TIRE NOISE PROPERTIES OF TWO RESURFACING MATERIALS USED ON HIGHWAY BRIDGES FOR REPAIR OF WEAR

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APPLIED • PHYSICS • LABORATORY
A DIVISION OF THE UNIVERSITY OF WASHINGTON

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The purpose of this study was to investigate the acoustic effects of two topping materials used on bridges in the Seattle area. One material was applied to the bridge on Interstate-5 which crosses the Duwamish River. It is an English product called Spray-Grip which is supposed to have very good anti-skid properties, as well as the ability to stick to the road in thin layers thus making it suitable for the repair of worn surfaces. The other material is an epoxy-asphalt mixture which was applied to some sections of the Evergreen Point Floating Bridge over Lake Washington, particularly over sections where worn grating was causing excessive noise. Hopefully, this substance will be capable of long-term sticking in relatively thin layers.

Of the two materials, it was found that the epoxy-asphalt topping on the Evergreen Point Floating Bridge was by far the quieter, and, at least as newly applied, proved to be very quiet at the road/tire interface. It is likely that this good acoustic performance is due to the smoothness of the surface rather than directly to the fact that the material contains epoxy. The role of the epoxy would be as an adhesive and to resist wear so that its original acoustic performance could be maintained for a considerable length of time. Spray-Grip, on the other hand, although slightly quieter than the rutted, worn roadway, was not as quiet as the original unworn road surface.

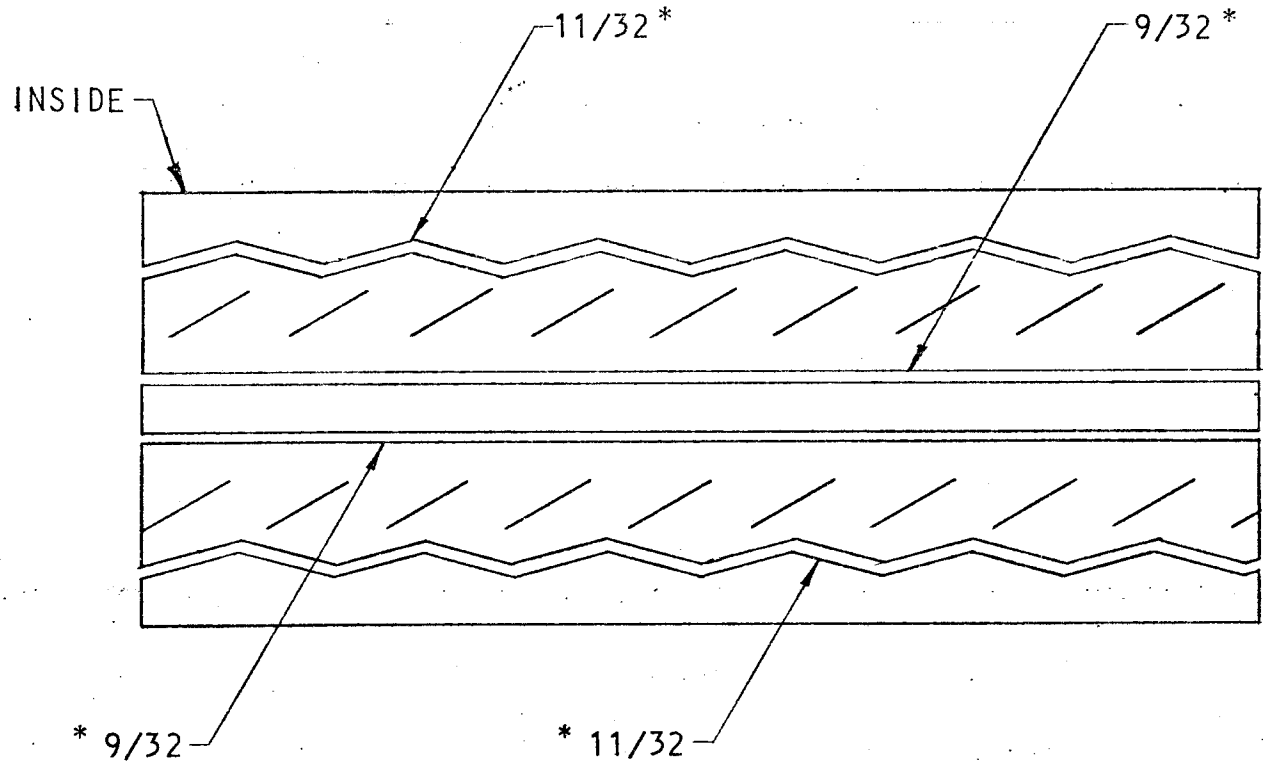
Experimental Procedures

The primary contribution of a road surface to the noise radiating from a vehicle is in the noise emitted at the road/tire interface; therefore, the major thrust of this effort was directed toward measuring this effect. There also were some measurements of community noise levels before and after the resurfacing of the bridges.

The tire noise tests were taken on the right rear wheel of a Laboratory station wagon upon which a new tire was mounted (a Pennsylvania Patrol Special, size 8.55-15). (The tread design and depth of this tire are shown on page 2.) This tire was mounted on a wheel and used on the vehicle only during tests. Between tests it was stored so that unnecessary wear would not change its acoustic characteristics.

The noise pickup device was a specially baffled microphone located about 7 inches from the road/tire interface by a bracket holding it on the outside of the tire. One of the major problems in making noise measurements of this type is to have a microphone that will pick up only tire noise and be baffled from wind noise. This problem has been solved by a microphone baffling system especially designed by this Laboratory. This allows relative tire noise measurements over a variety

TEST TIRE TREAD DESIGN



PENNSYLVANIA PATROL SPECIAL
6 PLY RATED 4 PLY
MAX LOAD RATING 1890 LBS
LOAD RANGE C
MAX PRESSURE 36 PSI
855-15 NYLON TUBELESS
DOT 148 V-1
TIRE PRESSURE - 28 PSI

* TREAD DEPTH IN INCHES

of road surfaces without having to clear roadways as would be required for roadside measurements. The results are also reasonably "pure" tire noise, uncontaminated by exhaust and other noise sources as would be the case with roadside measurement of a test car.

In this series of tests the noise picked up by the microphone was displayed inside the vehicle on a decibel meter for immediate, on-site assessment. For data recording, the noise signal was also sent to one of the sound channels of a video tape recorder in the vehicle. The other sound channel on the recorder was used for vocal commentary on events during the run. A video camera in the vehicle was aimed at the road ahead so that one could replay the run and establish the exact "geographic" cause of a tire noise change. Such information as what lane the test tire was in, where the expansion joints were, when the bridges were reached, uphill and downhill aspects, position of traffic ahead, etc., is all immediately apparent on the tape.

As mentioned earlier, noise samples in the surrounding communities were taken before and after the resurfacing. In the case of the Duwamish Bridge there was really no good community location. A site directly above the roadway, off the side of the Codiga, which crosses over the freeway bridge, was used.

A residence near the Lake Washington shoreline, several hundred feet south of the eastern end of the Evergreen Point Floating Bridge, was used as a noise pickup point for community noise levels associated with this bridge. The sound level information was transmitted through a 1000-ft cable to the overpass bridge near the toll plaza where it was recorded on a sound channel of a video tape recorder. A video camera was located in the center of the overpass bridge looking westward at the traffic; this was recorded simultaneously with the sound pickup. A General Radio, type 1562-A, sound level calibrator was used several times during the taping to give an accurate system calibration.

Discussion of the Data

Figures 1 through 5 are tire noise data for the Duwamish Bridge taken after the Spray-Grip was applied. In tests taken before the application, the tire noise over the bridge in a rutted traffic lane was the same as other nearby spots along I-5. Therefore, the noise level from a worn traffic lane was used as a relative reference. This particular level shows up well on the "after" test since there were many worn road surfaces on the test run. These graphs are pretty much self-explanatory. The vertical scale is in dBA levels with each major division of the graph scale representing 2 dB. The data line is shakey because it is indeed noise we are looking at. The "detector" time constant was chosen for rapid response which allows the system to display the actual instantaneous noise level (the recorder has response up to about 100 Hz).

The video tape allows one to relive the run at any time to check any newly thought-of subtlety. It is not possible, of course, to put that sort of display in a published report, however, the captions on each graph are quite complete

and tell most of the story.

In Fig. 1 a dip is seen as the test tire enters the curb lane; this occurs because the tire has run over an unworn place in the road, and the noise level briefly drops toward that of the original road before wear occurred. The next section is the currently rutted road surface in the curb lane, and this is followed by a section to which Spray-Grip has been applied (still in the curb lane). The next section is a stretch of freeway which is worn and has been grooved to prevent skidding. This is followed by worn highway which has not been grooved or re-surfaced. This graph shows that the noise level from the worn surface is not changed by grooving (unworn concrete might be noisier after it was grooved than it was before). Spray-Grip does not seem to lower the noise level appreciably. As this graph indicates, the sections with this material applied are perhaps only 1 dBA lower at 50 mph.

Figure 2 is for a similar run at 50 mph, except it is in the southbound lane. In this case the amount of noise reduction attributable to application of Spray-Grip is about 3 dBA.

Figure 3 shows another run, with the vehicle traveling uphill northbound at 60 mph. The Spray-Grip section is only about 1 dBA quieter than the rutted surface it replaced.

Figure 4 also shows a 60 mph run; this time it is southbound, slightly downhill. The lane next to the curb lane was used, and in this particular case, the Spray-Grip surface shows a quieting of almost 4 dBA.

The run shown in Figure 5 is southbound again, but the speed is 70 mph. On this test the way the lines have been drawn on the curve shows the Spray-Grip surface reducing the noise by about 3 dBA. However, note from the curves that the noise level of the rutted and worn road surfaces does vary. The exact number of decibels of quieting also will vary by perhaps 1 dBA, depending on exactly where the averaging lines are drawn. These data indicate, however, that in the northbound lanes the Spray-Grip is about 1 dBA quieter than the rutted road it replaced. The southbound lane sections with Spray-Grip are perhaps 3 dBA quieter at high speeds than the worn surfaces they replaced. This is compared to the noise level of the original pavement which was 5 or 6 dBA* quieter than the present worn surface (measured when the tire was near the edge of the road where the concrete has not been worn). In short, the Spray-Grip surface is quieter than the present rutted surfaces but not as quiet as the original surface when it was new.

The measurement site on the Codiga Bridge was too near the traffic to indicate the average vehicle noise; it picked up noise from individual vehicle (or groups of vehicles) as they went by so the sound level at any instant was dependent

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* This can be seen in the Evergreen Point Floating Bridge data in this report where such passes were made.

Figures 15, 16, and 17 show that on a 50 mph run, going uphill, the epoxy-asphalt is about 7 dBA quieter than the worn roadway on the floating section of the bridge; going downhill it is typically 9 dBA quieter. Overall then, at 50 mph this coating is 8 dBA quieter than the previous worn surface. It was previously shown that at 50 mph the filled gratings averaged 7 dBA noisier than the rough road surface; this means that the total improvement at the filled gratings has been 15 dBA. This is outstanding because a 15 dBA improvement means that at 50 mph the cupped worn grating was radiating 32 times as much acoustic tire noise power as it does now with the epoxy-asphalt coating. This factor of 32 reduction in noise power is physiologically interpreted by a typical human ear as being 3 times as quiet as it was previously. This represents a very appreciable improvement in tire noise. Further, the sections of ordinary worn roadway which has been covered with the epoxy-asphalt show an 8 dBA improvement at 50 mph; this is a significant noise reduction to the community,since these sections are much longer overall than the noise grating sections.

Community Noise Measurement by Evergreen Point Floating Bridge

Figures 18 and 19 show the sound levels obtained on the front porch of a house several hundred feet south of the bridge on the east shore of Lake Washington during the height of the rush hour, around 5:25 p.m. Figure 18 shows the noise level before the epoxy-asphalt application. A typical value was 60 dBA when there were no uniquely loud trucks or airplanes or other disturbances affecting the measurements. Figure 19 is taken from a tape made after the application of the epoxy-asphalt. This time the mean level is about 54 dBA which represents an overall quieting of 6 dBA.

At this time of day the car speeds are rather slow, perhaps closer to 25-30 mph than 50 mph; this of course reduces the amount of absolute noise per car. However, the greater traffic load would tend to increase the overall noise. In general, the reasons this measurement shows 6 dBA of quieting in the nearby community (even though the grating has been quieted by 15 dBA at 50 mph) are: the reduced speed of the cars; the grating was not the sole source of noise; untreated stretches of the road contribute to the total noise; and finally, other noises (other than tires) are important, particularly in the case of trucks where the exhaust and other systems contribute significantly to their noise output.

Summary

The results of the tests on the Duwamish Bridge on I-5 show that at 50 mph the Spray-Grip is perhaps 2 dBA quieter than the worn, rutted roadway surface it replaces. Furthermore, the tests show that a grooved road surface has about the same noise level as the worn surface before it was grooved; grooving apparently has no effect (beyond the wear already existing) on the amount of tire noise generated. This is contrasted with the original road surface before it became worn, which was 4 to 6 dBA quieter than it is now.

On the Evergreen Point Floating Bridge it was found that the epoxy-asphalt was about 15 dBA quieter at 50 mph than the filled grating which had been worn down to the steel, leaving it very cupped. Even where the new topping has replaced only the worn road surface, it is approximately 8 dBA quieter at 50 mph

than it was earlier. The epoxy-asphalt treatment should be very effective for quieting road noise, provided the surface will stand up to wear and thus retain these low noise properties.

The community noise measured at a house near the east end of the bridge showed a decrease of 6 dBA at 5:25 p.m. during rush-hour traffic, bringing the typical level there from 60 dBA down to 54 dBA.

I-5 DUWAMISH BRIDGE NORTHBOUND - CAR SPEED 50 MPH
12 SEPTEMBER 1972

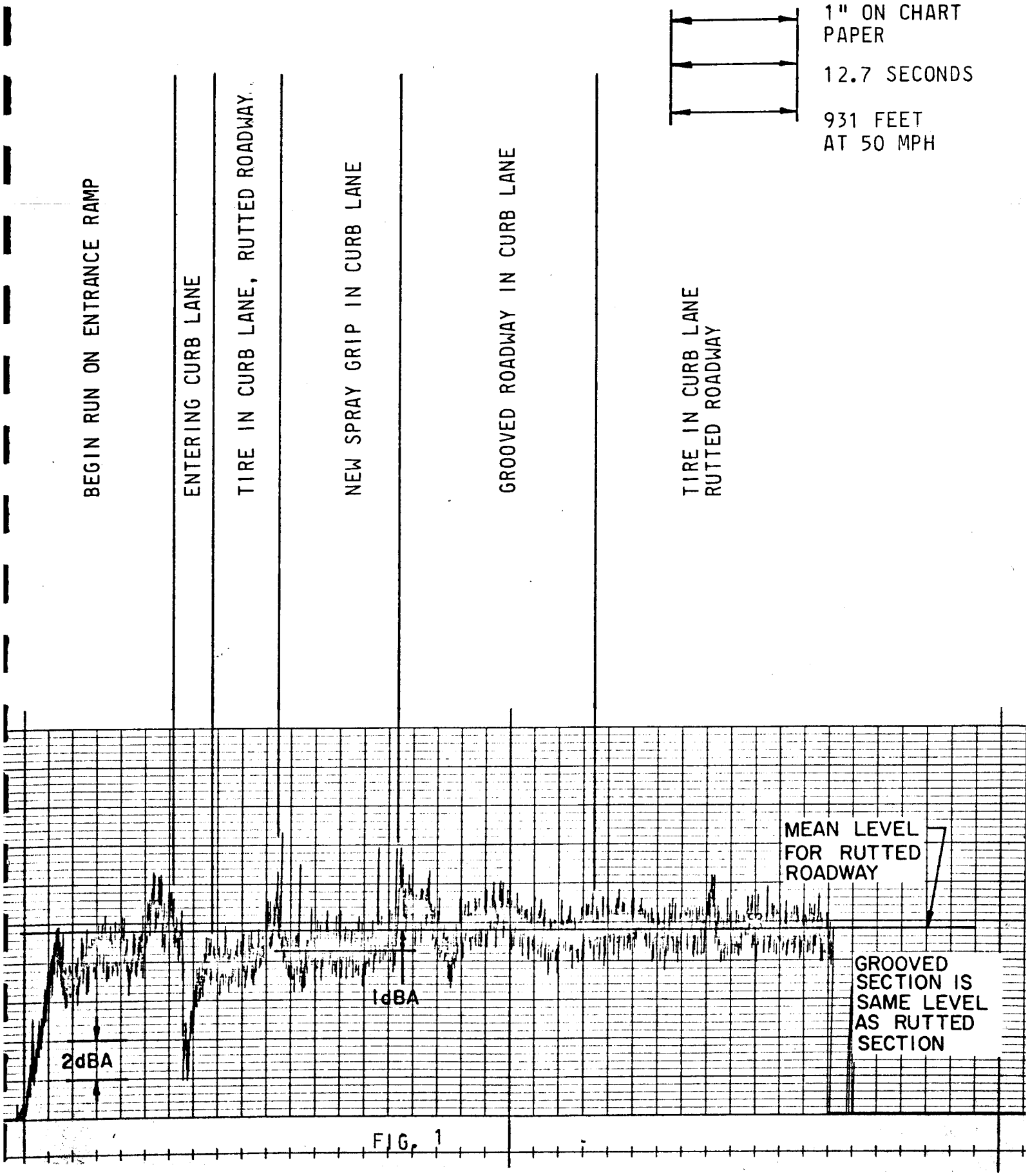


FIG. 1

I-5 DUWAMISH BRIDGE SOUTHBOUND - CAR SPEED 50 MPH
12 SEPTEMBER 1972

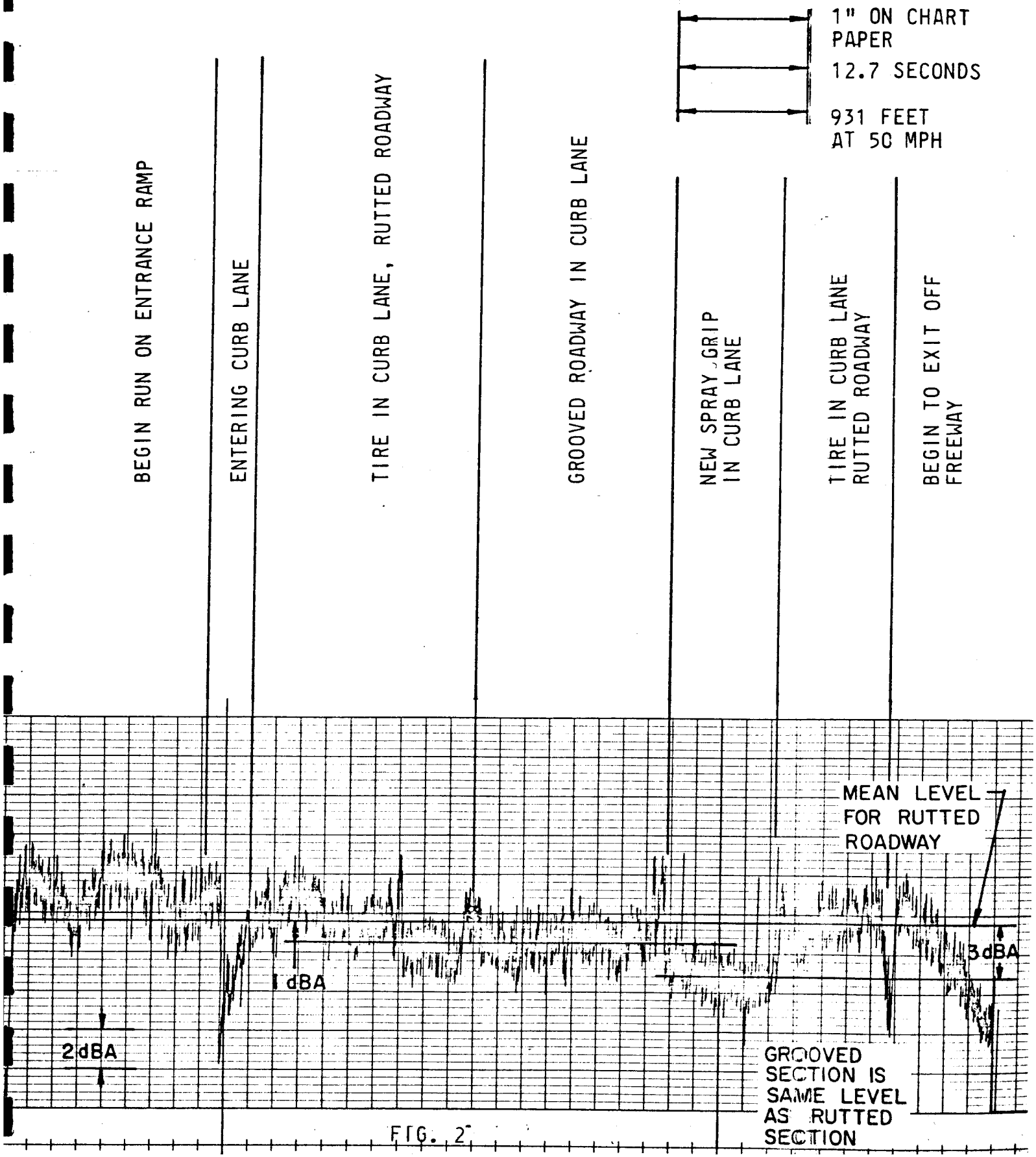


FIG. 2

I-5 DUWAMISH BRIDGE NORTH BOUND - CAR SPEED 60 MPH
12 SEPTEMBER 1972

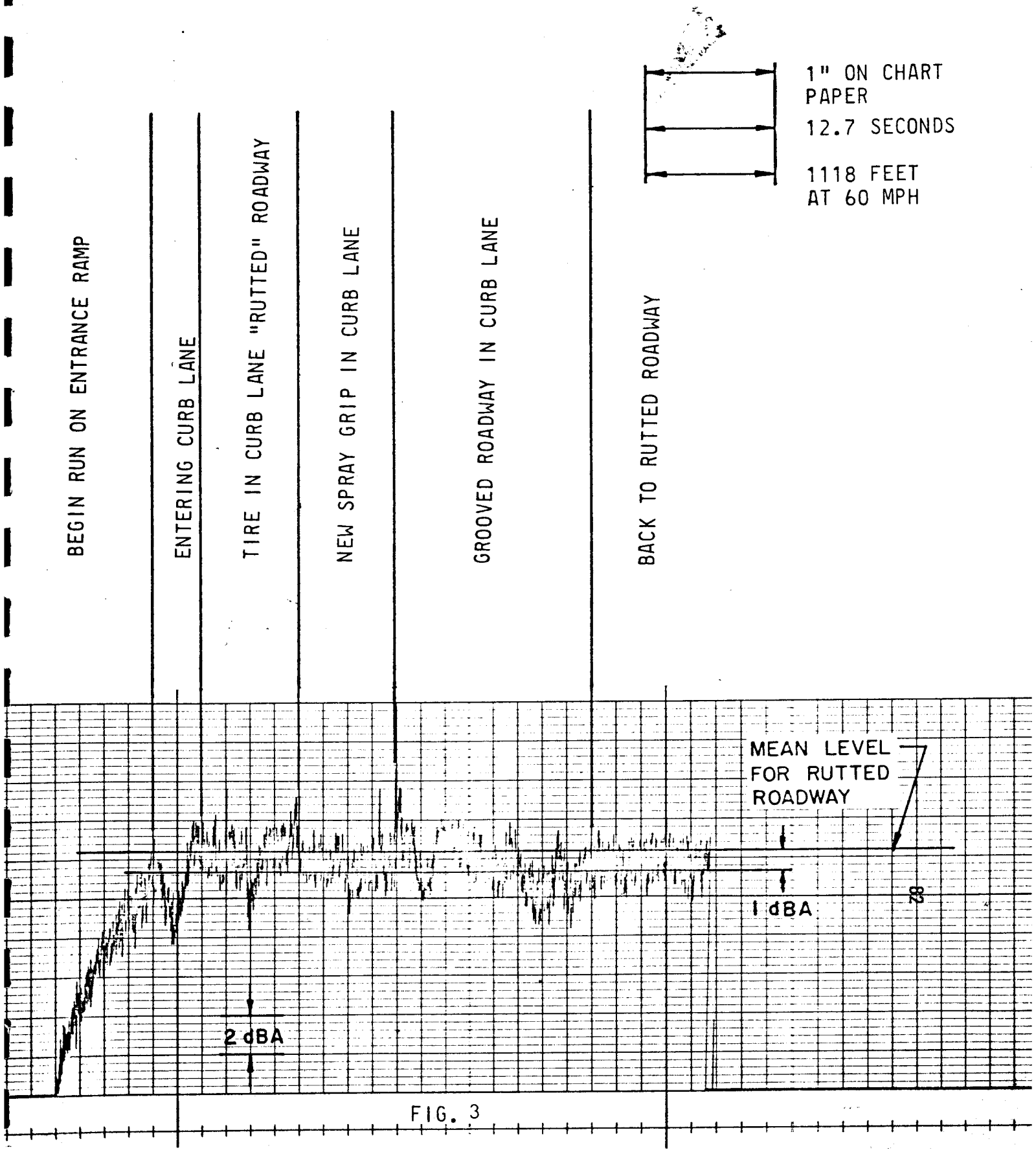


FIG. 3

I-5 DUWAMISH BRIDGE SOUTH BOUND - CAR SPEED 60 MPH
12 SEPTEMBER 1972

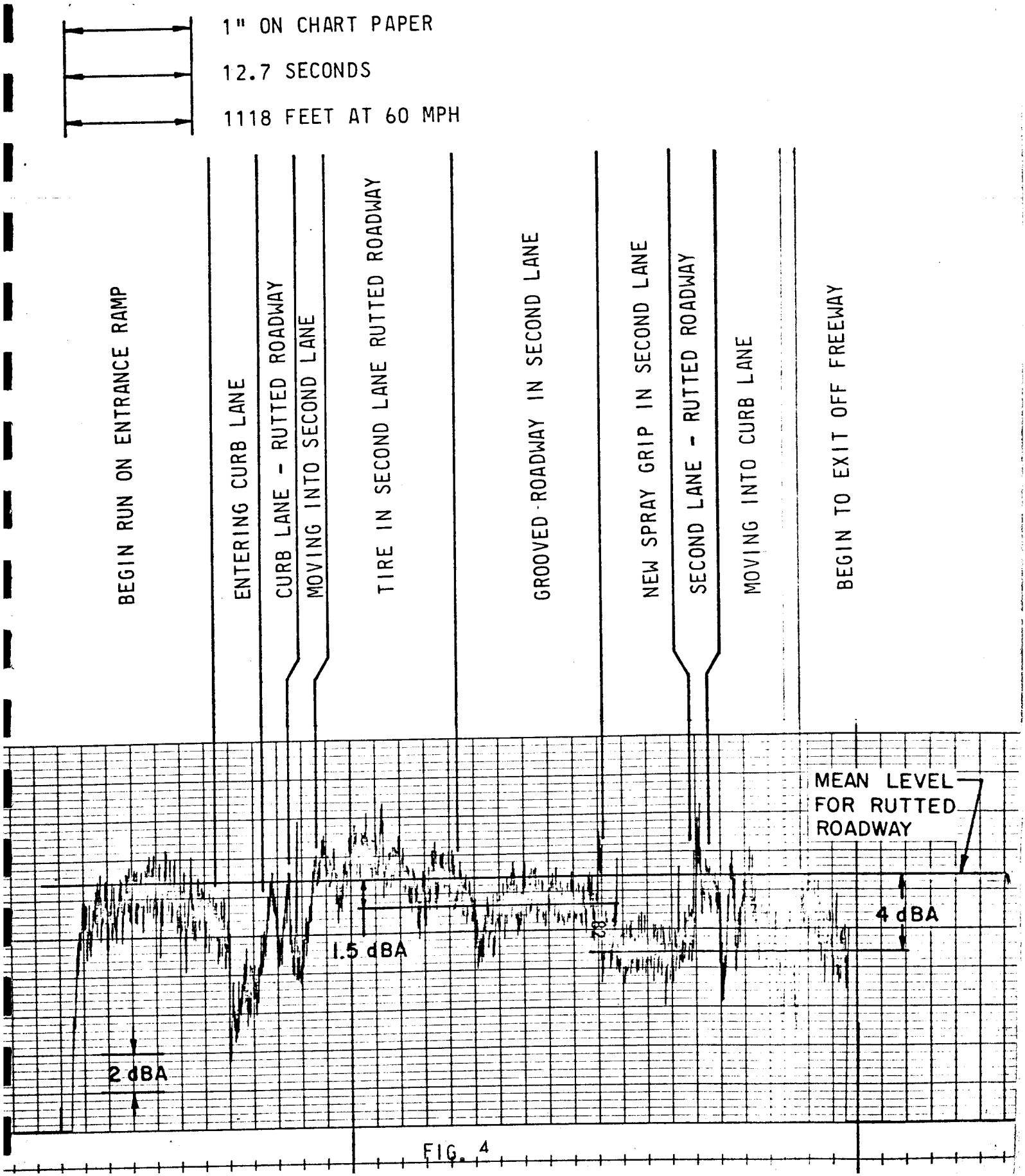
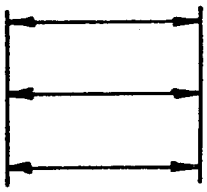


FIG. 4

I-5 DUWAMISH BRIDGE SOUTH BOUND - CAR SPEED 70 MPH
12 SEPTEMBER 1972



1" ON CHART PAPER

12.7 SECONDS

1304 FEET AT 70 MPH

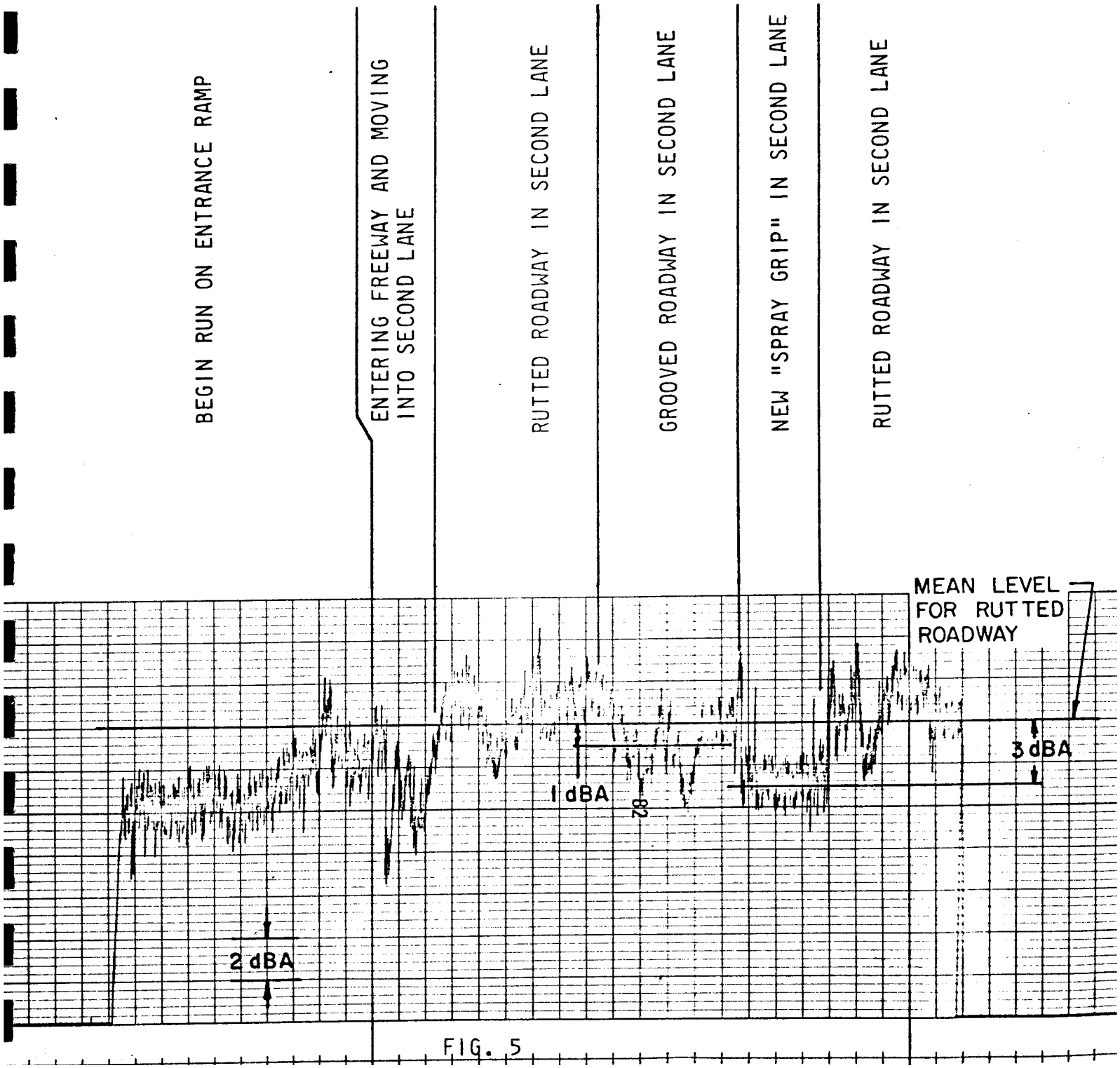
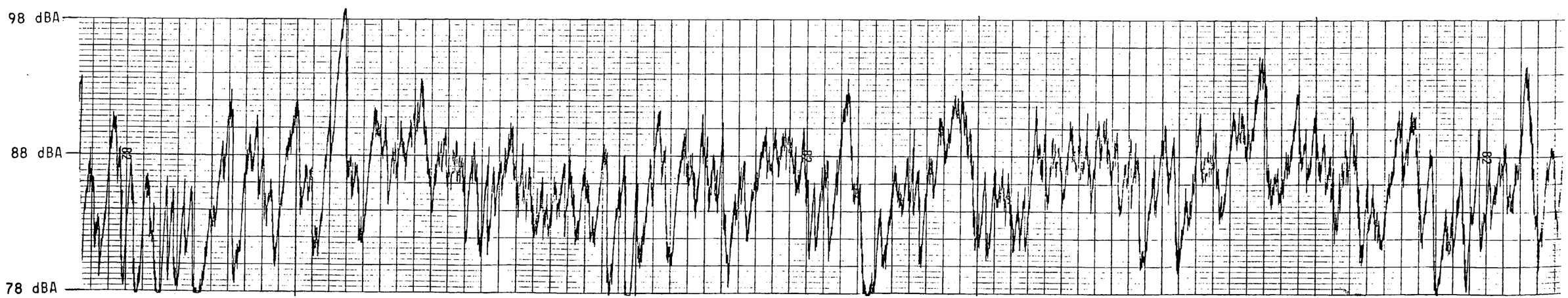


FIG. 5

DATA FROM SIDE OF CODIGA BRIDGE OVERLOOKING DUWAMISH BRIDGE ON I-5 "LOOKING" SOUTH
BEFORE SPRAY GRIP

THURSDAY, 13 JULY 1972
3:30 P.M.

1" = 12.7 SECONDS



EVERGREEN POINT FLOATING BRIDGE WEST BOUND - CAR SPEED 40 MPH
BEFORE EPOXY ASPHALT APPLIED
24 AUGUST 1972

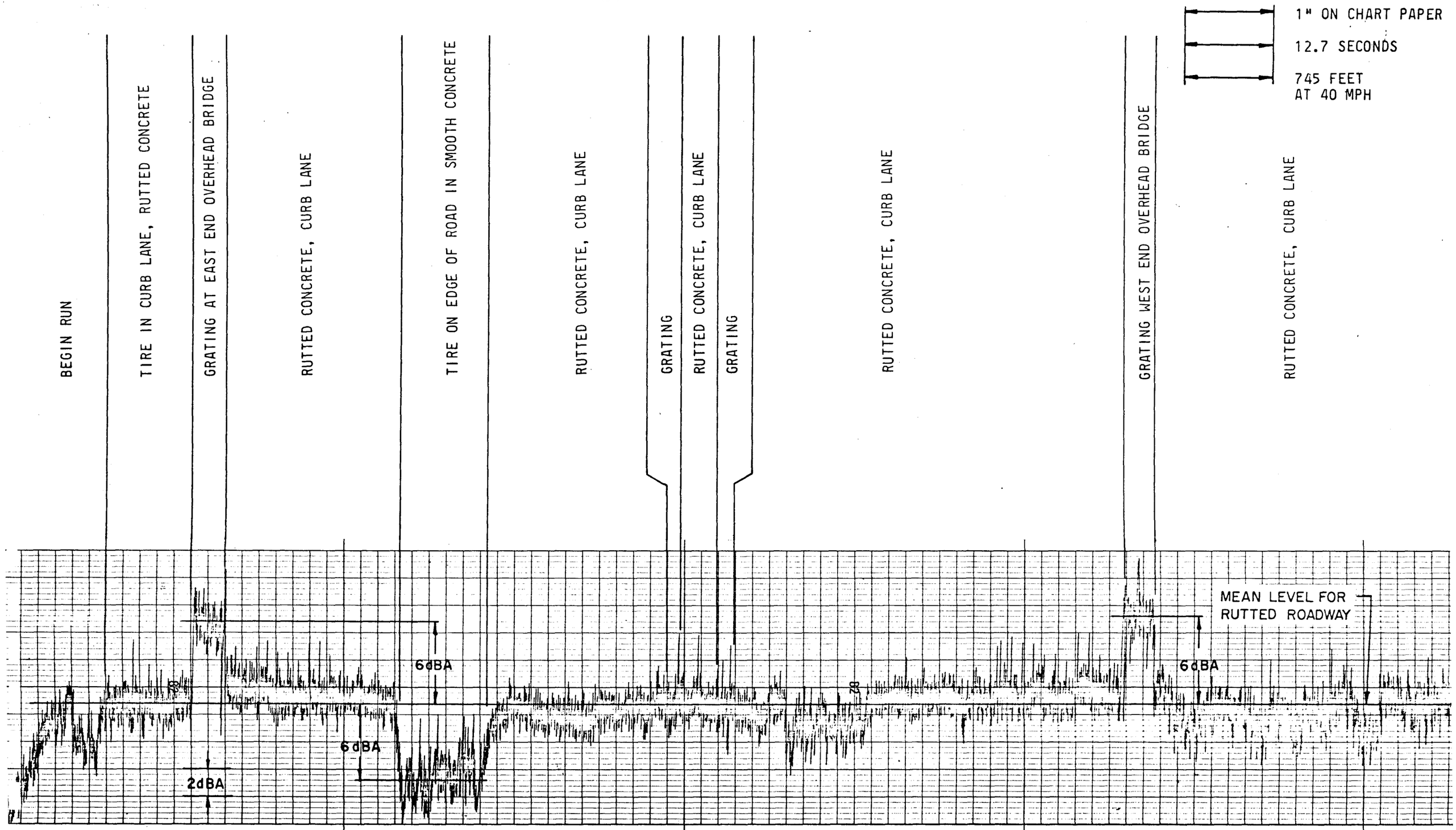


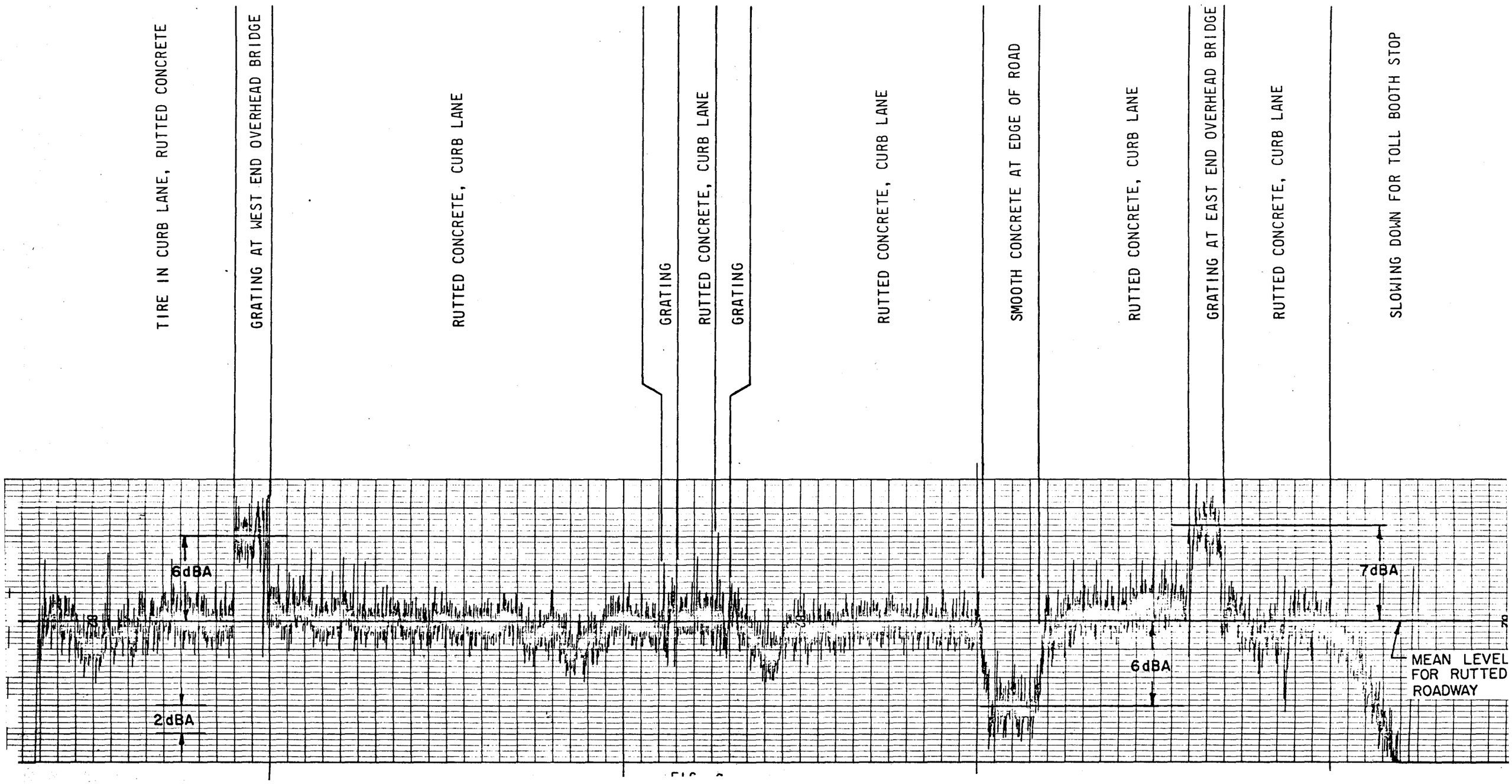
FIG. 7

1" ON CHART PAPER

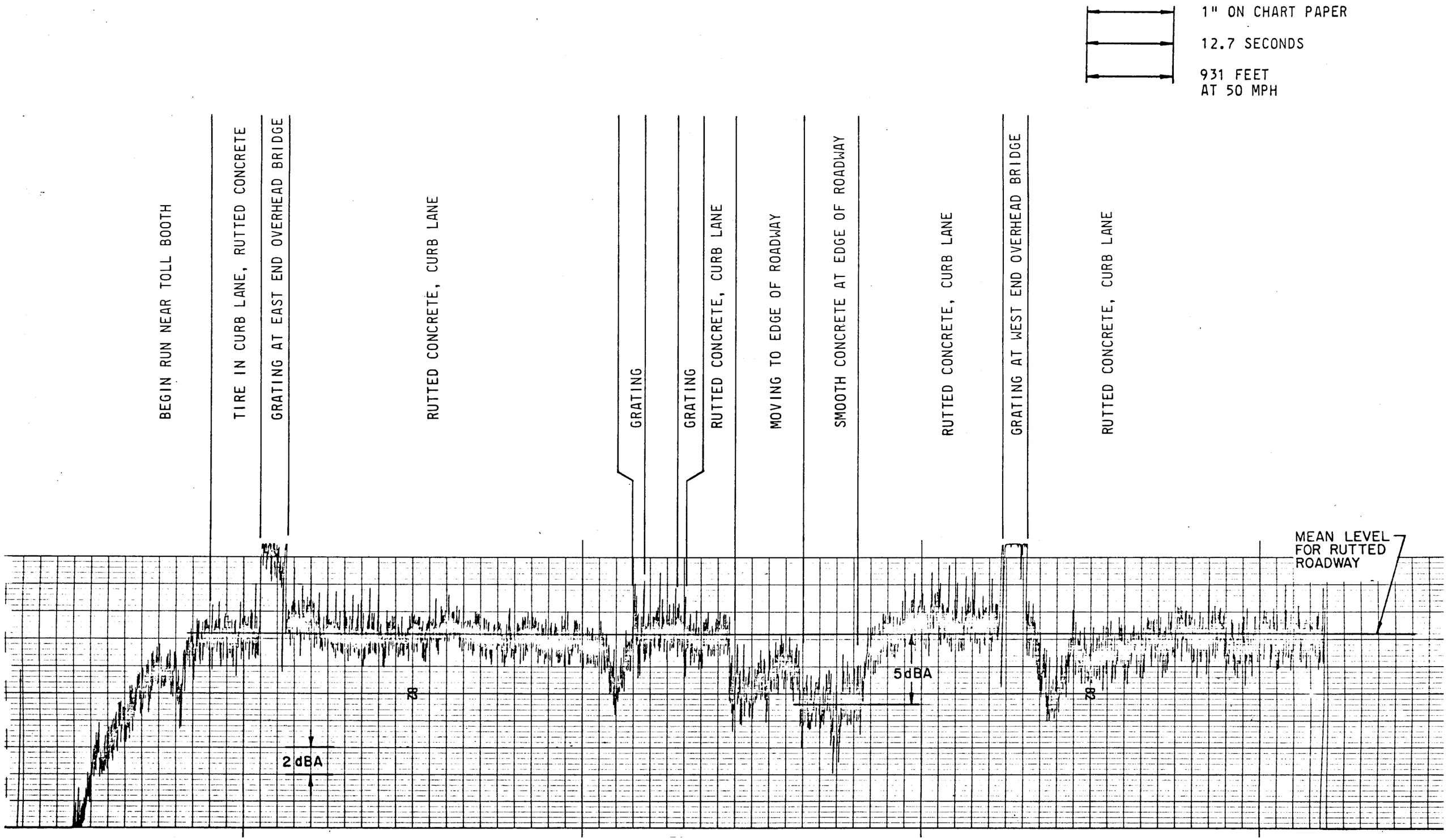
12.7 SECONDS

745 FEET
AT 40 MPH

EVERGREEN POINT FLOATING BRIDGE EASTBOUND - CAR SPEED 40 MPH
BEFORE EPOXY ASPHALT APPLIED
24 AUGUST 1972



EVERGREEN POINT FLOATING BRIDGE WESTBOUND - CAR SPEED 50 MPH
BEFORE EPOXY ASPHALT APPLIED
24 AUGUST 1972



EVERGREEN FLOATING BRIDGE WESTBOUND -CAR SPEED 50 MPH
BEFORE EPOXY ASPHALT APPLIED
24 AUGUST 1972

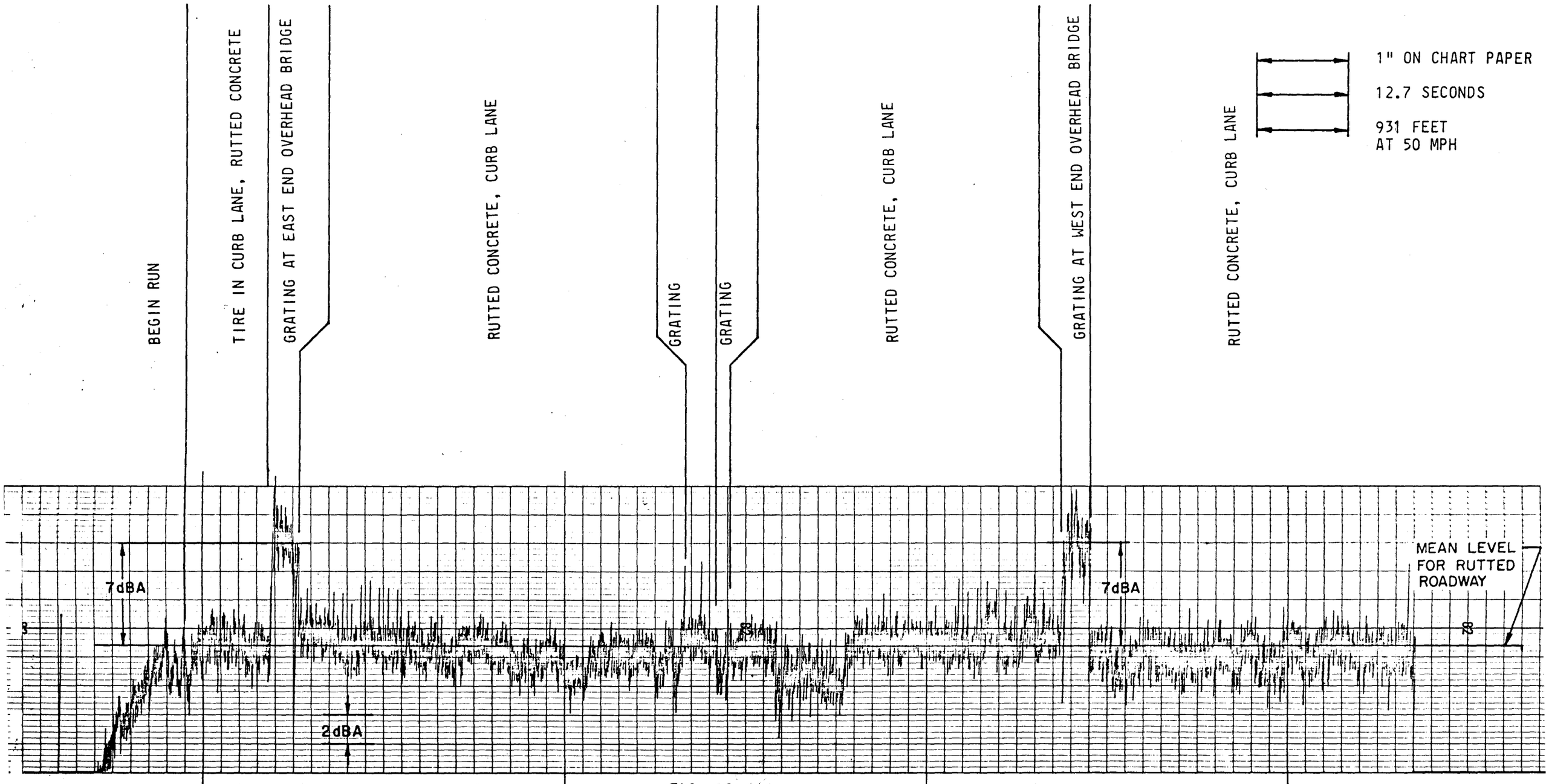


FIG. 10

EVERGREEN POINT FLOATING BRIDGE, EAST BOUND - CAR SPEED 50 MPH BEFORE EPOXY ASPHALT APPLIED

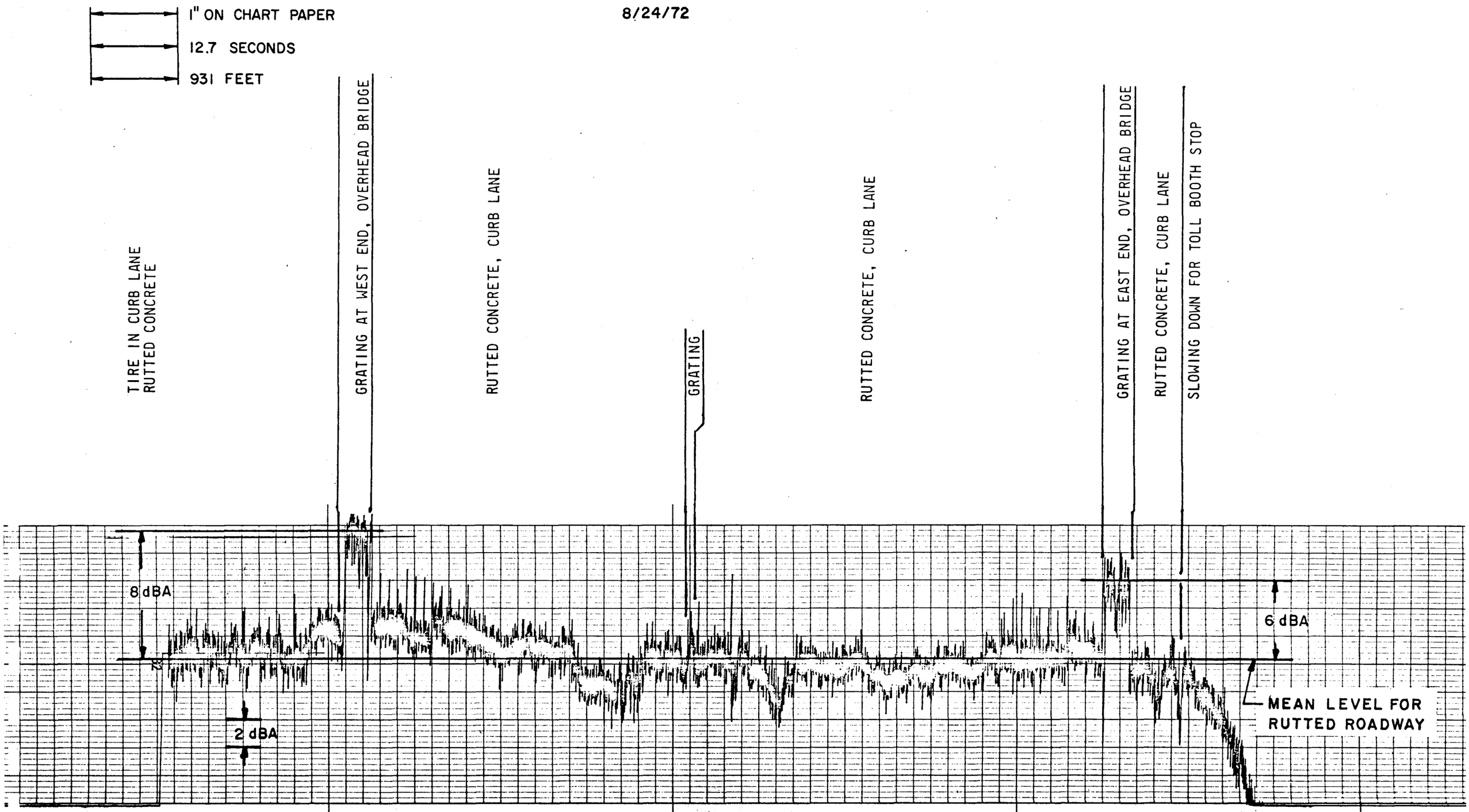


FIG. 11

EVERGREEN POINT FLOATING BRIDGE WESTBOUND - CAR SPEED 50 MPH
BEFORE EPOXY ASPHALT APPLIED
24 AUGUST 1972

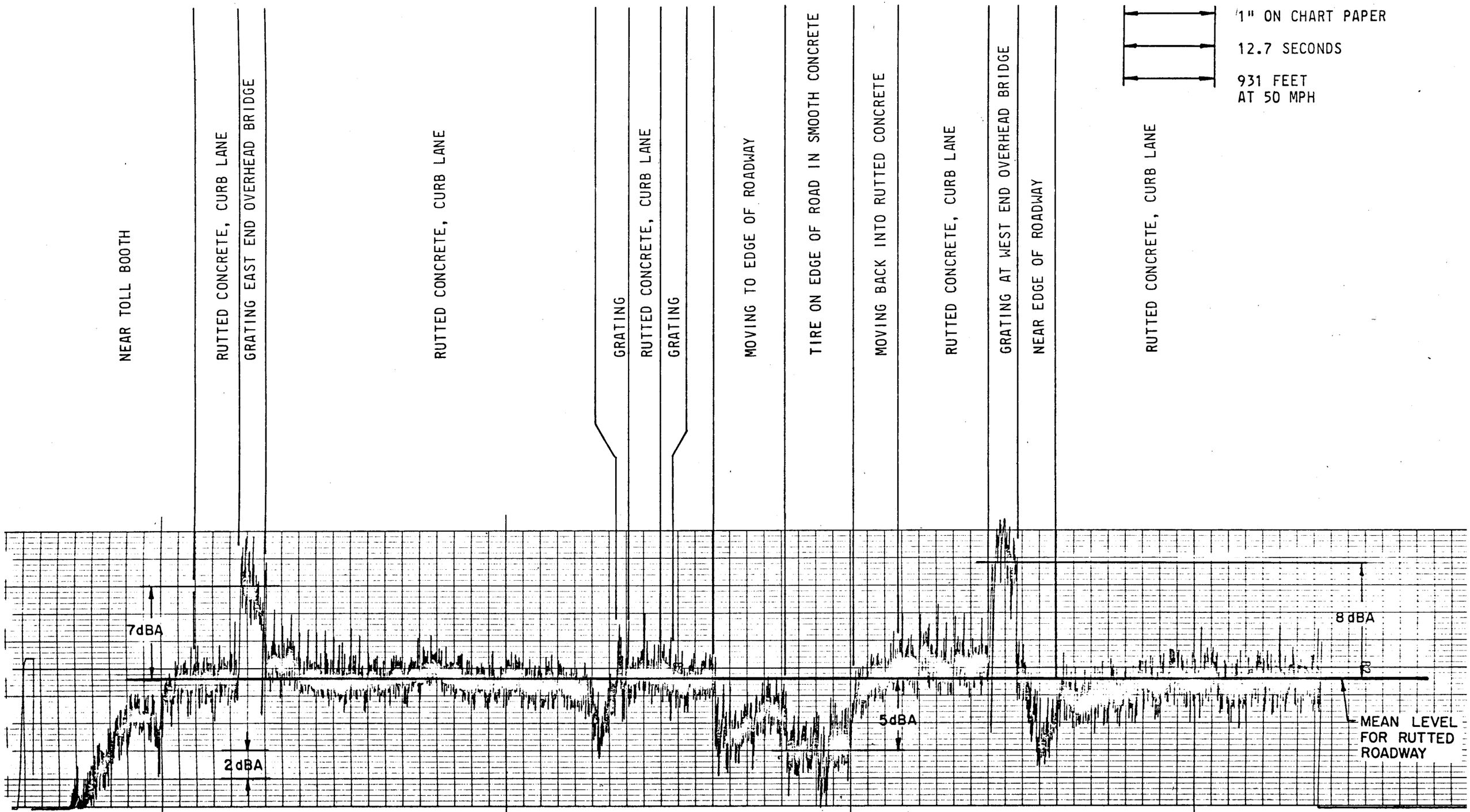
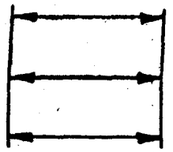


FIG. 12

EVERGREEN POINT FLOATING BRIDGE EAST BOUND - CAR SPEED 50 MPH
BEFORE EPOXY ASPHALT APPLIED
8/24/72



1" ON CHART PAPER

12.7 SECONDS

931 FEET

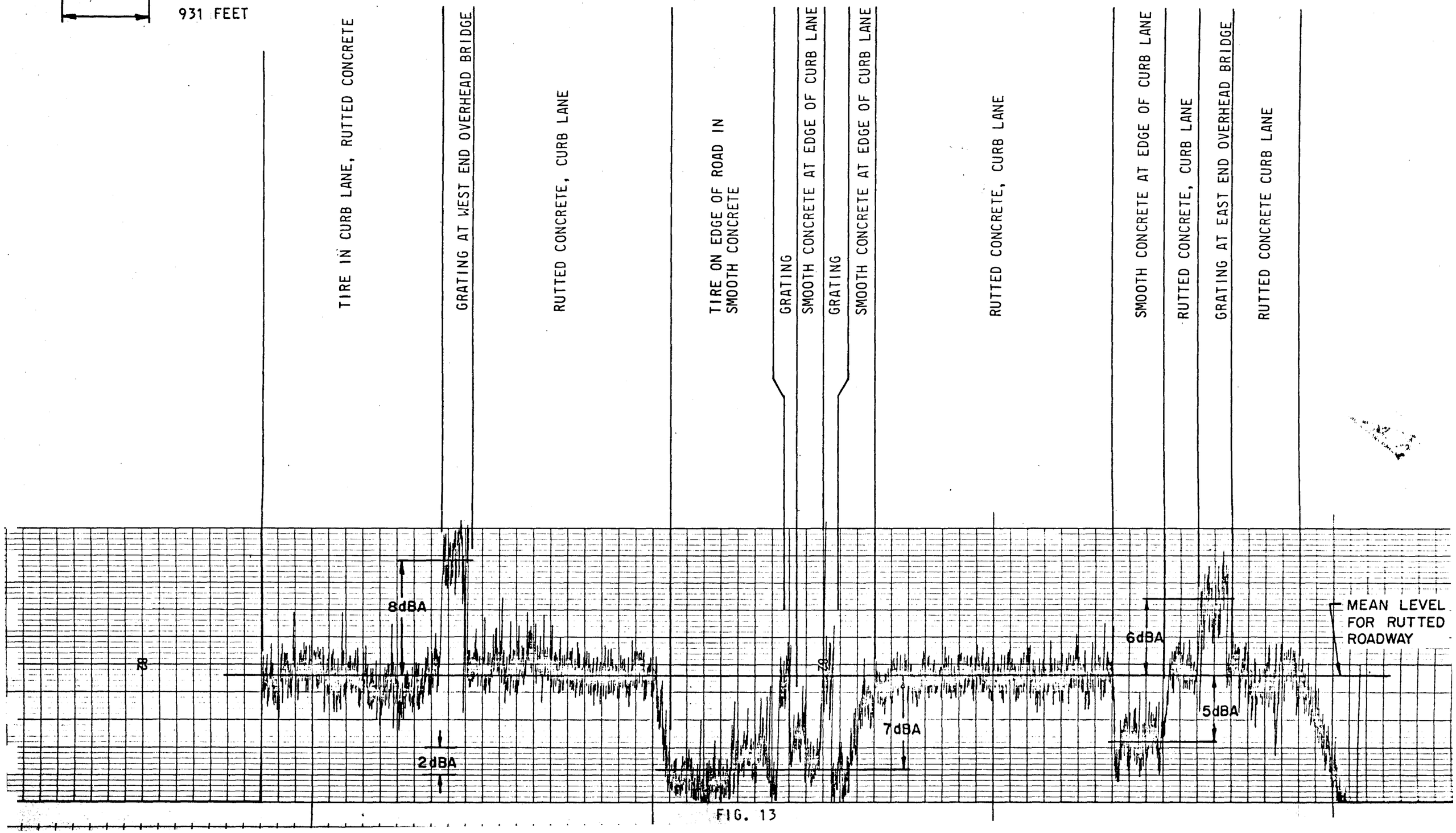


FIG. 13

EVERGREEN POINT FLOATING BRIDGE WEST BOUND - CAR SPEED 40 MPH
AFTER EPOXY ASPHALT APPLIED
4 OCTOBER 1972

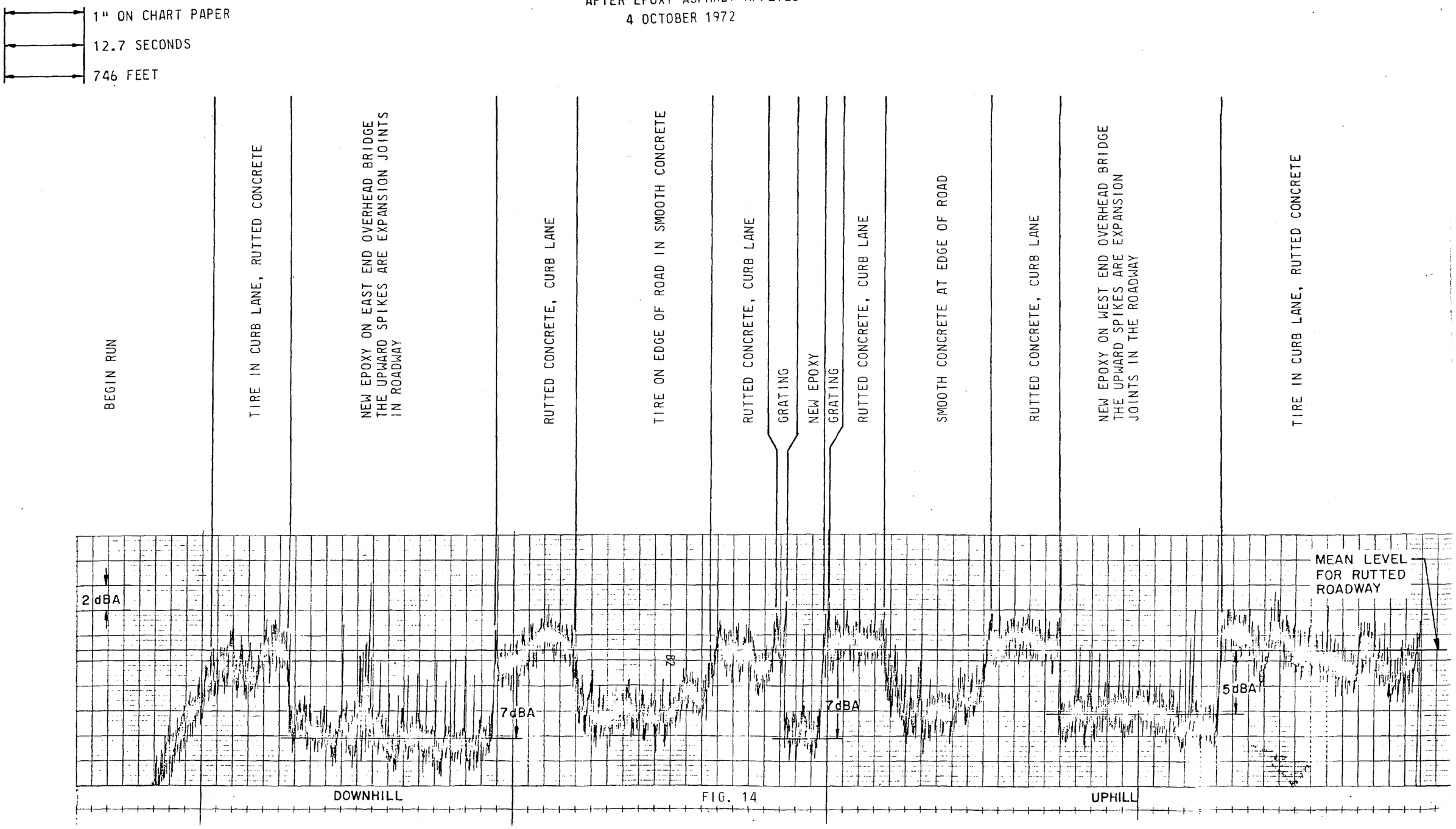


FIG. 14

EVERGREEN POINT FLOATING GRIDGE WEST BOUND - CAR SPEED 50 MPH
AFTER EPOXY ASPHALT APPLIED
4 OCTOBER 1972

1" ON CHART PAPER
12.7 SECONDS
931 FEET

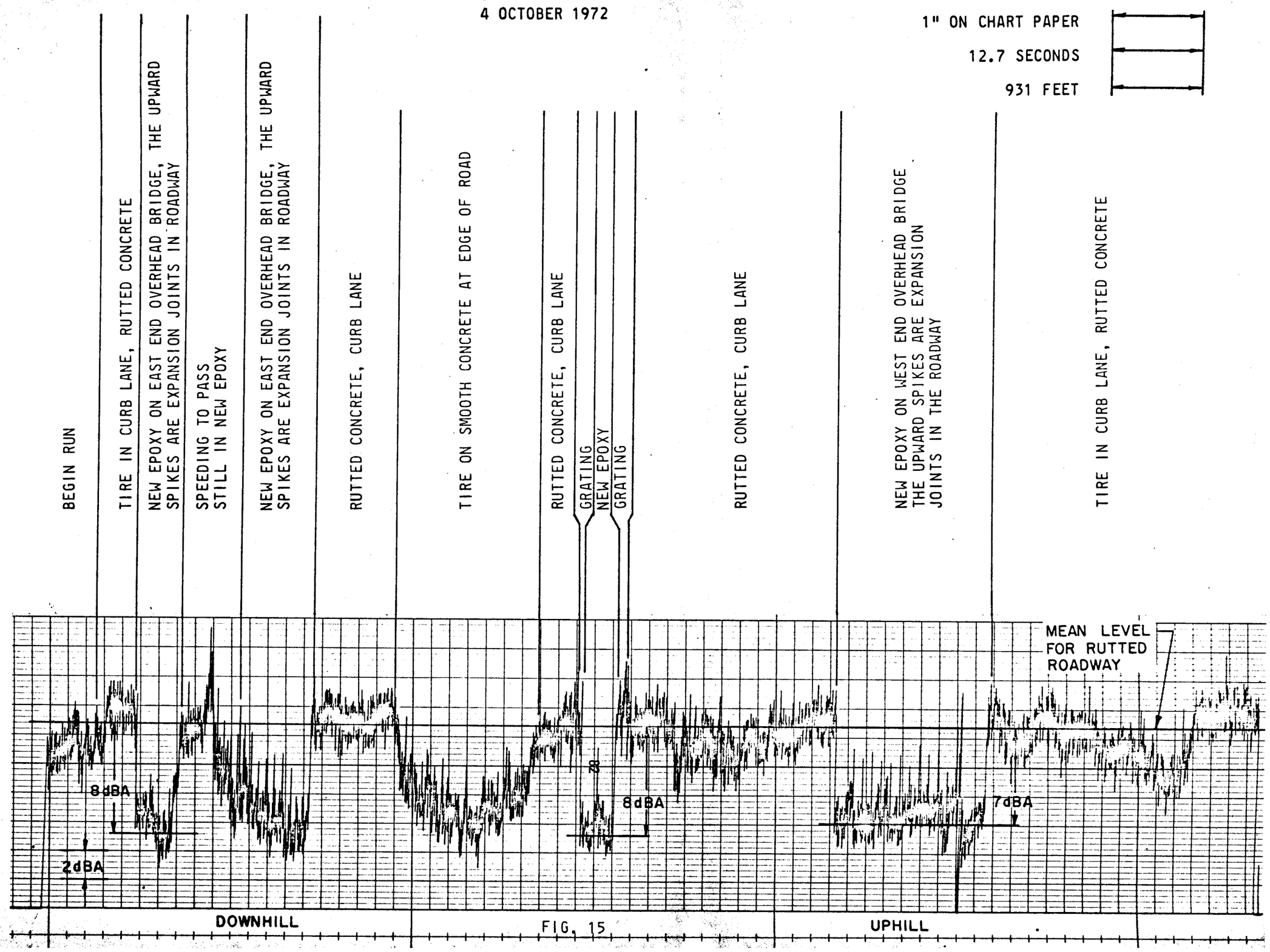


FIG. 15

EVERGREEN POINT FLOATING BRIDGE EAST BOUND - CAR SPEED 50 MPH
AFTER EPOXY ASPHALT APPLIED
10/25/72

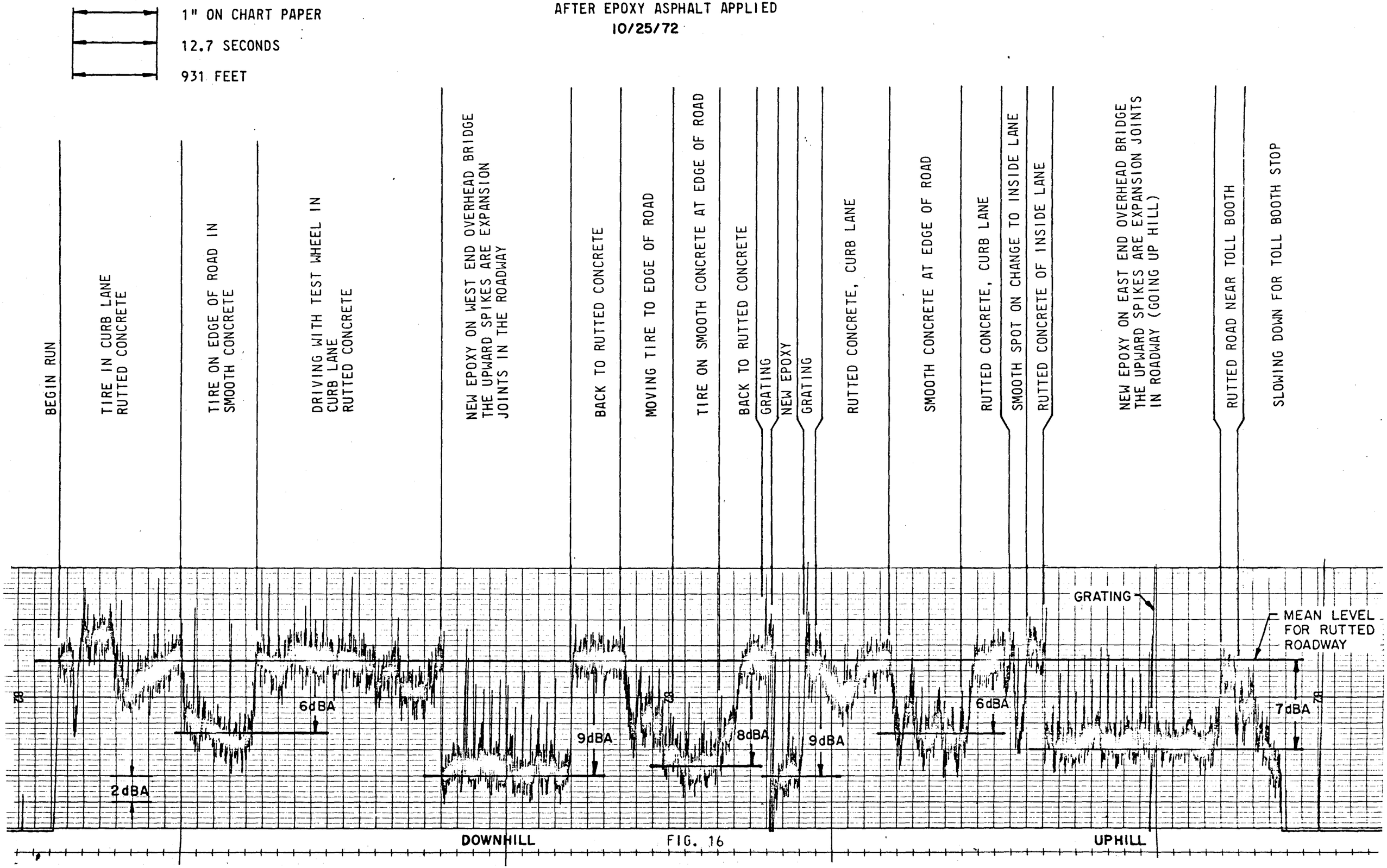


FIG. 16

EVERGREEN POINT FLOATING BRIDGE EASTBOUND - CAR SPEED 50 MPH
AFTER EPOXY ASPHALT APPLIED
4 OCTOBER 1972

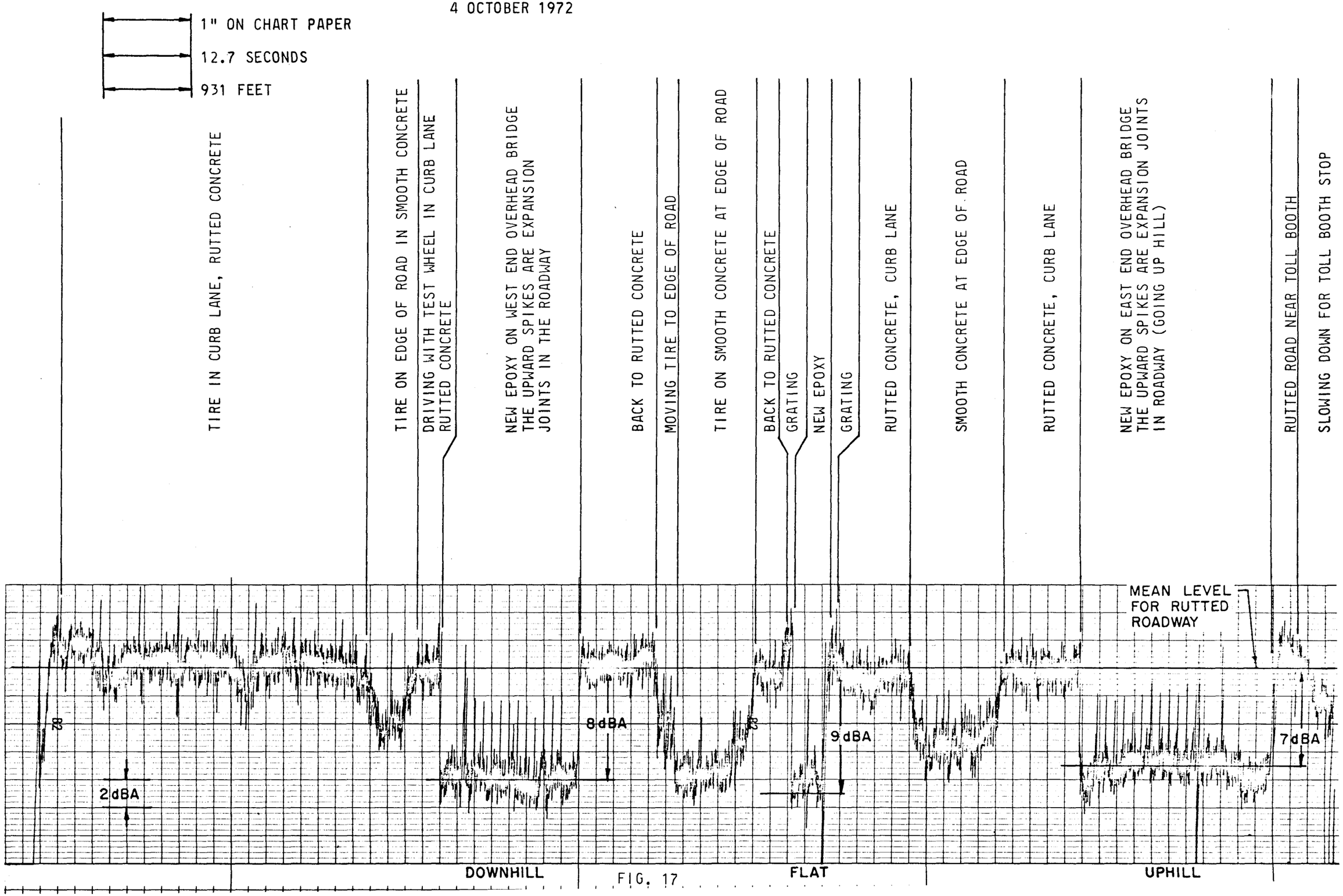


FIG. 17

EVERGREEN POINT FLOATING BRIDGE - BEFORE EPOXY ASPHALT APPLIED
THURSDAY, 24 AUGUST 1972

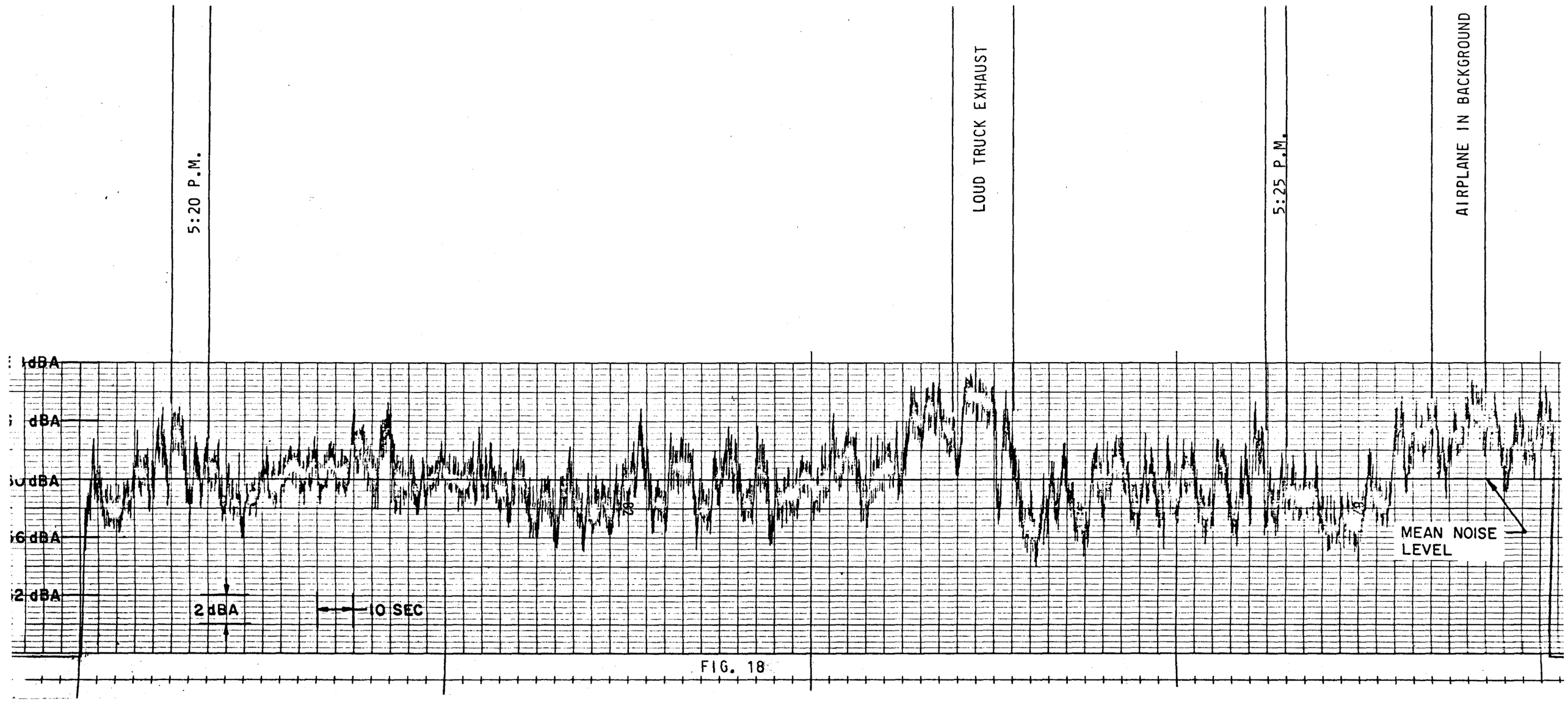


FIG. 18

EVERGREEN POINT FLOATING BRIDGE - AFTER EPOXY ASPHALT APPLIED

LOCATION: RESIDENCE ON SHORE SOUTH OF EAST END OF BRIDGE
TRAFFIC HEAVY AND SLOW

WEDNESDAY 25 OCTOBER 1972

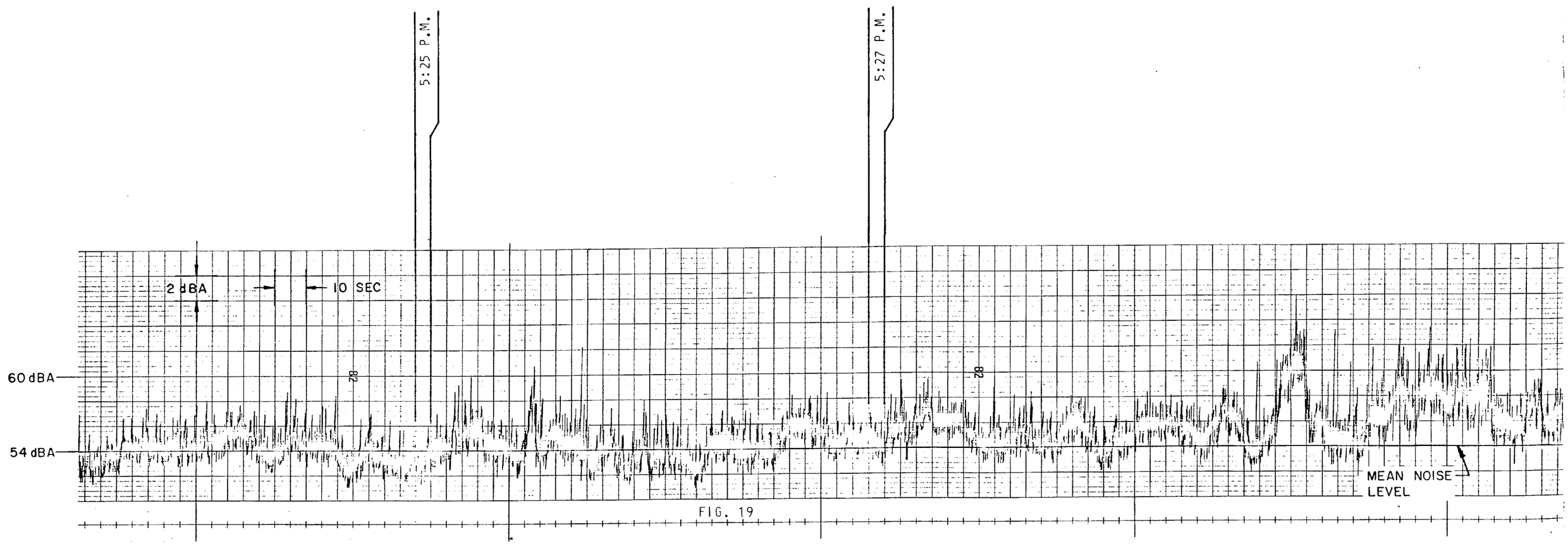


FIG. 19