UMTRI-83-20

EVALUATION OF BARRIER LIMIT CAPACITY FOR DIFFERENT CLASSES OF VEHICLES AND IMPACT CONDITIONS

Parameter Measurements of:

1978 Honda Civic
1979 Dodge B-200 Van
1979 Ford F150 Pickup

Interim Report

Subcontract L 300005(RF4798)

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16. Abstract

Parameter measurements of three vehicles—1978 Honda Civic, 1979 Dodge B-200 van, 1979 Ford F150 pickup—were made. Techniques used for making the measurements are described and results are given.

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1. INTRODUCTION

This document reports on the parameter measurements conducted on three test vehicles: (1) a 1978 Honda Civic, (2) a 1979 Dodge B-200 van, and (3) a 1979 Ford F150 pickup truck. These three vehicles were purchased by UMTRI and will be shipped to TTI for crash testing. Under this subcontract, UMTRI will measure the parameters of three additional vehicles: (4) a Chevrolet S-10 pickup, (5) a 1979 or later Chevrolet C-10 pickup, short wheelbase model, and (6) a 1979 or later Ford E-150 van. These vehicles will be rented by UMTRI for measurement and will not be subjected to further testing.

Parameter data to be provided for each of the six vehicles are:

Total Vehicle Inertial Properties:

center of gravity position
three principal moments of inertia

Unsprung Mass, Front and Rear:

weights
position on the vehicle

Suspension Properties, Front and Rear:

vertical force deflection characteristics
including bump stop location

shock absorber damping coefficient applicable
to large displacement, low frequency regime

UMTRI has performed the measurements and is reporting the results herein for all the parameters of the three purchased vehicles except shock absorber data. As regards shock absorber data, the decision was made, in consultation with Mr. E. Buth of TTI, to install new replacement shocks (Monroe) on all three vehicles and obtain the required descriptive data from the shock absorber manufacturer. (It appears that this was a good decision since the shock absorbers of the vehicles as purchased were not in good condition. In particular, at least one strut of the Civic was badly bent.) That data is currently being obtained and will be forwarded as soon as it becomes available.

Section 2 of this document describes the measurement procedure. Resulting data is presented tabularly in Section 3. References appear in Section 4.

2. MEASUREMENT PROCEDURES

2.1 Total Vehicle Inertial Measurements

Center of Gravity Position. Center of gravity position was measured vertically and longitudinally (and assumed to be on the plane of symmetry laterally) for each vehicle. For the two heavier vehicles, measurements were made using the UMTRI pitch plane inertial measurement facility [1]. Shown in Figure 1, this facility is a pendulum-like device. Center of gravity position is measured by applying a known torque to the pendulum with the vehicle in place and measuring the resulting pitch attitude. These data, along with vehicle weight and known properties of the facility, are used to calculate the longitudinal and vertical c.g. position of the test vehicle.

The pitch plane facility is not intended for the measurement of very light vehicles. Accordingly, a different procedure was used to determine the c.g. position of the Honda Civic. In this case, the vehicle was hung from an overhead cable, once in a "horizontal" condition and once in a "vertical" condition. The vertical hang is shown in Figure 2. (The vehicle's suspensions were constrained to their normal ride height during testing.) For each hang, a plumb line, passing through the support point, was marked on each door of the vehicle and the intersection of these lines indicates the c.g. position vertically and longitudinally.

C.g. heights are reported "above the ground," but also relative to a vertical reference fixed in the sprung mass. Given the variabilities associated with tire and suspension deflections, we feel that the second reporting method is more reliable.

Total Vehicle Moment of Inertia. Pitch and roll moments of inertia were measured for each vehicle using a compound pendulum measurement technique. In this procedure, the vehicle is placed on a pendulum supporting device and oscillated freely in the direction of interest. The period of oscillation is measured and used, along with vehicle weight and c.g. position and the known properties of the device, to calculate the moment of inertia of the vehicle.

Figure 1. 1979 Ford pickup on pitch plane inertial measurement facility.

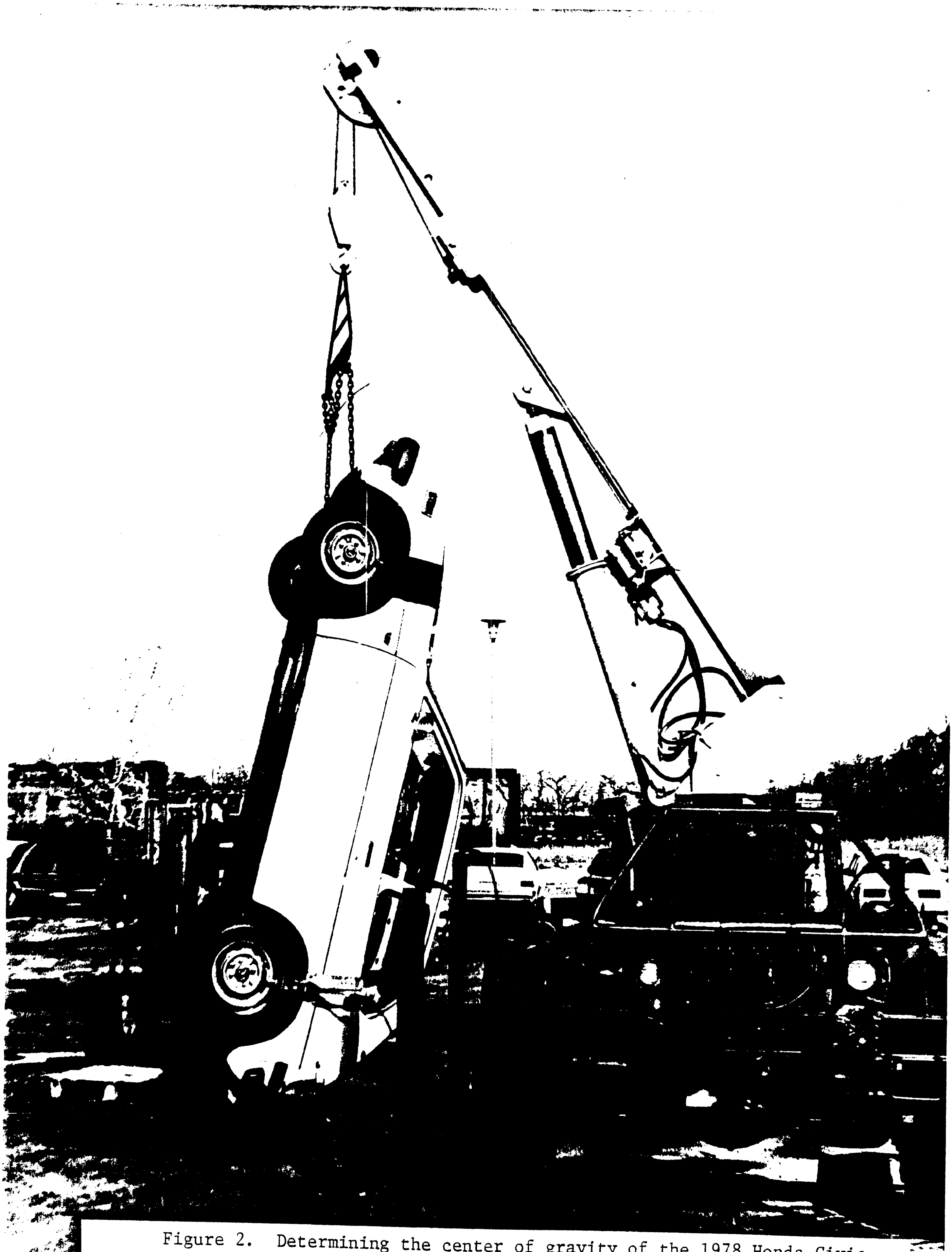


Figure 2. Determining the center of gravity of the 1978 Honda Civic.

In the case of the two heavier vehicles, the pitch plane facility was used to determine pitch moments. The roll moments of inertia of all these vehicles, plus the pitch moment of the Civic, were measured on the pendulum shown in Figures 3 and 4.

Yaw moment of inertia of each vehicle was measured using a multi-filar pendulum technique. Figure 5 illustrates the device used in each case. In this case, the vehicle is oscillated freely in yaw and the period of oscillation is measured. Again, using vehicle weight (the vehicle is oriented on the device with its c.g. on the centroid of the filars) and known properties of the device, yaw moment of inertia is calculated.

The results of all of these measurements are quite consistent with expectations, based on UMTRI's previous experience in inertial parameter measurement [1].

Unsprung Masses. The effective unsprung masses were measured by two different methods. (1) For the solid rear axles of the Ford and Dodge, the entire assembly was removed (with springs and without shocks) and weighed as a unit (Figure 6). Then, one leaf spring was removed and weighed separately. (2) For indpendent suspensions, the suspension spring element and (except for the Honda) the shock absorbers were removed from the vehicle. In this condition, the sprung mass was supported by an overhead crane, and the effective weight of the unsprung mass was measured by determining the tire vertical load using a balance scale (Figure 7). The proper ride height and chassis attitudes were maintained. The effects of Coulomb friction were accounted for by making this measurement once following a rebound stroke and once following a compression stroke and averaging the results. Spring and shock were weighed separately.

Assuming the unsprung mass c.g. to be on the spindle axis, straightforward tape measurements were taken to locate the unsprung masses.

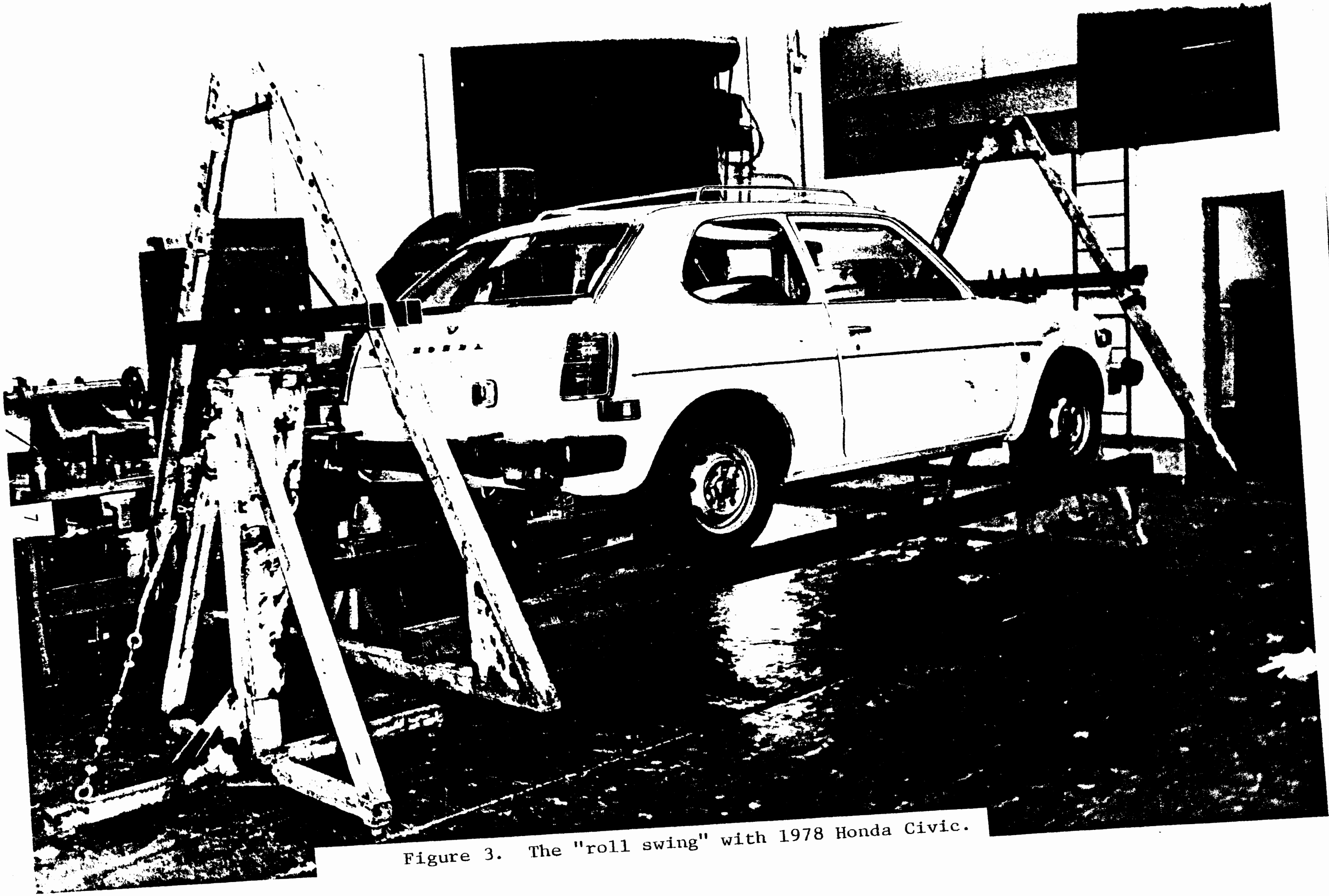


Figure 3. The "roll swing" with 1978 Honda Civic.

Figure 4. Measuring the pitch moment of inertia of the 1978 Honda Civic.

Figure 5. 1979 Dodge van on the multi-filar pendulum.

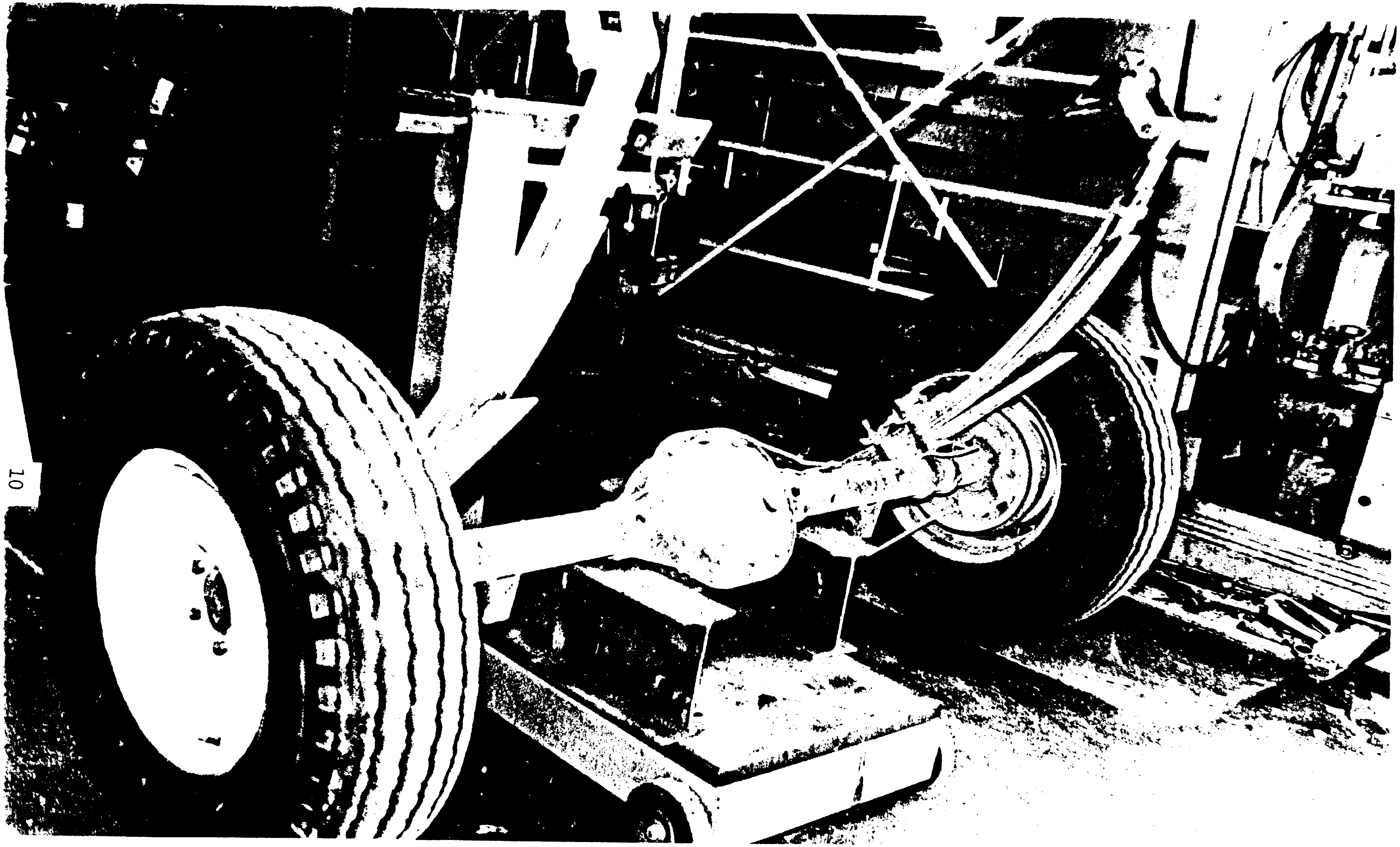


Figure 6. Weighing a rear, unsprung mass.

Figure 7. Weighing a front, unsprung mass—shock and spring removed.

Suspension Force-Deflection Properties. Suspension vertical rate properties were measured on UMTRI's heavy vehicle suspension measurement facility [2]. The facility was modified, however, to provide a vertical load measurement transducer more appropriate to light vehicles. A test setup is shown in Figure 8.

Resulting data are presented graphically in Section 3 and contain information describing vertical wheel rate (in the "normal range," as well as in the range of bump stop contact), ride height, and bump stop "location."

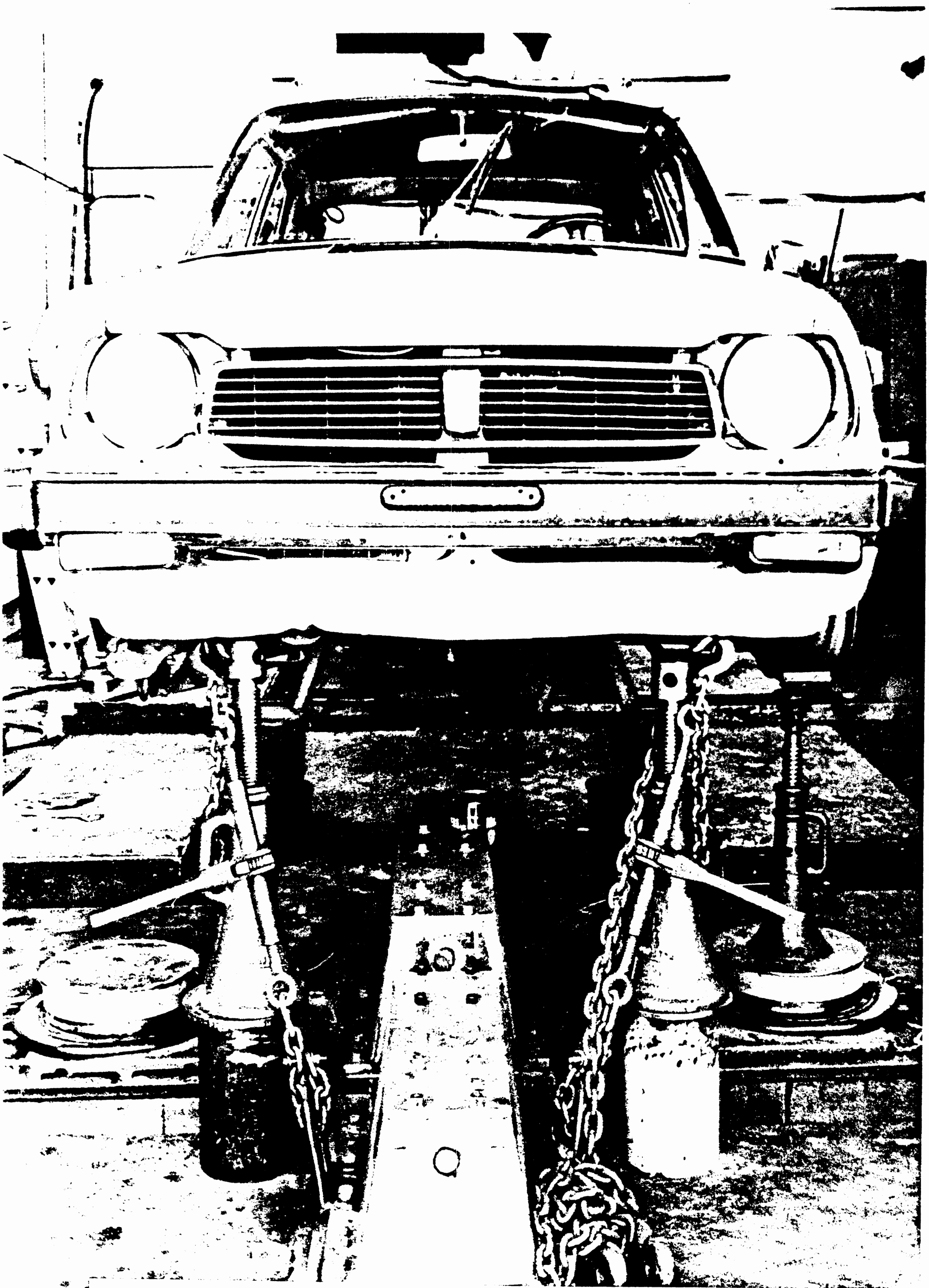


Figure 8. 1979 Honda Civic on the suspension measurement facility.

3. VEHICLE PARAMETERS

All parameters given herein were gathered with the test vehicles in an empty condition, including empty fuel tanks.

Total Vehicle Inertial Properties

Vehicle	Weight (lb)	Wheelbase (in)	C.G. Position (in)			Principal Moments of Inertia (in-lb-sec^2)		
			Vertical		Longitudinal			
			Above Ground	Above Vehicle Reference*	Aft of Front Axle Center	Roll I_{xx}	Pitch I_{yy}	Yaw I_{zz}
1978 Honda Civic	1,699	86.25	20.38	13.1	31.75	~~1640~~ 2119	~~8465~~ [illegible]	7828
1979 Dodge B-200 Van - 3/4 ton	3,808	128	29.48	14.41	48.96	~~7984~~ 10923	37474	39633
1979 Ford F150 Pickup - 1/2 ton	3,863	132	26.09	10.22	56.09	~~4891~~ 8013	42384	42367

*Vehicle reference for each vehicle is the lower edge of body pinch mold (beneath door sill) at longitudinal c.g. position

Unsprung Masses

Weights

1978 Honda Civic

Effective front unsprung weight without spring, one side:	87 lb
Front spring weight, one side:	4-1/2 lb
Effective rear unsprung weight without spring, one side:	67 lb
Rear spring weight, one side:	3-1/2 lb

Note: Unsprung weights include upper (fixed in sprung mass) strut parts. I would estimate that these are 1-2 lbs and that, therefore, no addition should be made to these numbers to account for a portion of the spring.

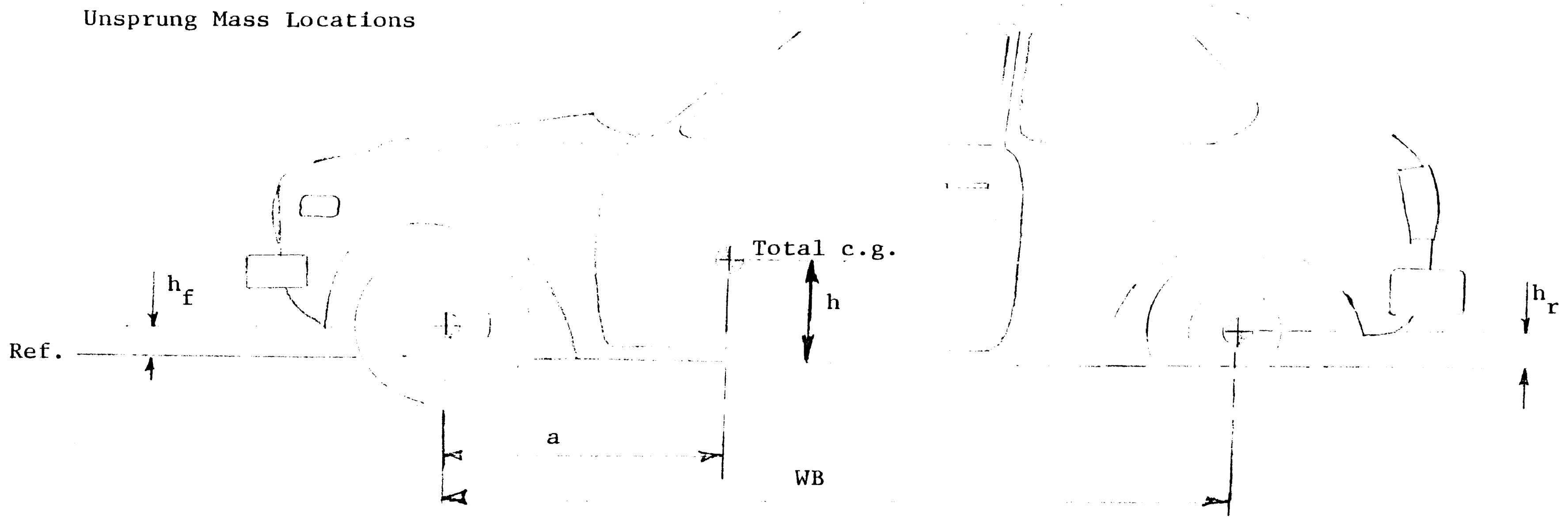
1979 Dodge B-200 3/4 Ton Van

Effective front unsprung weight without spring or shock, one side:	137 lb
Front spring, one side:	17-1/2 lb
Front shock, one side:	2-1/2 lb
Rear unsprung weight complete, with springs, without shocks:	464 lb
Rear spring, one side:	68 lb
Rear shock, one side:	4 lb

1979 Ford F150 1/2 Ton Pickup

Effective front unsprung weight without spring or shock, one side:	127 lb
Front spring, one side:	16 lb
Front shock, one side:	2 lb
Rear unsprung weight complete, with springs, without shocks:	455 lb
Rear spring, one side:	52 lb
Rear shock, one side:	1 lb

Unsprung Mass Locations



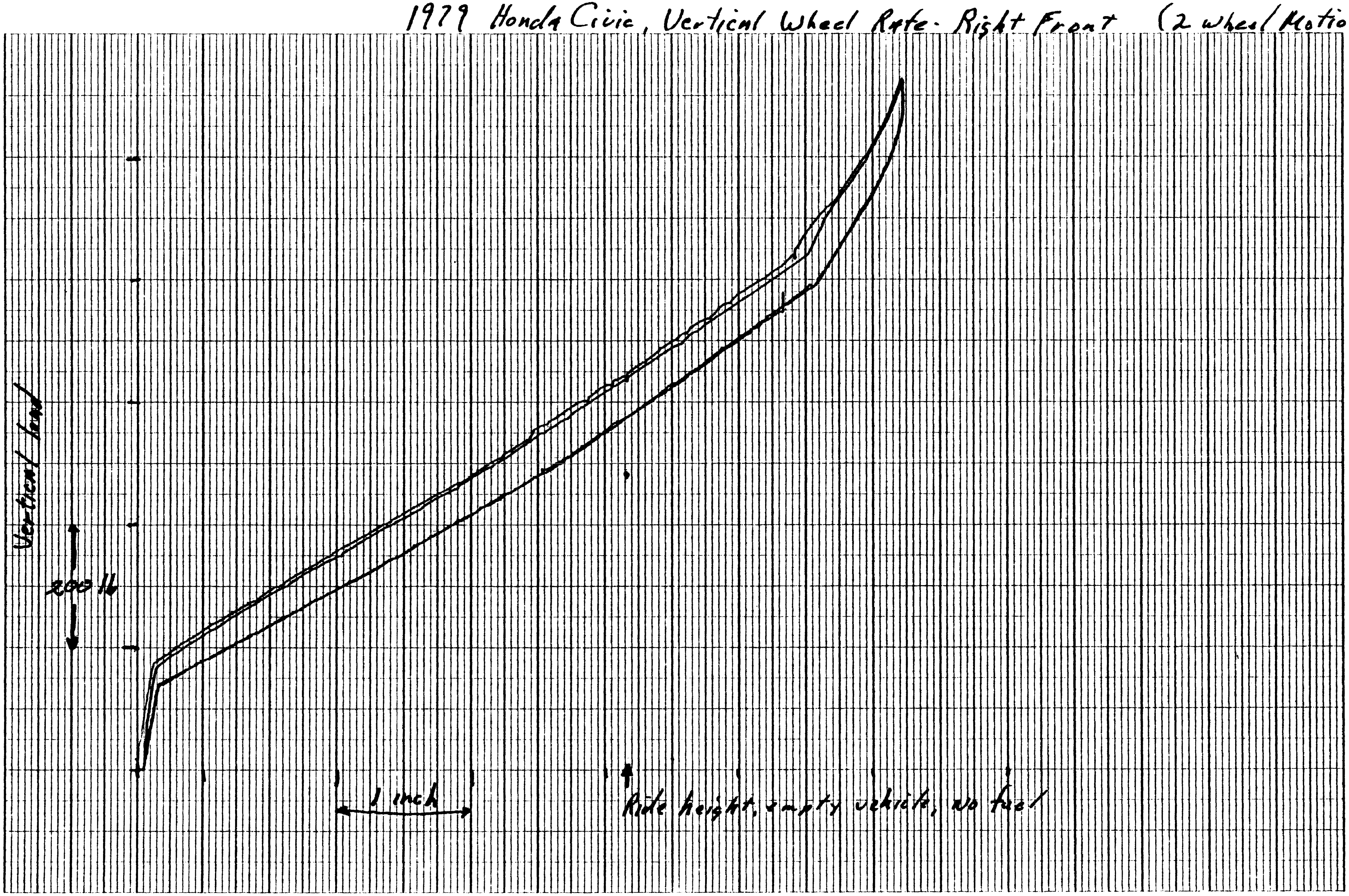
	Height Above Vehicle Reference* (in)			Distance Aft of Front Axle (in)	
	h	h_f**	h_r**	WB	a
1978 Honda Civic	13.1	2.9	3.0	86.25	31.75
1979 Dodge B-200	14.4	-1.0	-1.25	128	49.0
1979 Ford F150	10.2	-1.75	-1.56	132	56.1

*Reference is low edge of pinch weld below door sill at longitudinal c.g. position

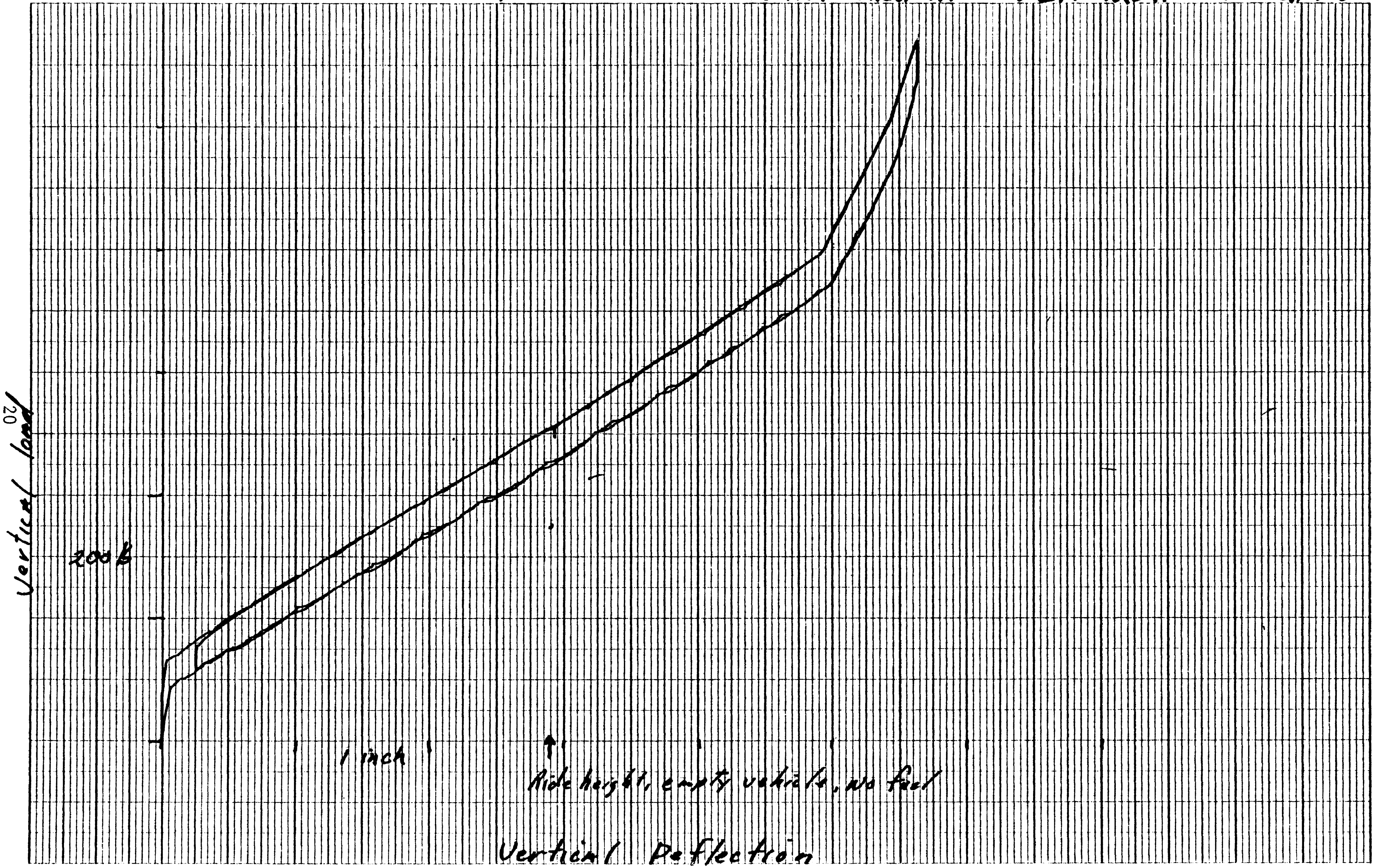
**h_f and h_r vary with loading and tire inflation pressure

Suspension Properties

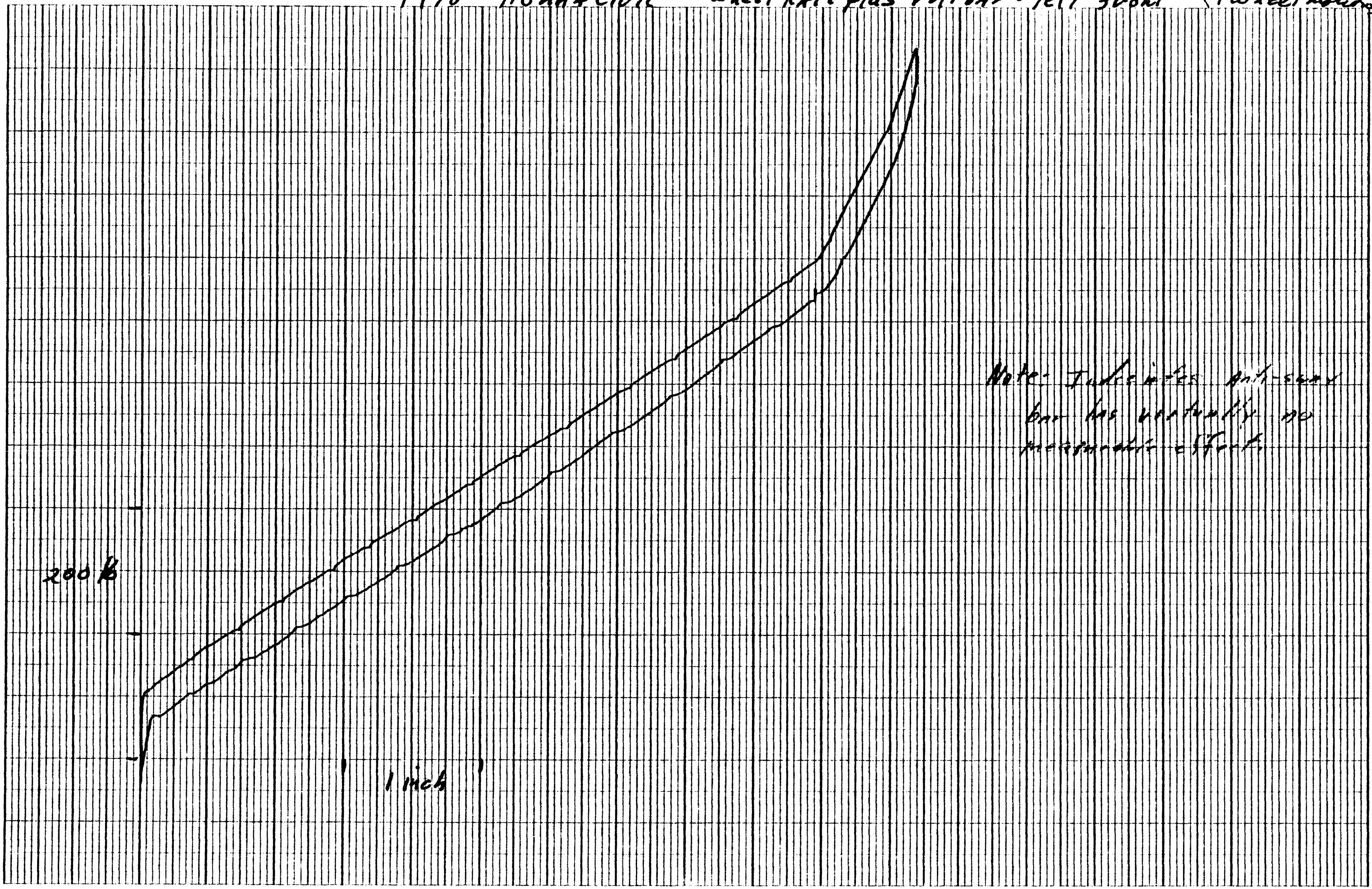
46 1320

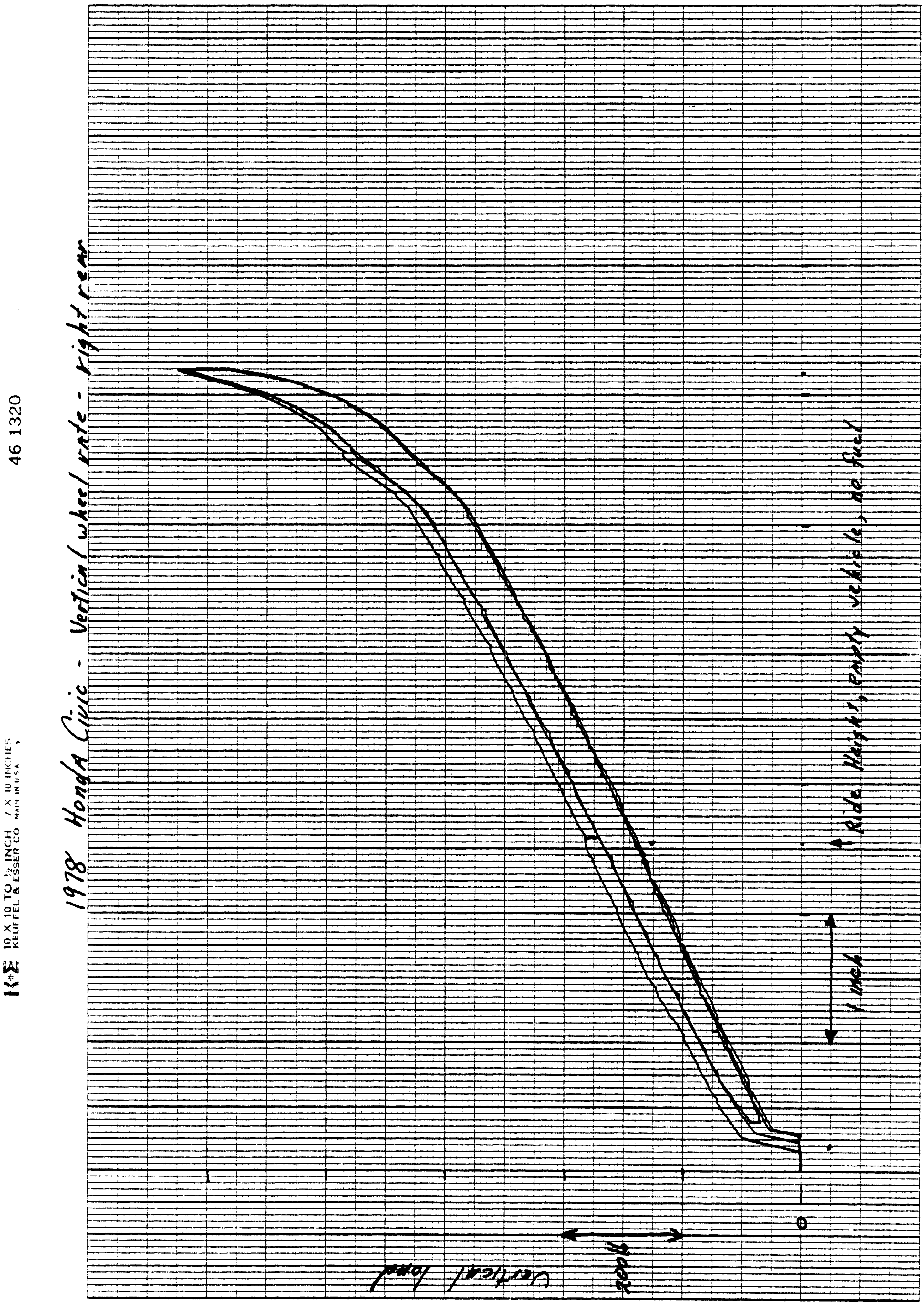

1979 Honda Civic, Vertical Wheel Rate - Right Front (2 wheel Motion
Vertical load
200 lb
1 inch
Ride height, empty vehicle, no fuel

1978 Honda Civic - Vertical Wheel Rate - Left Front (2 wheel motion)

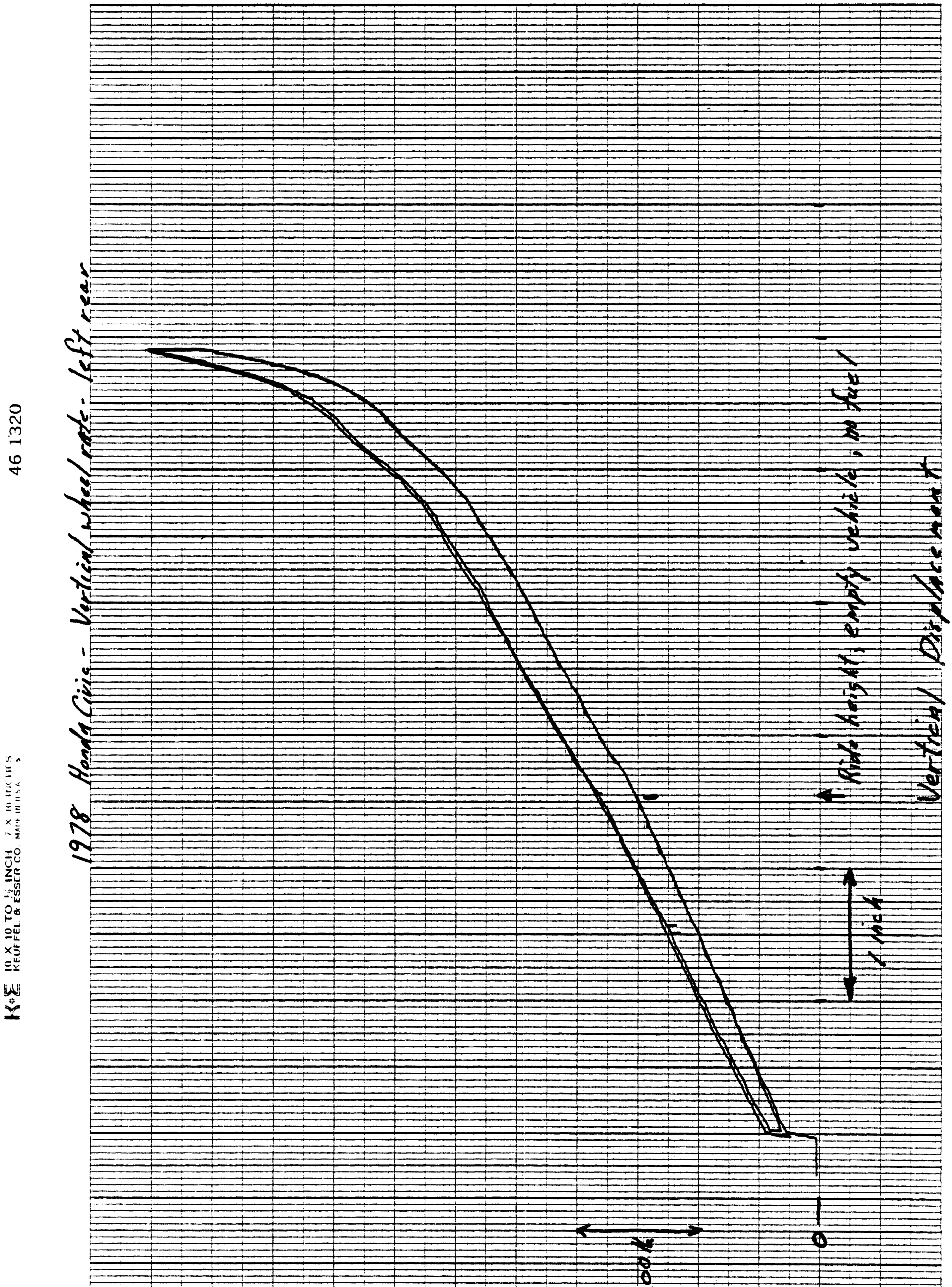


1978 Honda Civic – Wheel Rate plus roll bar – left front (1 wheel/motion)



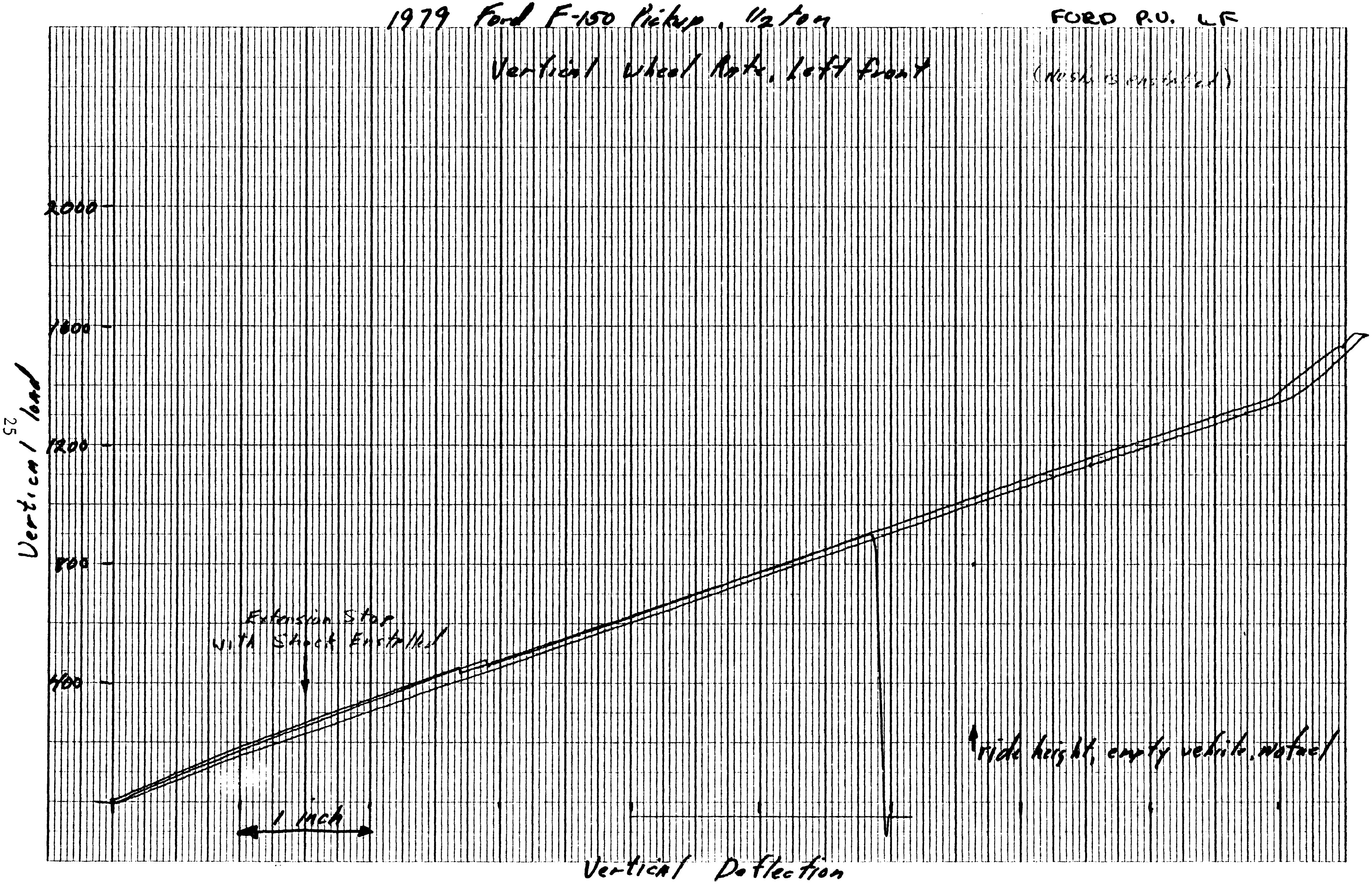


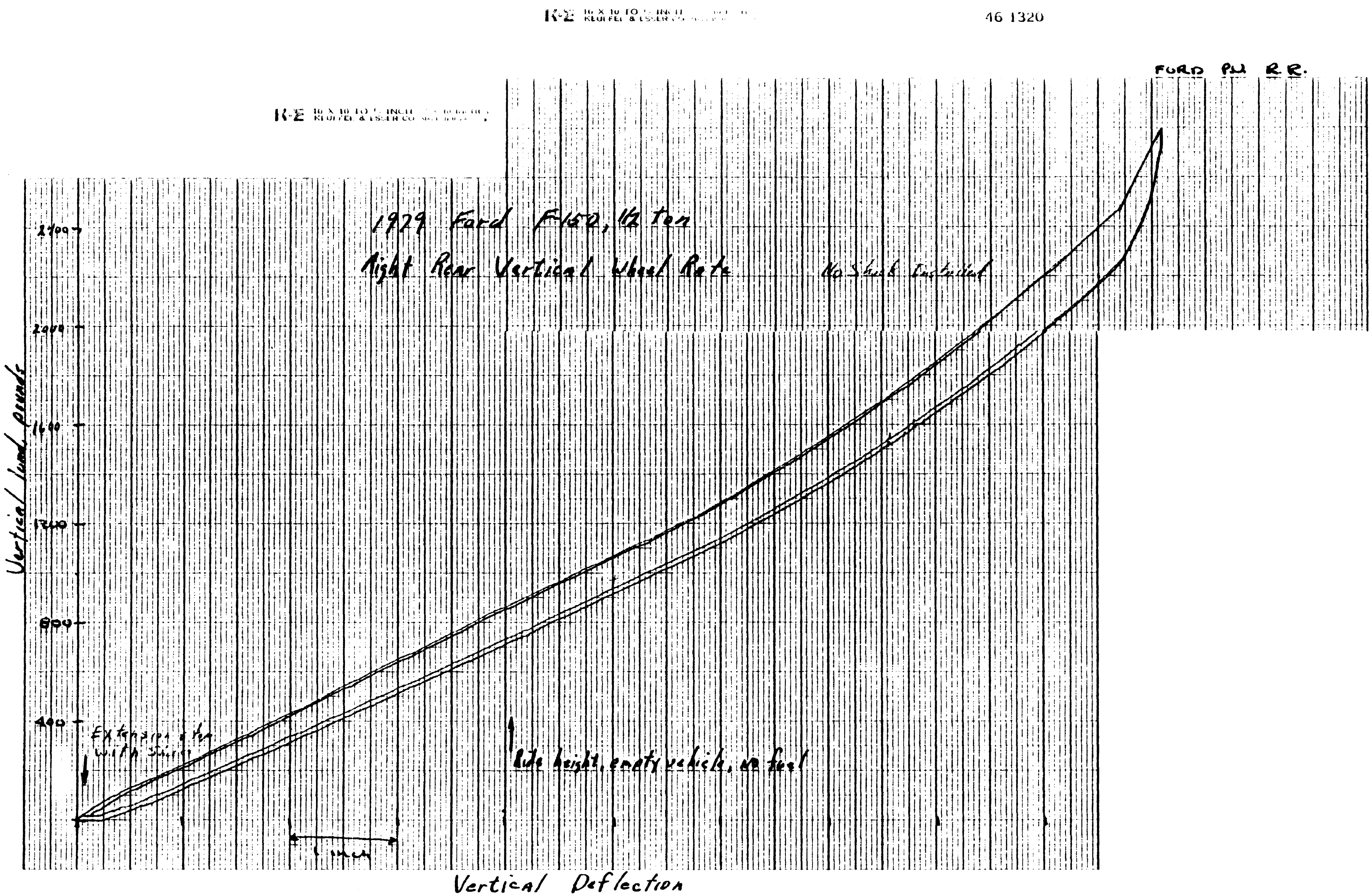
1978 Honda Civic - Vertical wheel rate - right rear
Ride Height, empty vehicle, no fuel
1 inch
0
Vertical load
200#
46 1320
10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.


1978 Honda Civic - Vertical wheel rate - left rear
Ride height, empty vehicle, no fuel
Vertical Displacement
1 inch
200 lb
0
Vertical load
46 1320
10 X 10 TO 1/2 INCH
KEUFFEL & ESSER CO.

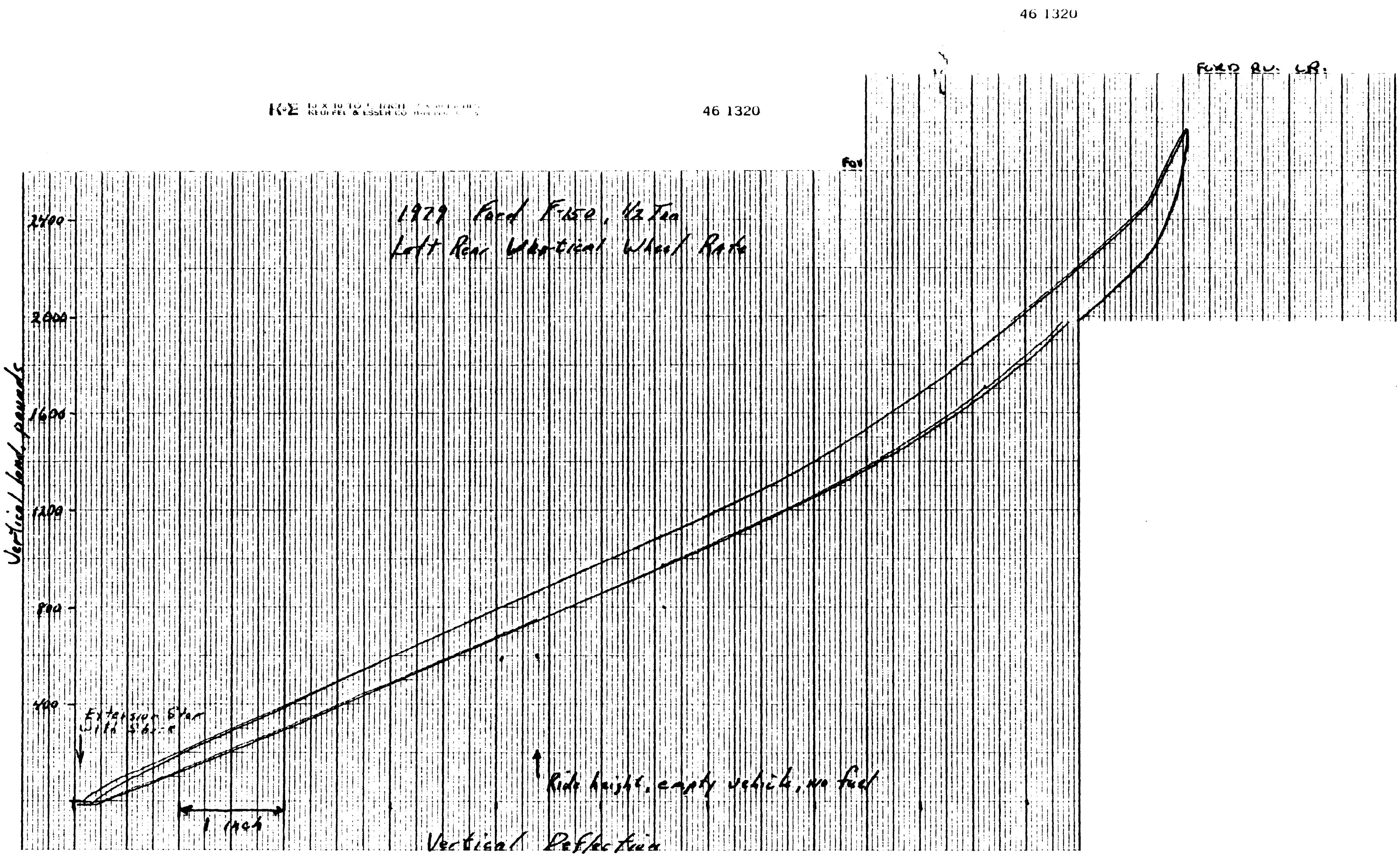
LEAD EDGE
46 1320
46 1320
1979 Ford F-150 Pickup, 1/2 ton
Vertical Wheel Rate, Right Front
Ford P.U. RF
No Shock Installed
Ride height, curb vehicle, no fuel
Extension Stop With Shock Installed
Vertical Deflection
Vertical load
2000
1600
1200
800
400

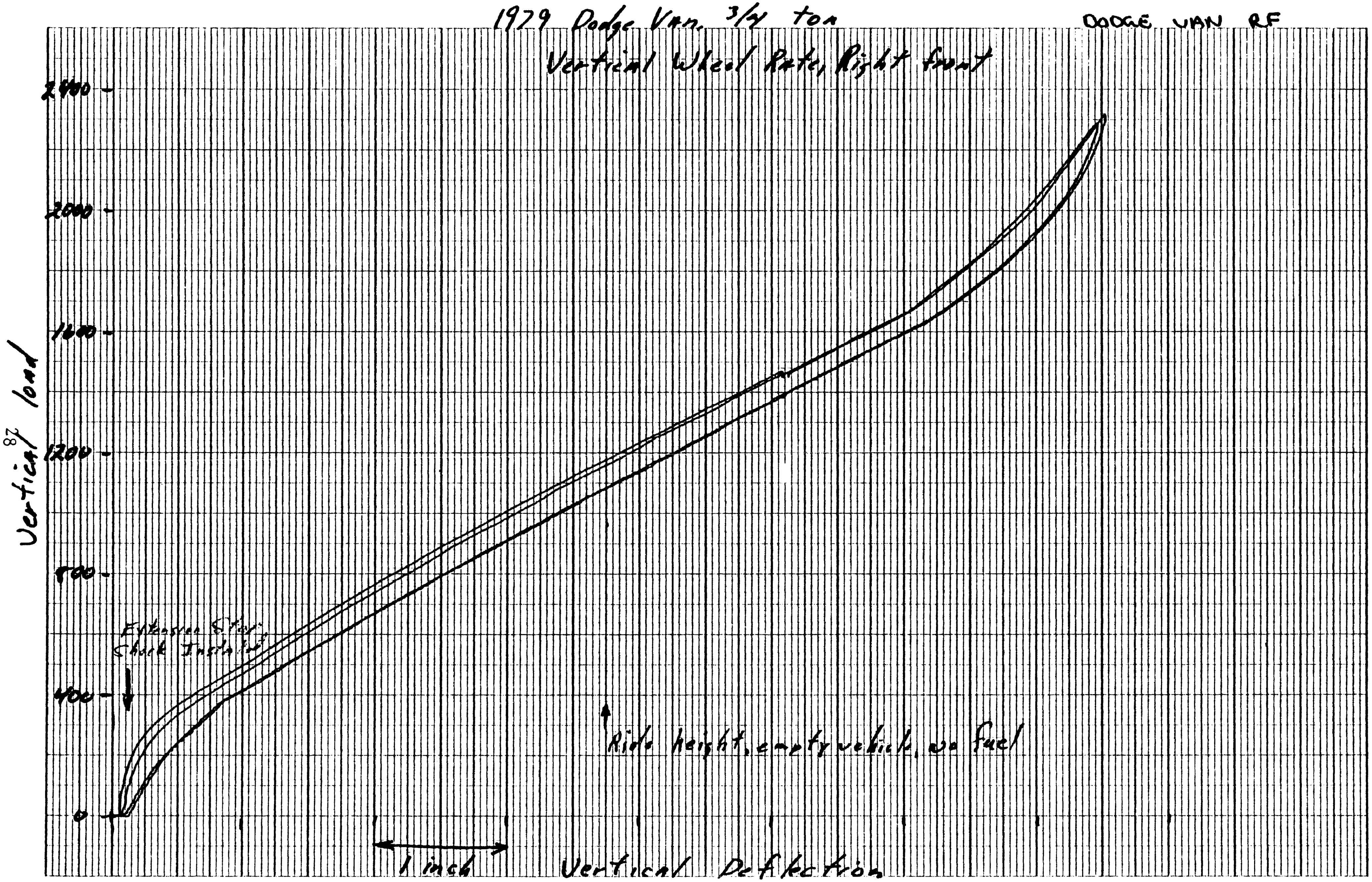
46 1320


1979 Ford F-150 Pickup, 1/2 ton
FORD P.U. LF
Vertical Wheel Rate, left front
2000
1600
1200
800
400
Vertical load
Extension Stop
with Shock Installed
1 inch
ride height, empty vehicle, no fuel
Vertical Deflection

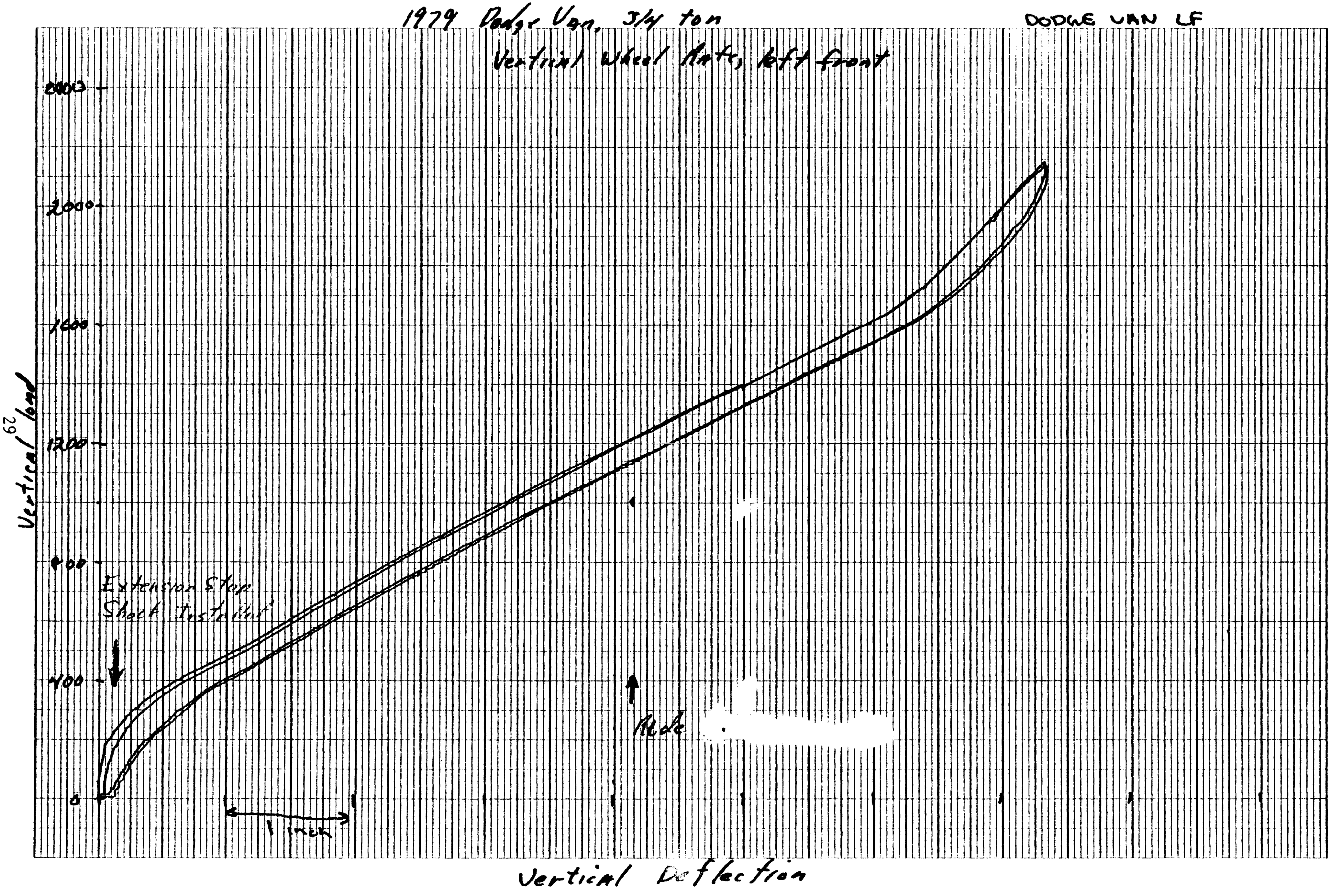


46 1320
FORD PU R.R.
1929 Ford F150, 1/2 ton
Right Rear Vertical Wheel Rate
No Shock Installed
2400
2000
1600
1200
800
400
Vertical load, pounds
Extension stop with shock
Ride height, empty vehicle, no fuel
1 inch
Vertical Deflection

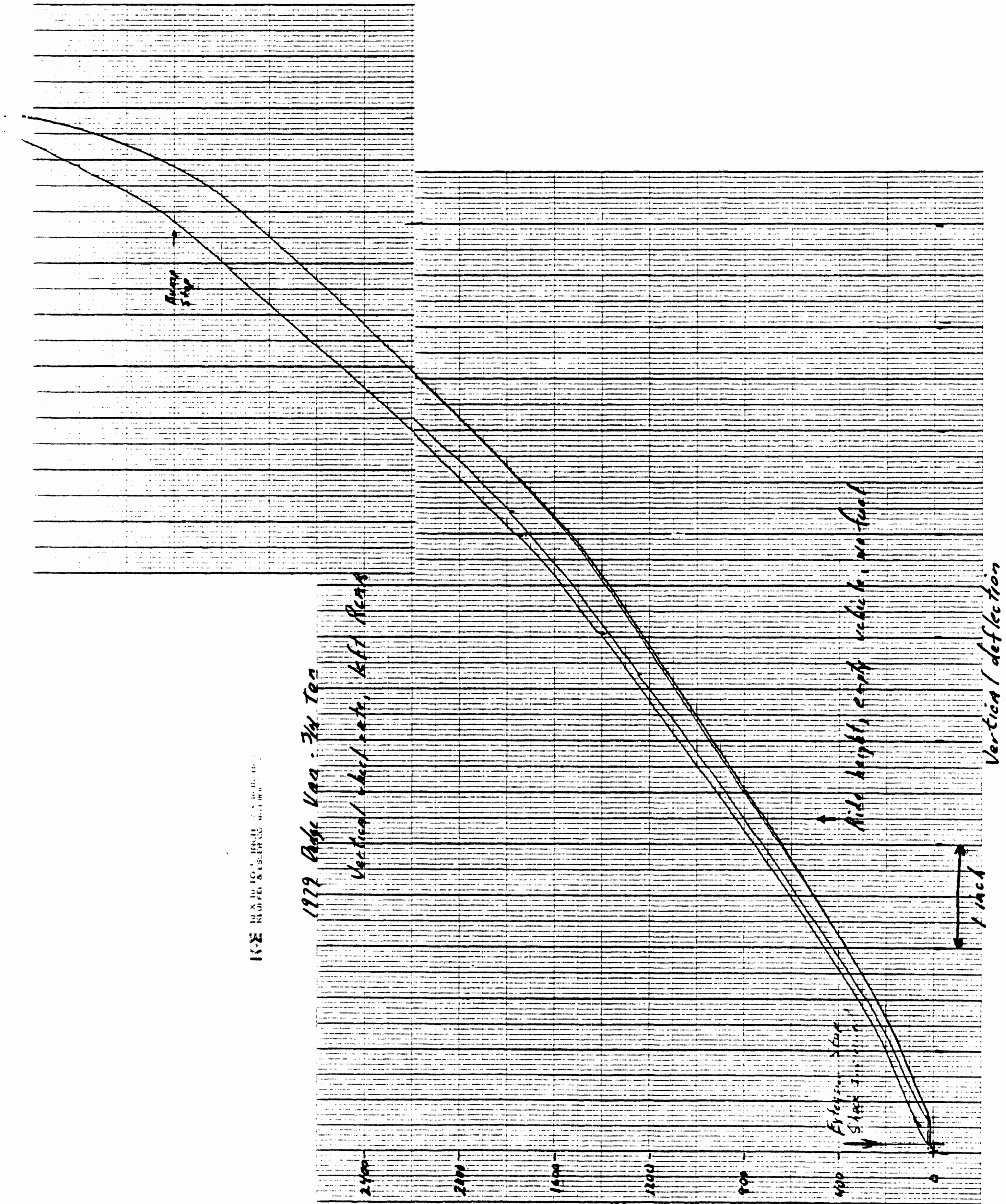

46 1320
FORD RD. LR.
K-E 10 X 10 TO 1/2 INCH
KEUFFEL & ESSER CO.
46 1320
1979 Ford F150, 1/2 Ton
Left Rear Vertical Wheel Rate
2400
2000
1600
1200
800
400
Vertical load, pounds
Extension Stop
1 inch
Ride height, empty vehicle, no fuel
Vertical Deflection

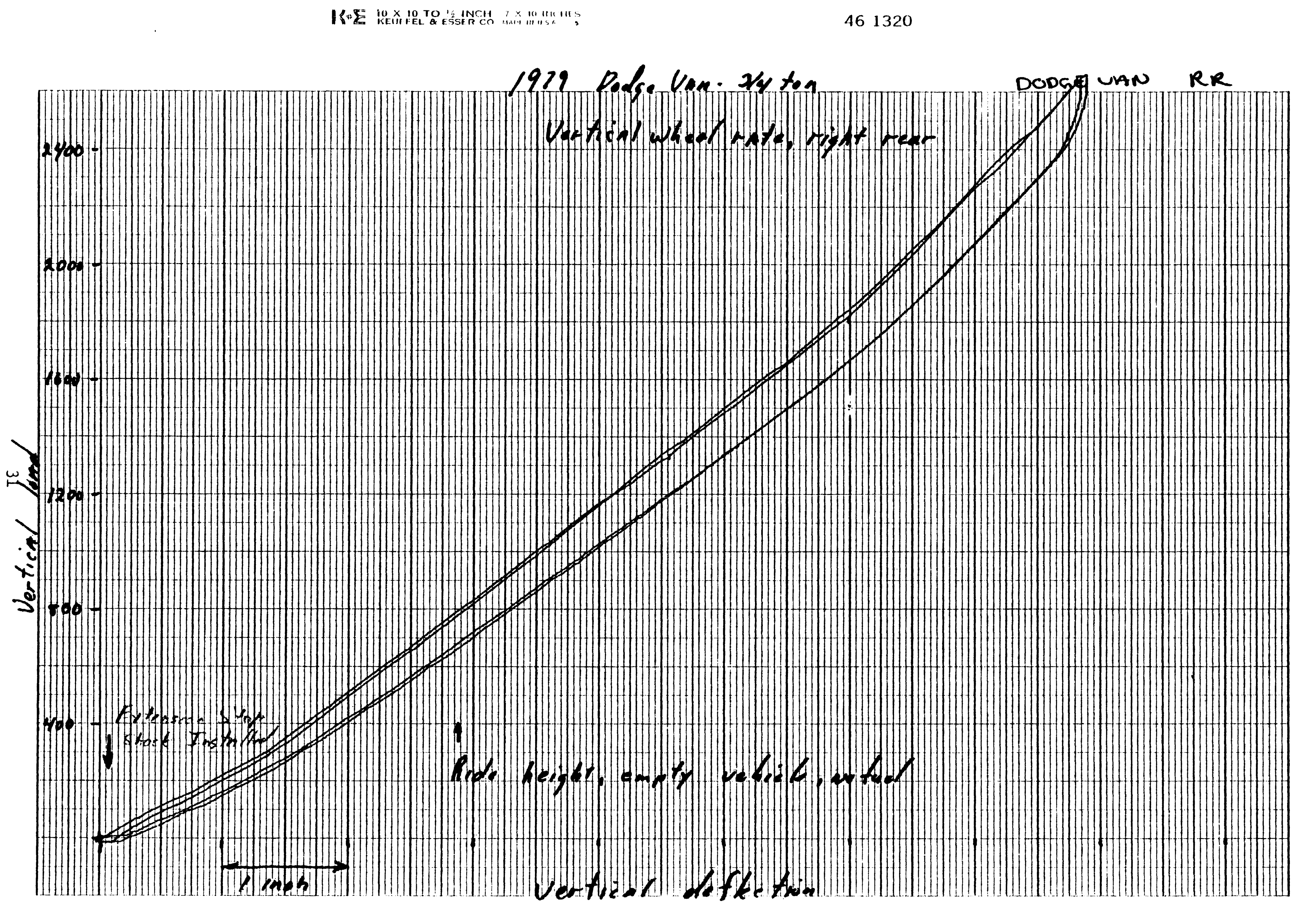

1979 Dodge Van, 3/4 ton
Vertical Wheel Rate, Right front
DODGE VAN RF
2400
2000
1600
1200
800
400
0
Vertical load
Extension Stop; Shock Installed
Ride height, empty vehicle, no fuel
1 inch
Vertical Deflection

46 1320



1979 Dodge Van, 3/4 ton
Vertical Wheel Rate, left front
DODGE VAN LF
2400
2000
1600
1200
800
400
0
Vertical load
Vertical Deflection
Extension Stop
Shock Installed
Ride
1 inch


1979 Dodge Van · 3/4 Ton
Vertical characteristic, Left Rear
Ride height, empty vehicle, no fuel
Vertical deflection
1 inch
Bump Stop
Extension Stop
2400
2000
1600
1200
800
400
0
Vertical load


K+E 10 X 10 TO ½ INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 1320
1979 Dodge Van · 3/4 ton
DODGE VAN RR
Vertical wheel rate, right rear
2400
2000
1600
1200
800
400
Vertical load
Extension Stop
Shock Installed
Ride height, empty vehicle, w/ fuel
1 inch
Vertical deflection

4. REFERENCES

1. Winkler, C.B. "Inertial Properties of Commercial Vehicles. Descriptive Parameters Used in Analyzing the Braking and Handling of Heavy Trucks." Vol. 2, 2nd Ed., Report No. UMTRI-83-17, April 1983.

2. Winkler, C.B. and Hagan, M. "A Test Facility for the Measurement of Heavy Vehicle Suspension Parameters." SAE Paper No. 800906, August 1980.