combination of vehicles towed by such motor vehicle...	76 dB (A)	82 dB (A)

23130.5. (a) Not withstanding the provisions of subdivision (a) of Section 23130, the noise limits, within a speed zone of 35 miles per hour or less on level streets, or streets with a grade not exceeding plus or minus 1 per cent, for the following categories of motor vehicles, or combinations of vehicles, which are subject to registration, shall be:

* Amended 11/71.

(1) Any motor vehicle with a manufacturer's gross vehicle weight rating of 6,000 pounds or more and any combination of vehicles towed by such motor vehicle.....	82 dB (A)
(2) Any motorcycle other than a motor-driven cycle	77 dB (A)
(3) Any other motor vehicle and any combination of vehicles towed by such motor vehicle	74 dB (A)

27100. (a) No person shall sell or offer for sale, a new motor vehicle which produces a maximum noise exceeding the following noise limit at a distance of 50 feet from the centerline of travel under test procedures established by the department:

(1) Any motorcycle manufactured before 1970..	92 dB (A)
(2) Any motorcycle, other than a motor-driven cycle, manufactured after 1969, and before 1973	88 dB (A)
(3) Any motorcycle, other than a motor-driven cycle, manufactured after 1972 and before 1975	86 dB (A)
(4) Any motorcycle, other than a motor-driven cycle, manufactured after 1974 and before 1978	80 dB (A)
(5) Any motorcycle, other than a motor-driven cycle, manufactured after 1977 and before 1988	75 dB (A)
(6) Any motorcycle, other than a motor-driven cycle, manufactured after 1987	70 dB (A)
(7) Any snowmobile manufactured after 1972	82 dB (A)
(8) Any motor vehicle with a gross vehicle weight rating of 6,000 pounds or more manufactured after 1967 and before 1973	88 dB (A)
(9) Any motor vehicle with a gross vehicle weight rating of 6,000 pounds or more manufactured after 1972 and before 1975	86 dB (A)

(10) Any motor vehicle with a gross vehicle weight rating of 6,000 pounds or more manufactured after 1974 and before 1978. . . .	83 dB(A)
(11) Any motor vehicle with a gross vehicle weight rating of 6,000 pounds or more manufactured after 1977 and before 1988	80 dB (A)
(12) Any motor vehicle with a gross vehicle weight rating of 6,000 pounds or more manufactured after 1987	70 dB (A)
(13) Any other motor vehicle manufactured after 1967 and before 1973	86 dB (A)
(14) Any other motor vehicle manufactured after 1972 and before 1975	84 dB (A)
(15) Any other motor vehicle manufactured after 1974 and before 1978	80 dB (A)
(16) Any other motor vehicle manufactured after 1977 and before 1988	75 dB (A)
(17) Any other motor vehicle manufactured after 1987. . . .	70 dB (A)

Colorado

Connecticut

Proposed legislation under consideration which would follow California's standards.

Delaware

Presently has no law except for the requirement that vehicles be equipped with mufflers. A proposal is under study which would limit noise emissions from vehicles at 50 feet to approximately 80 dB for automobiles and a somewhat higher limit for trucks.

Florida

Noise study underway; no funding available so the Legislature in 1971 directed the Department of Pollution Control (noise being its responsibility) to work with the Department of Transportation in establishing the maximum decibels of sound permissible from motor vehicles and trucks operating on Florida highways.

Georgia

No law which sets a specific dB noise level for motor vehicles; however, every motor vehicle must be equipped with a muffler in good working order to prevent excessive or unusual noise.

Idaho

Presently in effect is the following law:

(1) Every motor vehicle must be equipped with a muffler to prevent the emission of excessive or unusual noise.

(2) Excessive or unusual noise includes any sound made by a motor vehicle at any time under any condition of grade, speed, acceleration or deceleration which exceeds 92 dB (A) measured at a distance of not less than 20 feet to the side of the vehicle.

Illinois

At present there is no law. Regulations governing stationary noise sources and airport noise will be submitted to the Illinois Pollution Control Board soon, after which motor vehicle noise will be investigated.

Indiana

Iowa

No existing or proposed law.

Kansas

No enacted or proposed law concerning noise abatement.

Kentucky

Highway noise-limiting legislation currently being studied.

Louisiana

No law which sets a specific dB noise level for motor vehicles; however, every motor vehicle must be equipped with standard mufflers and exhaust systems.

Maine

No existing or proposed legislation, except vehicles are required by law to have mufflers. A bill authorizing the study of noise pollution was introduced but failed to pass.

Maryland

Proposals to include noise as an area of air pollution whereby the noise standard shall not be greater than 108 PNdB (perceived noise, in decibels) failed to be enacted. Another bill presently proposed includes as an area of air pollution "noise which unreasonably interferes with the proper enjoyment of the property of others." No specific dB limits were proposed nor did the bill specifically mention the noise emitted by motor vehicles. No law at present.

Massachusetts

Michigan

Currently in effect is a law requiring that every motor vehicle be equipped with a muffler to prevent the emission of excessive or unusual noise. A noise bill patterned after California is presently being proposed.

Minnesota

Presently in effect is the following law.

(169.691) No person shall operate a motor vehicle or combination of vehicles at any time or under any condition of grade, road, acceleration or deceleration which exceeds the noise limit specified below at a distance of 50 ft from the center of the lane of travel within the speed limits specified:

	35 mph or less	more than 35 mph
(1) Any motor vehicle with a manufacturer's gross vehicle weight rating of 6,000 lb or more, any combination of vehicles towed by such motor vehicle, and any motorcycle:		
(a) Before Jan. 1, 1975	88 dB(A)	90 dB(A)
(b) On and after Jan. 1, 1975	86 dB(A)	90 dB(A)
(2) Any other motor vehicle and any combination of vehicles towed by such motor vehicle	82 dB(A)	86 dB(A)

(169.692) No person shall sell or offer for sale a new motor vehicle which produces a maximum noise exceeding the following noise limit of a distance of 50 ft from the centerline of travel:

Any motorcycle manufactured	
(1) Before Jan. 1, 1972	92 dB(A)
(2) On or after Jan. 1, 1972 and before Jan. 1, 1973	88 dB(A)
(3) On or after Jan. 1, 1973	86 dB(A)
Any motor vehicle with a gross vehicle weight rating of 6,000 lb or more manufactured	
(4) On or after Jan. 1, 1972 and before Jan. 1, 1975	88 dB(A)
(5) On or after Jan. 1, 1975	86 dB(A)
Any other motor vehicle manufactured	
(6) On or after Jan. 1, 1972 and before Jan. 1, 1975	86 dB(A)
(7) After Jan. 1, 1975	84 dB(A)

Mississippi

Missouri

No enacted or proposed law.

Montana

No existing or proposed law.

Nebraska

Nevada

Law patterned after that of California (pre-amended).

New Hampshire

Letter forwarded to Legislative Services for response.

New Jersey

Presently there are no regulations governing noise; some bills proposed in the past and patterned after the California Law did not pass. However, the New Jersey Dept. of Environmental Protection has been authorized to make up regulations to control noise from motor vehicles and other sources.

New Mexico

Currently has no noise abatement law although legislation similar to that of California has been proposed in this session of the legislature. The city of Albuquerque has a comprehensive ordinance which prescribes noise levels for various vehicles.

New York

Presently in effect is the following law.

Sec. 386 of the Vehicle and Traffic Law - Motor vehicle noise limits

(1) No motor vehicle, other than an authorized emergency vehicle or a vehicle moving under special permit, which makes or creates excessive or unusual noise, shall operate upon a public highway.

(2) A motor vehicle which produces a sound level of 88 dB or more on the "A"scale shall be deemed to make or create excessive or unusual noise.

New York (cont.)

(Excessive or unusual noise is defined as a sound pressure level (SPL) of 88 dBA or more measured on a standard sound level meter. The measurements of SPL shall be made at speeds of less than 35 mph with the microphone positioned 50 ft, ± 2 ft, from the center of the lane in which the vehicle is traveling. SPL measurements shall be made according to the practices outline in the Society of Automotive Engineers Standard J672, "Measurement of Truck and Bus Noise" as approved Jan. 1957.)

(3) No arrest shall be made in cases where the noise limit is exceeded by less than a 2 dB tolerance.

(4) Every motor vehicle shall be equipped with an adequate muffler to prevent the emission of excessive or unusual noise.

North Carolina

No existing or proposed legislation except that no vehicle may emit excessive or unusual noise and must be equipped with a muffler to accomplish this.

North Dakota

The present law authorizes the state health council to establish reasonable standards and regulations necessary to prevent and minimize hazards to health and safety caused by the excessive noise of all sources including motor vehicles. No specific regulations were provided.

Ohio

Two bills have been introduced to the General Assembly but no action has been taken.

Oklahoma

No enacted or proposed law.

Oregon

Five bills introduced to the Legislature and only one passed; this measure requires Environmental Quality Commission to establish rules and regulations governing the noise emissions of various sources including motor vehicles.

Pennsylvania

Presently in effect is the following law.

(1) No motor vehicle, except for emergency vehicles, at any time or under any condition of grade, load, acceleration or deceleration,

Pennsylvania (cont.)

may exceed the following noise limit for the category of motor vehicle measured 50 ft from the center of the lane of travel within the speed limits specified:

	35 mph or less	more than 35 mph
(a) Any motor vehicle with manufacturer's gross vehicle weight rating of 7,000 lb or more, any combination of vehicles towed by such motor vehicle, and any motorcycle	90 dB	92 dB
(b) Any other motor vehicle and any combination of vehicles towed by such motor vehicle	82 dB	86 dB

(2) No new motor vehicle, except for emergency vehicles, may be sold which produces a maximum noise exceeding the following noise limit measured 50 ft from the center of the lane of travel.

(a) Same as (a) above with the addition of manufactured after Jan. 1, 1973	90 dB
(b) Same as (b) above with the addition of manufactured after Jan. 1, 1973	84 dB

Rhode Island

No enacted or proposed legislation.

South Carolina

No enacted or proposed legislation because of the highly rural nature of the state.

South Dakota

No exisiting or proposed legislation.

Tennessee

The present law requires all motor vehicles to be equipped with a muffler to prevent excessive or unusual noise. Proposed is a law which would limit the sound pressure level emitted by racing vehicles to be 86 dBA measured 50 ft from the centerline of the track or course.

Texas

No existing or proposed legislation except for a muffler-type law.

Utah

No enacted or proposed law.

Vermont

Currently has no law although it is expected that legislation will be proposed giving the Secretary of Environmental Conservation authority to establish regulations governing noise levels for vehicles.

Virginia

Washington

No enacted legislation but efforts to get noise level limits passed are continuing.

West Virginia

No enacted or proposed legislation.

Wisconsin

Legislation patterned after that of California is presently being proposed in both houses of the state legislature.

Wyoming

No enacted or proposed legislation.

Canadian Provinces *

Alberta

Presently there is no legislation for the whole province; however Calgary and Edmonton have fairly comprehensive noise abatement laws.

British Columbia

The 1971 Legislature has authorized the establishment of noise levels for motor vehicles. These limits will not be established until the present program for developing vehicle noise measurement techniques in Motor Vehicle Inspection Stations is completed.

Manitoba

Presently in effect is a law which requires a motor vehicle to be equipped with a muffler which would limit the noise emission below the level set for that class of motor vehicle under the regulations. However, the regulations prescribing the specific dB limits have not been drafted pending the possible adoption of noise level limits for motor vehicles at the manufacturers' level by the Federal government.

Ontario

No enacted or proposed law although studies of the whole field of noise pollution are being carried out by the Department of Environment.

Quebec

No enacted or proposed law.

Saskatchewan

The only legislation in effect to control noise levels is restricted to adequate muffling of vehicles to prevent undue or excessive noise.

Note: The Federal Department of Transport, which is responsible for implementing standards governing new motor vehicles offered for sale in Canada, has established noise limits for new motor vehicles. Heavy duty vehicles are required to emit not in excess of 88 dBA measured in accordance with SAE J366 while light duty and off-road utility vehicles are required to emit not in excess of 86 dBA measured in accordance with SAE J986a.

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* No information was solicited from New Brunswick

APPENDIX G

COMPILATION OF MUFFLER DATA

ALEXANDER-TAGG INDUSTRIES (ATI) - Manufactures truck and bus mufflers only. No specific noise or back pressure specifications are given although it is stated that ATI "Engine Mated" mufflers comply with the 88 dB(A) noise limit set by some states when installed without drastic deviations from OEM (original equipment manufacture) exhaust systems. These mufflers also meet or better engine back pressure requirements and are also said to last a minimum of 100,000 miles.

AMF BEAIRD - The mufflers produced by AMF are primarily used on stationary land-based or marine installations. Typical attenuation curves over the audio spectrum (37.5 Hz - 9.6 kHz) were shown for the MAXIM standard silencers. The attenuation provided by the silencers averaged 25 dB in the low frequency range.

DONALDSON - Gives specific exhaust noise and back pressure information for muffler systems on particular engines. The exhaust noise levels for different muffling systems range from 78 dBA to 88 dBA at 50 feet. However, this is only the exhaust noise and does not take into account other truck noise contributions which may equal or even surpass the exhaust noise level. The conditions under which the information was taken (i.e. horsepower and rpm--usually maximum load) are also given. Data are given for Cummins and Detroit diesel mufflers wherein the particular engine series is listed opposite the mufflers which will satisfy certain silencing requirements. These requirements are divided into two major categories:

I. Automotive Silencing

A. 125 "sones" and 88 dB(A): Mufflers in this class meet both AMA 125 "sone" and state 88 dB(A) limits for over highway trucks.

B. 88 dB(A): Mufflers in this class meet state 88 dB(A) legal requirements.

II. Construction & Industrial Silencing

A. Moderate Silencing: Mufflers recommended will control exhaust, noise at operator's position to California 95 dB(A) contour.

B. SAE 90 dB(A): Mufflers will control exhaust noise to meet SAE spectator noise spec of 90 dB(A) at 50 feet.

C. Spark Arresters: For applications where only a minimum degree of muffling is required.

The life expectancy of their mufflers is over 100,000 miles.

GILL - Produces spark-arrester mufflers which are concerned with the entrapment of carbon and ash particles in the exhaust stream in order to reduce fire hazards. No noise or back pressure specifications are given.

HAPCO - No Noise or back pressure specifications were available.

HAVILAND - The Haviland Co. manufactures automotive mufflers and could not furnish any noise or back pressure information.

HAYES-ALBION - No noise or back pressure specifications were available.

OXY-CATALYST INC - They manufacture catalytic mufflers which are primarily concerned with the removal of carbon monoxide and other harmful fumes from vehicle exhaust. Although no specific noise or back pressure information was given, it was stated that these catalytic mufflers have noise reduction and back pressure characteristics similar to standard acoustic mufflers.

RIKER - No exact noise or back pressure specifications were given. However, a line of primarily "sound" mufflers are rated from 85-88 dBA depending upon truck make, model, and engine. The conditions and method under which these mufflers were rated was not stated. The company's present goal is mufflers which can satisfy a noise level of 84-87 dBA measured according to SAE J366 recommended practice. The average life of all Riker mufflers is about 200,000 miles.

STEMCO - Generally, no specific noise or back pressure levels are given although a group of mufflers is listed which keeps the pure exhaust noise down to 78-82 dBA (at 50 feet and maximum engine load) and will satisfy California's 88 dBA law. For over-the-road diesel trucks muffler life ranges from 200,000 to 300,000 miles.

APPENDIX H

DEFINITION OF dB TERMS

The common unit for measuring noise is the decibel (dB). If, in addition, the frequency response is shaped for the A-weighting scale,* the result is referred to as dBA. The logarithmic scale for sound level was first introduced by telephone company engineers many years ago. They simply took the logarithm of the amount of power change that occurred in an amplifier or attenuator and named this unit a "Bell" in honor of their founder, Alexander Graham Bell. It was soon found that this was too coarse a unit, and it became common practice to use a unit ten times smaller, called a "decibel" (deci- meaning one-tenth).

In the case of sound measurement the level is always related to the sound pressure level of 0.0002 dyne/cm^2. This particular sound pressure level represents (approximately) the faintest sound that a human ear can hear in a very quiet room. This means that a sound with a level of 60 dB is approximately a million times more powerful than the faintest sound which can be heard. A sound level of 120 dB (which is near the threshold of pain) represents sound which is a million million times more powerful than the faintest audible sound.

If there are two noise sources and the noise power of each is known, the decibels are not added together to get the total sound level. Instead, one must change from decibels to sound pressures, add them, and reconvert to decibels. For example, if an automobile which is radiating a level of 80 dBA (as measured from a distance of 50 ft) is put next to an identical automobile also radiating 80 dBA, the resultant noise field will have twice the power. This will not give 160 dBA, but 83 dBA. Doubling the power adds only 3 dBA to the existing level. If the power is doubled again by adding two more such vehicles, the net result would be an 86 dBA sound level. Again doubling (for a total of eight such vehicles) would result in a total of 89 dBA, and further doubling (sixteen vehicles) would add 12 dBA to the level for a total of 92 dBA. In a hypothetical situation then, it would take 16 automobiles, each emitting 80 dBA, to equal one truck which is emitting 92 dBA.

The dBB scale is similar to the dBA scale described above, except that it allows more low-frequency sound to be "counted," hence a truck with a noisy exhaust would probably read higher on the dBB scale than on the dBA scale. The dBB scale is more representative of human hearing response to loud sounds.

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*This scale discriminates against both high- and low-frequency sounds in somewhat the same manner as does the human ear.