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Dr. Walter Menaker
69-09 108th Street
Forest Hills, New York 11375

Dear Dr. Menaker:

When I took your letter home to file with my material concerning the assassination of President Kennedy, I pulled out a couple of the graphs, and brought them in to the laboratory so that I could duplicate them and send them to you for your own use and so that you could send one of them to Dr. Josiah Thompson.

The first chart shows the angular acceleration of the optical axis of Mr. Zapruder's camera, as a function of frame number, reading down in five separate graphs. I'll make a few comments on notations and marks on the chart. First of all you will see that the three main trains of acceleration impulses last for almost exactly one second each. In addition to the three one-second long trains on the first, second and fifth lines, there is the shorter and less intense train starting about 290 that I explained to my own satisfaction, and told you about in my last letter. On the middle line, there are two pulses that are just "out of the noise". By this I mean that there were two photographs where I thought that points were slightly spread out, and I listed these as minimum signals. These are responsible for the two little indications of a back and forth acceleration of the line of sight. (I would like to stress that the data that I show is all original raw data, and I never did anything to smooth out any data, or go back and remove points that I thought had significance on the first survey. Therefore the two noise pulses on the middle line are just at the minimum detectable limit, and since there is always noise in any measurement, I don't think they have to be treated seriously.) I am sorry that I do not have the first 170 frames available, but as I said in my letter, Dr. Wyckoff did measure these, and found that there were no appreciable acceleration pulses, although there were of course streaks due to a high angular velocity of the camera during Mr. Zapruder's enthusiastic panning. (Subtraction of the streak length in neighboring frames gives differences too small to measure.)

On the right-hand column, it says "camera turns cwld", which is physics shorthand for clockwise looking down. Which means that the initial motion of Mr. Zapruder's camera was such as to move the optical axis of his camera suddenly towards the right, and then back to the left. This motion occurred in frame 313, and is of the proper sign to be caused by the shock wave from the buliet, which passed very close to the camera on

the way to the automobile. I believe that this "first motion" was a direct interaction of the shock wave on the camera, and did not involve Mr. Zapruder's neuromuscular reaction. Of course that reaction can be seen very strongly in the next few frames, but it is my belief that the first reaction was occasioned by the shock pressure acting on the camera itself. This same pressure is of course what breaks windows when a supersonic airplane flies overhead. (In the earlier shots, the bullet didn't pass so close to the camera and was therefore not strong enough to cause this direct interaction.)

The two circles on the first and second lines are my best guess as to when the shot was fired -- about 1/3 of a second before Mr. Zapruder's neuromuscular system went into oscillations. There is much in the literature that says that the response time of the human neuromuscular system is a third of a second, and therefore it seems reasonable that the first reaction would come about a third of a second after the system had been stimulated. (You will note that the pulses are about one third of a second apart.) For this reason, my best guess as to the times of the three shots are approximately 177, 217, and of course 313.

I have never checked to see what Mr. Wyckoff said, until this very moment, when I looked at your letter again. I see you say that he quotes 190 and 227, which of course are different than my best guesses. (Let me remind you again that the reason I asked CBS to get someone like Mr. Wyckoff to do the job, was so that I wouldn't be spending the rest of my life writing letters explaining why I thought it was one frame number while somebody else thought it was another. I still like the numbers I selected better than the ones Dr. Wyckoff did, but please let's not get into an argument about this.)

The Warren Commission, according to the notation I made on the chart, said that the shot that they could identify came somewhere in the range of frames 206 to 225. As far as I can tell this came largely from an examination of Mr. Kennedy's reaction in putting his hand to his throat. I think it is interesting that my suggestion that it happened at frame 217 comes almost halfway between the two limits set by the Warren Commission report.

Before I leave this figure, I should say that I believe it could be reproduced by anyone who took the trouble to examine and measure the photographs reproduced in volumes that were appended to the Warren Report. I should say that I started out measuring each streak with a fine scale and a pair of dividers, but after I had gone about halfway through the frames, I concluded that I could do just about as well by looking at the streaks and assigning them an estimated value between 1 and 5, together of course with the algebraic sign saying which way the acceleration moved the camera axis. I mention this only to say that a remeasurement might

change the magnitudes of the accelerations, but it would certainly not change their signs, nor change the frame numbers at which they occurred. I did the measurements as well as I could, and as I said earlier I never changed any numbers, and I certainly did not go back and repeat the measurements. For this reason, I may have made a mistake or two, but I do not think that the general pattern of the trains of acceleration pulses can be changed by further measurements. Certainly it does absolutely no good to use a microscope or a magnifying glass, since the pictures available are all half tones, and one can actually see better without a magnifying glass under those conditions.

The second figure shows the position of the car relative to the background, from frames 260 to 340. I was most interested to read the details of the testimony by the FBI photo interpretation expert, who said that it was absolutely impossible to tell where the car was in this period, since there were no marks on the background against which to make the measurements. If you look at these pictures, you will see that there was a shiny piece of metal or glass on the grass, and this reflected light directly from the sun into Mr. Zapruder's camera. As a result of this, there is a streak in the background which one can use as a perfect reference mark, and measure the position of the car certainly better than ± 4 inches, in real space. The curve shows that the car was going at a very uniform speed very near to 12 miles an hour, from frame 260 to about frame 300, and after that it again went at a very constant speed, but closer to 8 miles per hour. All of the points on this graph are again original data, with no smoothing of any sort. The fact that the line goes through practically the center of each point indicates the extreme accuracy of the measurements. At an average of about 10 miles an hour, the car moved about 15 feet per second, or close to 1 foot per frame. The very small scatter of the points will convince you that I knew exactly where the car was during this whole period, and that the sudden change in the velocity was a real thing, and that it should be explained in some way.

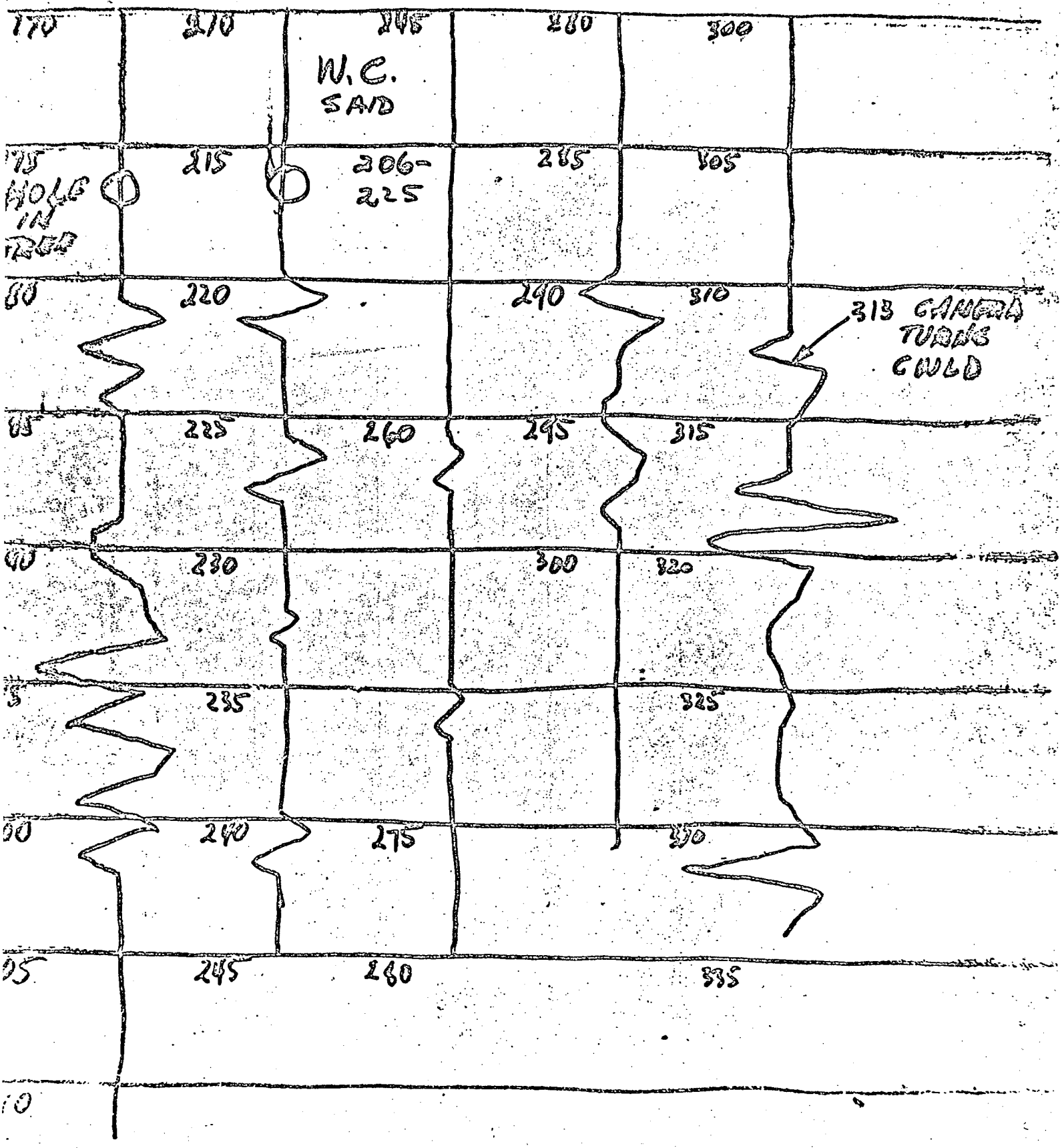
In addition to the two curves that I show here, I made a number of others, one of which showed quite conclusively that the camera was not running at 24 frames per second, as Mr. Zapruder was at one time quoted as saying. It took me several weeks to find a "clock", that would let me make such a statement unequivocally. From the point of view of the physics of the investigation I made, I got more personal satisfaction out of that discovery than out of anything else, since it took a good deal of observation and analytical experience, to make the deduction. I don't believe that anyone seriously questions the camera speed any more, so it can simply remain a bit of personally satisfying detective work that I did on that matter.

I have just reread your letter, and am really quite astounded that you would think I would change my letter to agree with something that Mr. Wyckoff said. Once a scientist comes to believe that he should only publish things that are the consensus of the measurements of all of his scientific associates or competitors, he stops being a scientist. Unfortunately I am finding that many of my young associates feel that they should never publish anything until they have telephoned to all of the people they know who are doing similar experiments in this country and abroad, to see if they are "getting the right answer". I am intensely opposed to this way of doing science, and that is why I reacted so strongly to your suggestion that I change something that I stated with some conviction in my letter. (Of course anyone can make typographical errors, and had you pointed out such an error, I would have been happy to change it. But the thought that I should change my personal conclusion because it disagrees with something Mr. Wyckoff said, is absolutely shocking to me.)

Very sincerely,

Luis W. Alvarez

LWA:am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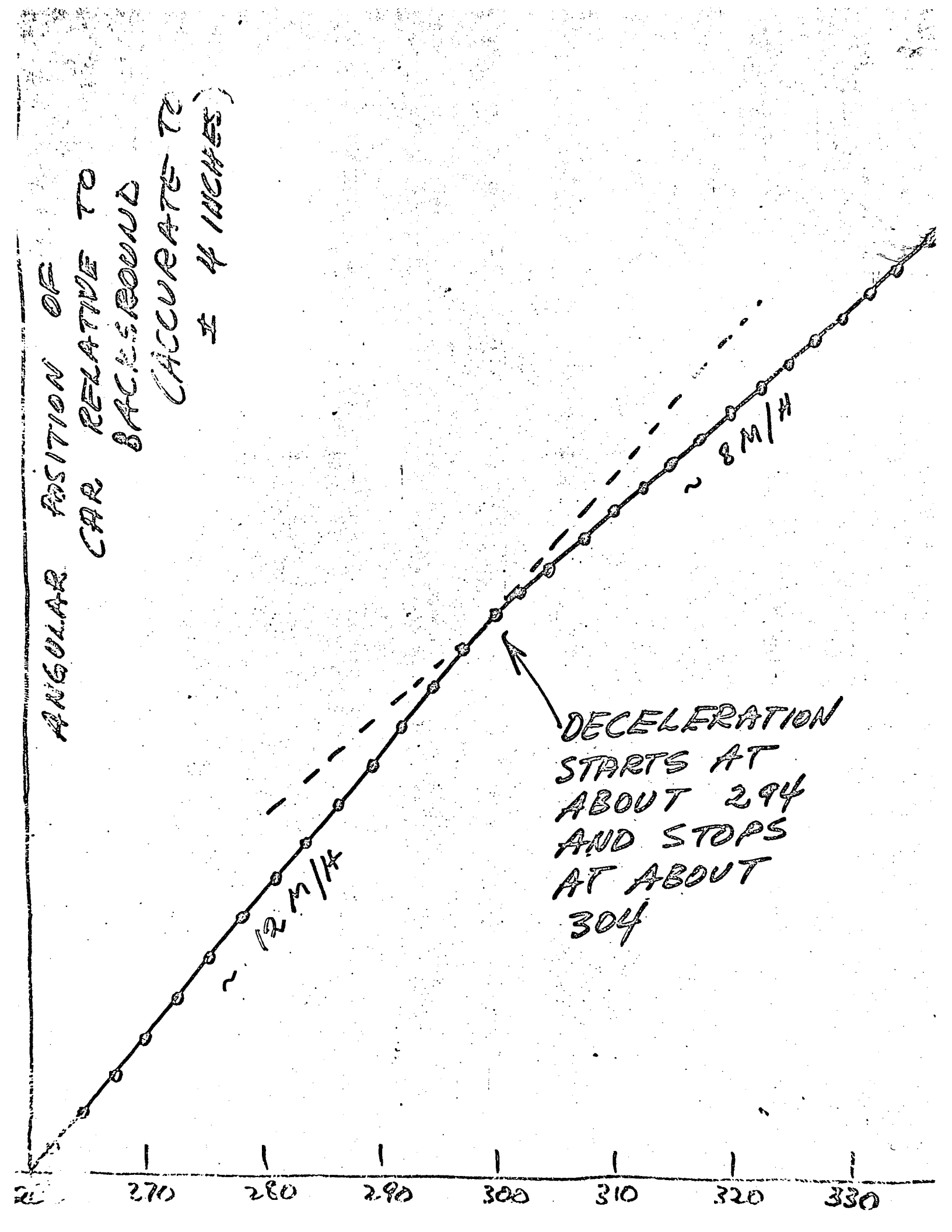
ANGULAR POSITION OF CAR RELATIVE TO BACKGROUND (ACCURATE TO ± 4 INCHES)
~ 12 M/H
~ 8 M/H
DECELERATION STARTS AT ABOUT 294 AND STOPS AT ABOUT 304
270
280
290
300
310
320
330