UMTRI-83-37

VEHICLE PARAMETER MEASUREMENTS OF AN LAV WITH 90 mm. CANNON

Final Report

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C.B. Winkler

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16. Abstract

Vehicle parameter measurements were made on a Light Armored Vehicle. Measurements of inertial, suspension, and tire properties were made. Techniques are briefly described and results presented.

17. Key Words c.g. position, moments of inertia, suspension properties, tire spring rate, cornering stiffness	18. Distribution Statement

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VEHICLE PARAMETER MEASUREMENTS OF AN LAV WITH 90mm. CANNON

Inertial Properties

The LAV was separated into its two component parts (viz. the "vehicle" less the turret, and the "turret" equipped with a 90mm. cannon) for inertial testing. For each of these two parts, weight, center of gravity position in the vertical, lateral and longitudinal directions, and the roll, pitch and yaw moments of inertia about the c.g. were measured.

Weight, plus center of gravity position in the pitch plane and the pitch moment of inertia of the vehicle, were all measured using the UMTRI heavy vehicle pitch plane inertial test facility. Roll moment of inertia was measured using a similar compound pendulum device. The vehicle's yaw moment of inertia was measured by oscillating the vehicle in yaw against a coil spring of known rate, while the vehicle was supported vertically on "zero-friction," hydrostatic bearings.

The turret was weighed using a strain gauge load cell. Its center of gravity position was determined by suspending the entire assembly from an overhead crane and determining the plumb line from the suspension point with a precision transit. Repeating this procedure using several points of suspension identifies the center of gravity as the single point in the body at which all plumb lines intersect. Roll and pitch moments of inertia of the turret were determined using the compound pendulum device used to measure roll moment of the vehicle. Yaw moment of inertia of the turret was measured using a multi-filar (torsional) pendulum device.

Results of the inertial measurements are presented in the following two tables.

Vehicle Inertial Properties*

Weight	22,178 lbs.
Center of Gravity Position	
Longitudinal (aft of front axle center)	62.1 inches
Vertical (above lower face of belly plate at fore/aft c.g. position)	17.0 inches
(above ground in test condition)	39.9 inches
Lateral (right of center)	2.0 inches
Moments of Inertia about c.g.	
Yaw	294,990 in-lb-sec^2
Pitch	294,690 in-lb-sec^2
Roll	94,130 in-lb-sec^2

*Less turret; inclusive of unsprung masses in static ride height position; fully loaded ammo rack; fuel tank full.

Turret Inertial Properties*

Weight	4689 lbs.
Center of Gravity Position	
Vertical (above plane of lower face of turret drive gear)	3.88 inches
Longitudinal (forward of lateral center-line of turret drive gear)	4.88 inches
Lateral (right of longitudinal center-line of turret drive gear)	0.75 inches
Moments of inertia about c.g.	
Yaw	14,250 in-lb-sec^2
Pitch	15,280 in-lb-sec^2
Roll	599.0 in-lb-sec^2

*With 90mm. cannon horizontal, eight dummy rounds in storage racks.

Tire Properties

A variety of properties of the LAV tire were measured using the UMTRI Flat Bed Tire Tester. Tire properties measured were:

- o standing tire vertical spring rate
- o standing tire lateral spring rate
- o tire sideforce response to slip angle
- o peak friction of the standing tire on a concrete surface in the longitudinal and lateral directions

As originally proposed, these properties would have been measured for two tires, each at two inflation pressures and three vertical load conditions, thus providing a matrix of 12 test conditions (two tires x two pressures x three loads). By agreement with M. Ricketts, the test matrix was altered such that the tire properties of interest were measured for one tire removed from the LAV. Each property was determined under conditions of 0, 45, and 65 psi. inflation pressure and at 1500, 3500, 5500, and 7500 lbs. vertical load. This matrix also provided for 12 test conditions (one tire x three pressures x four loads), and, therefore, an equivalent volume of tire data as originally proposed.

The results of the tire tests are contained in the series of graphs which follow. Note that the friction coefficient of the standing tire was measured on new concrete which was prepared with both "smooth" and "rough" surface sections. Moderate differences are seen in the resulting data. Side force data for the uninflated tire is also of interest. Note that the tire behaves remarkably well at low levels of slip angle, but above four degrees of slip, the side wall apparently becomes unstable and side force literally "goes away." (The tire is very erratic in its behavior under these conditions such that the data sampling and averaging routines employed may not be appropriate. Accordingly, data in the unstable regime should be considered to be qualitative only.) Drivers should be aware that, with flat tires (particularly at the rear), the vehicle may handle reasonably well at low maneuvering levels (possibly providing a false sense of security) but may rapidly become unstable at moderate levels of maneuvering severity.

Suspension Properties

The suspension properties requested by the reference solicitation were measured using UMTRI's heavy vehicle suspension test facility. The vehicle's rearmost axle was chosen as the "rear" axle for test, while the second axle from the front was chosen as the "front" axle for test. Tires and wheels were removed from the test axles and replaced with "rigid" surrogates. Thus, the properties measured are those of the suspension only, and do not include the influences of tire compliances.

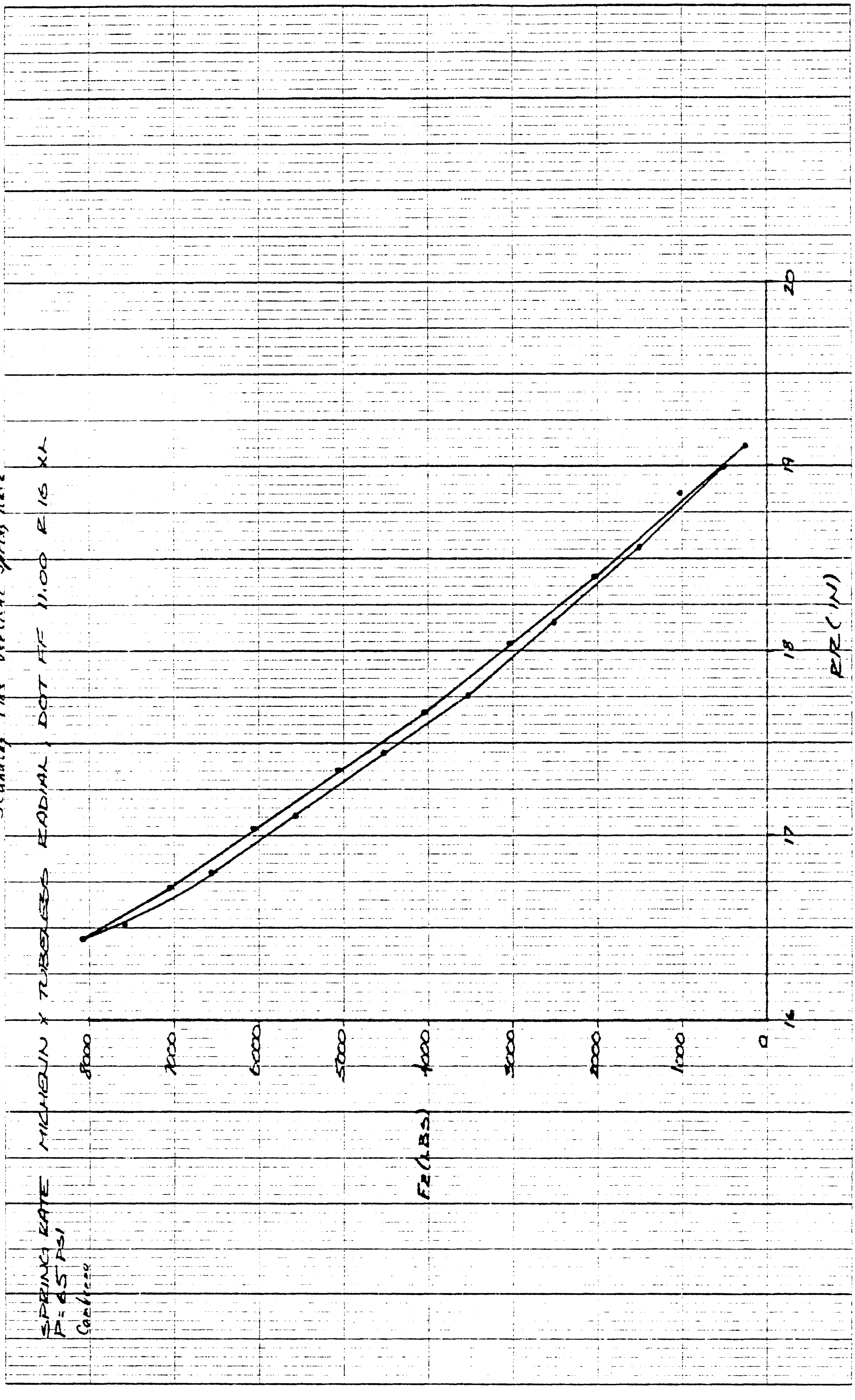
Test results are presented in the several graphs which follow. Vertical rate is shown over the full suspension travel, with bump stop effects clearly evident. Coulomb friction is relatively low in both vertical and roll rate data. The rear suspension shows virtually no roll steer and little aligning moment compliance steer as would be expected from this stout, "pure" trailing arm suspension. Front suspension roll steer is significant, however, and front suspension aligning moment steer reveals a substantial steering system compliance. As is typically the case, the front aligning moment compliance steer data also reveal steering system lash (i.e., the more vertical, central portions of the data) but there is a somewhat large level of Coulomb friction (evidenced by the horizontal spacing of the hysteresis loops) also apparent in the data.

In addition to the data presented graphically, roll center height of both suspensions was determined. As predicted by theory, the roll center of the trailing arm rear suspension was found to be at the ground plane. For the front suspension measured, roll center heights were found to be as follows:

Total Axle Load (pounds)	6000	7000	8000
Suspension Roll Center Height (inches below reference*)	35.75	36.5	36.75

*Vertical reference is the sharp, outer body edge at the longitudinal position of the axle.

Tire Properties Graphs



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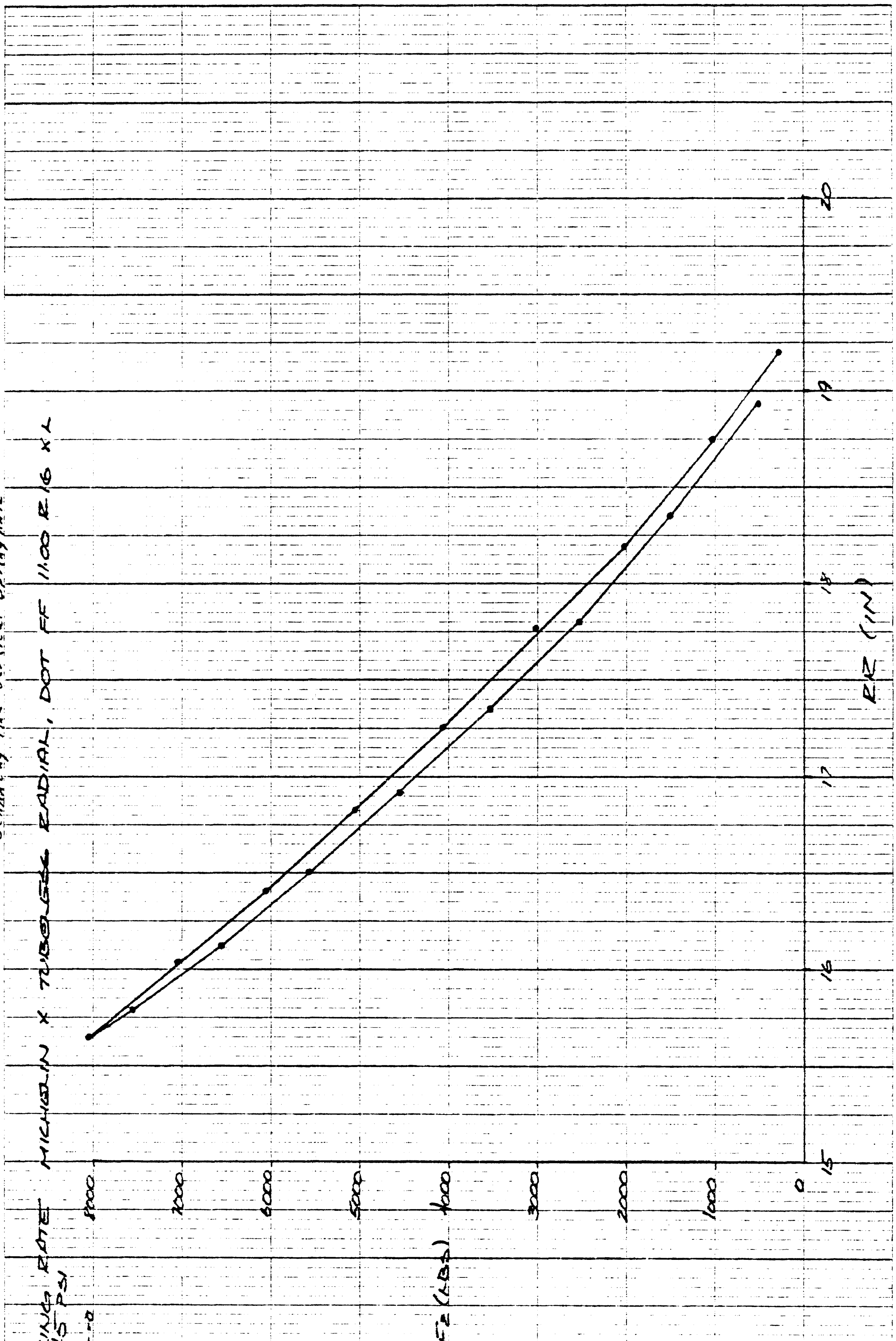

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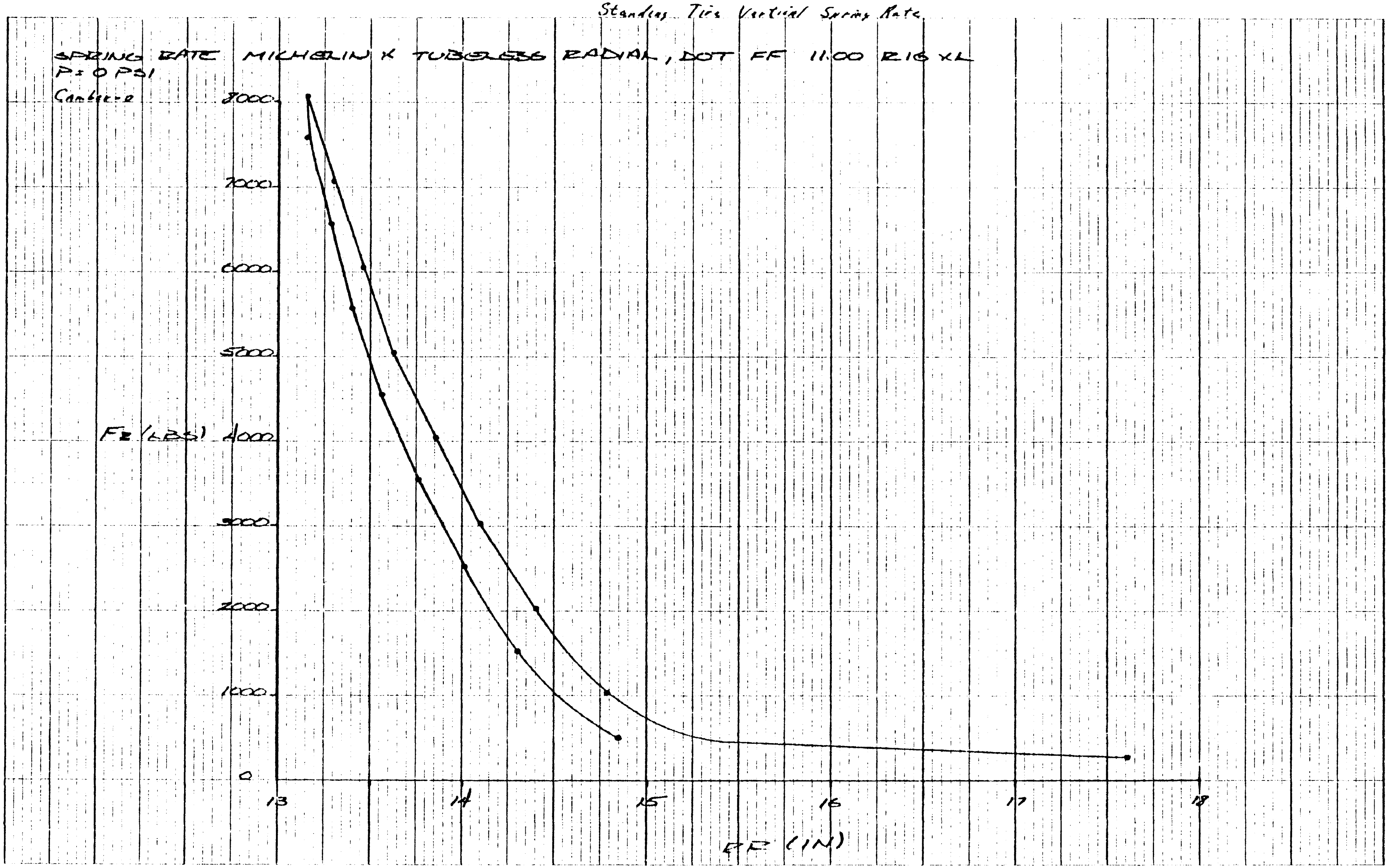

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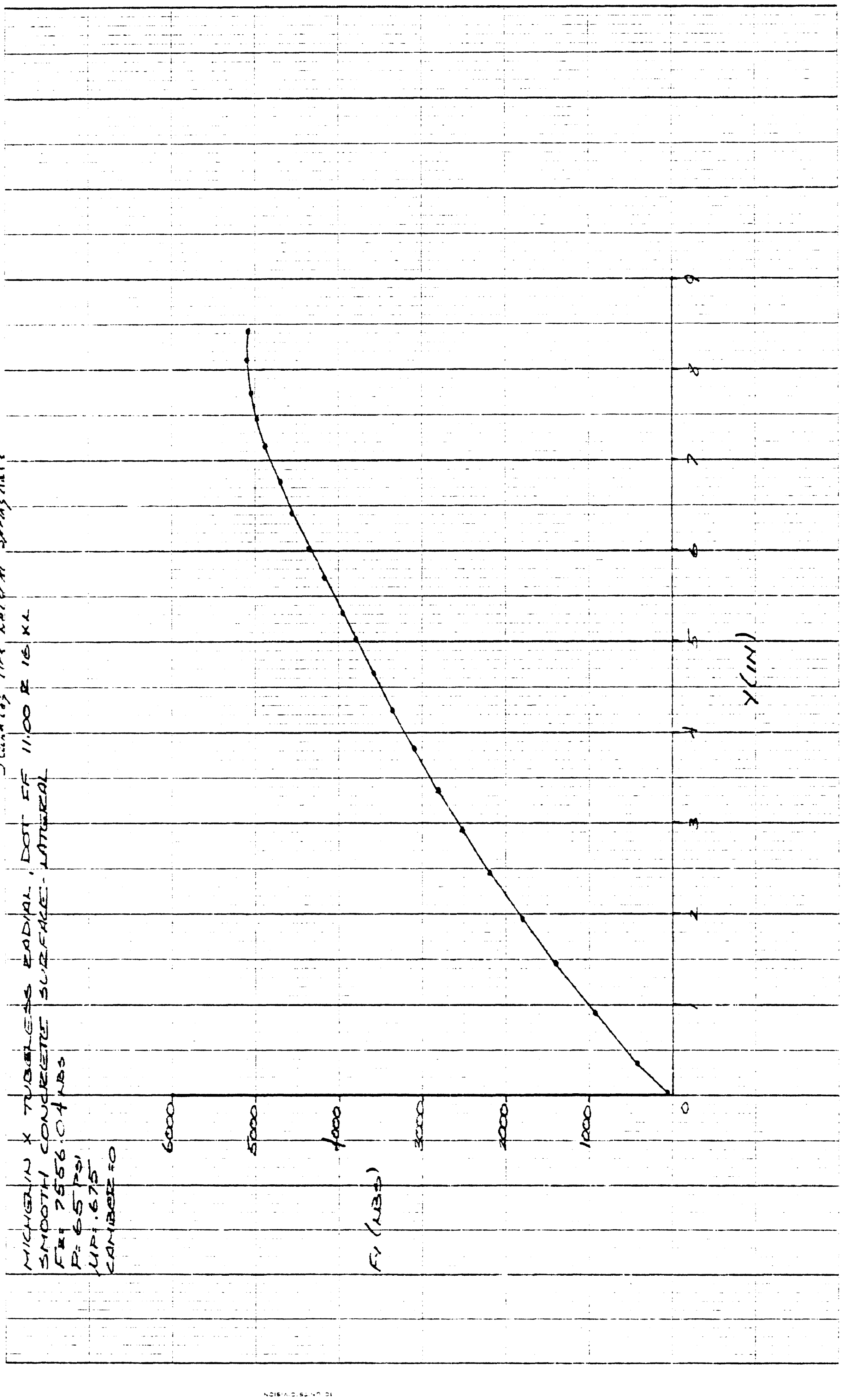
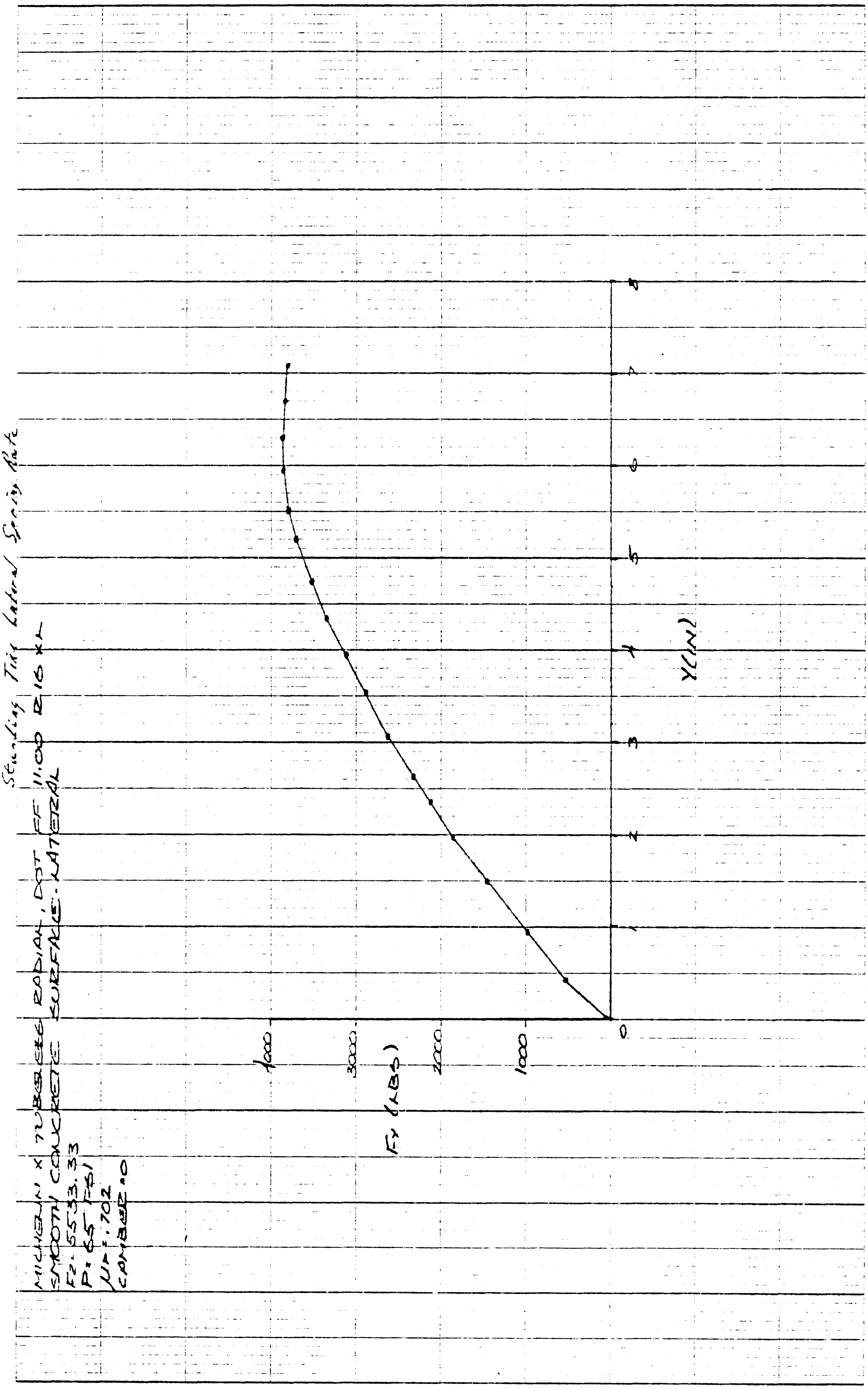

Standing Tire Lateral Spring Rate
MICHELIN X TUBELESS RADIAL, DOT FF 11.00 R 16 XL
SMOOTH CONCRETE SURFACE- LATERAL
Fz: 7556.04 LBS
P: 65 PSI
UP: .675
CAMBER = 0
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
Fy (LBS)
Y (IN)



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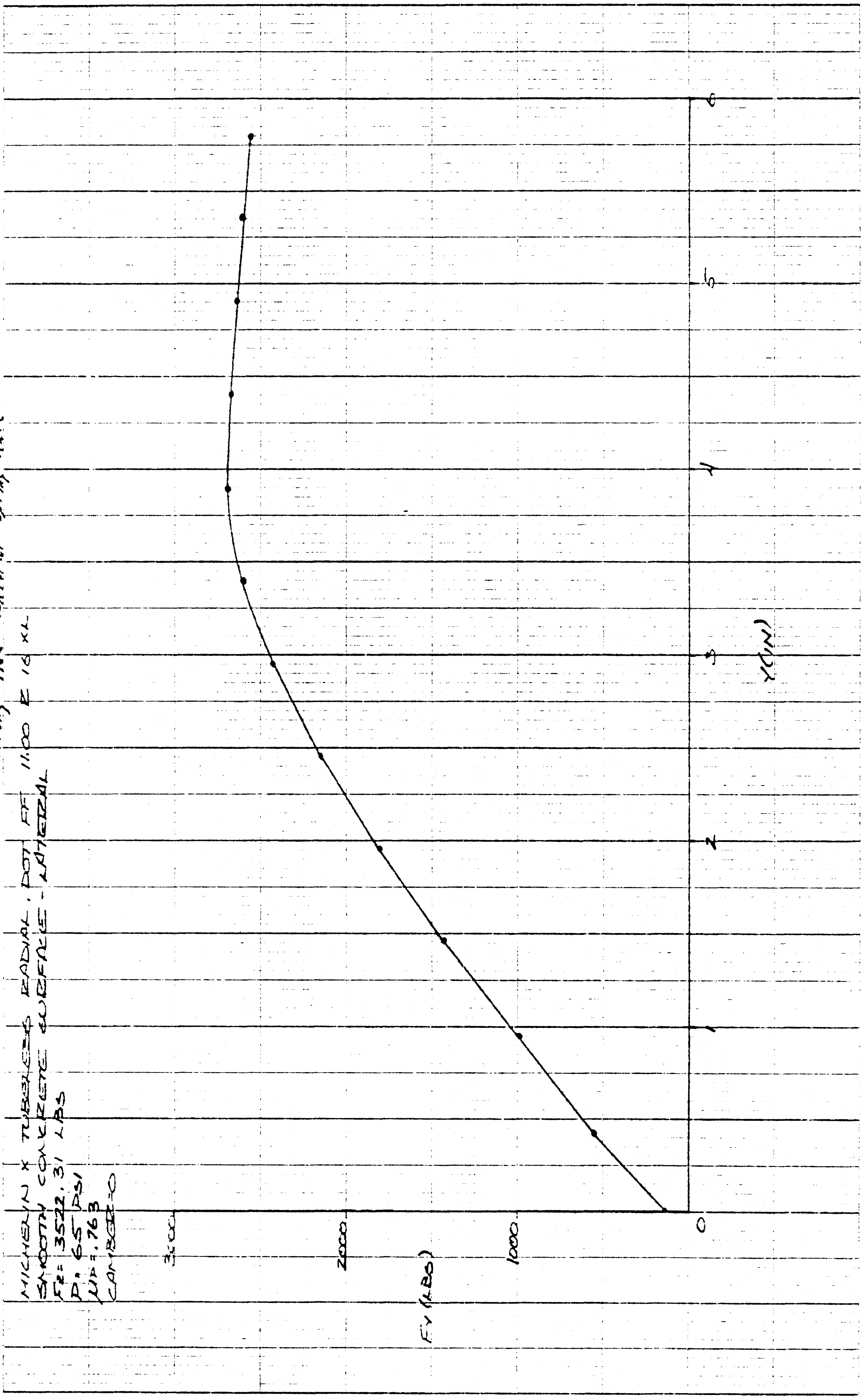

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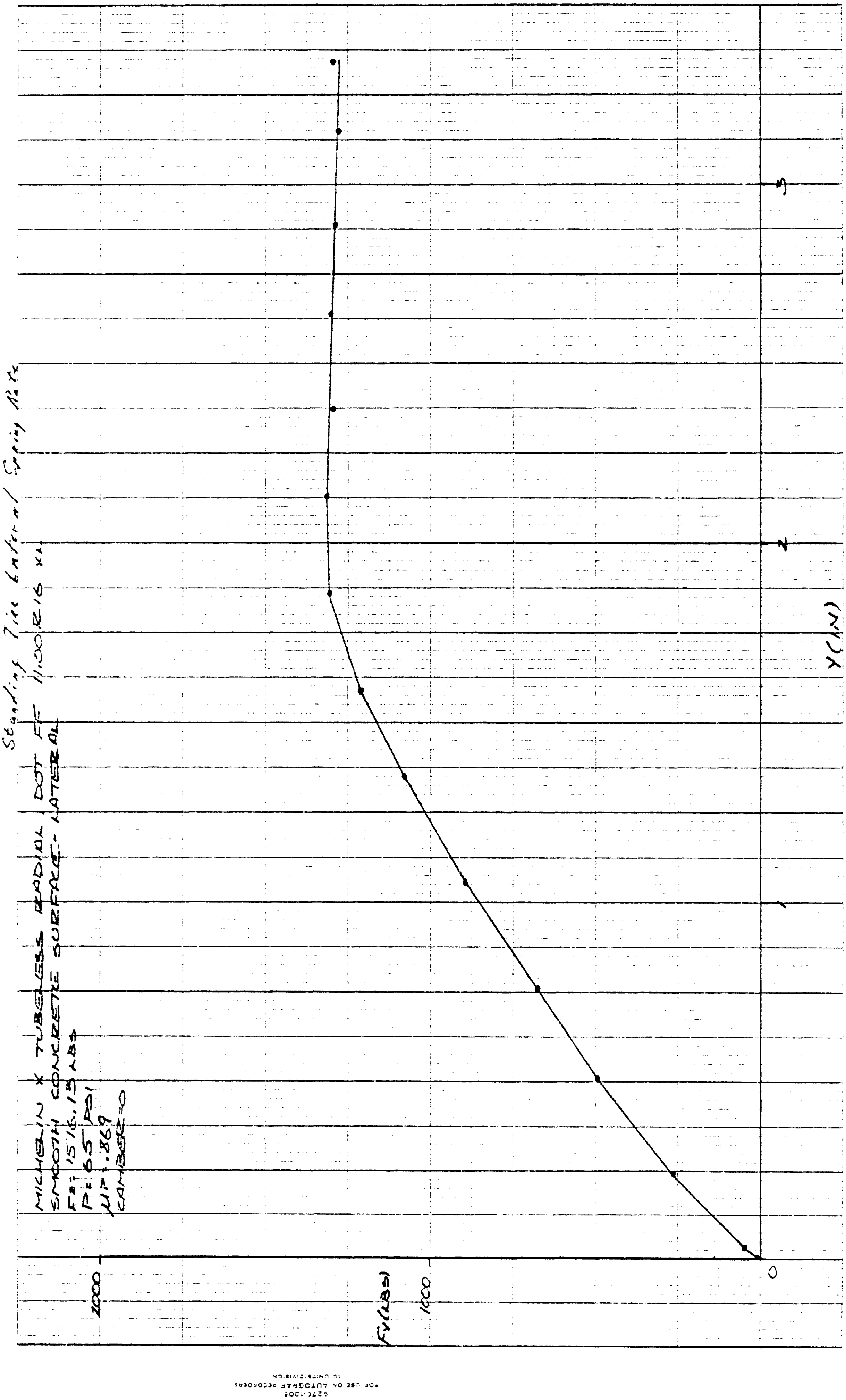

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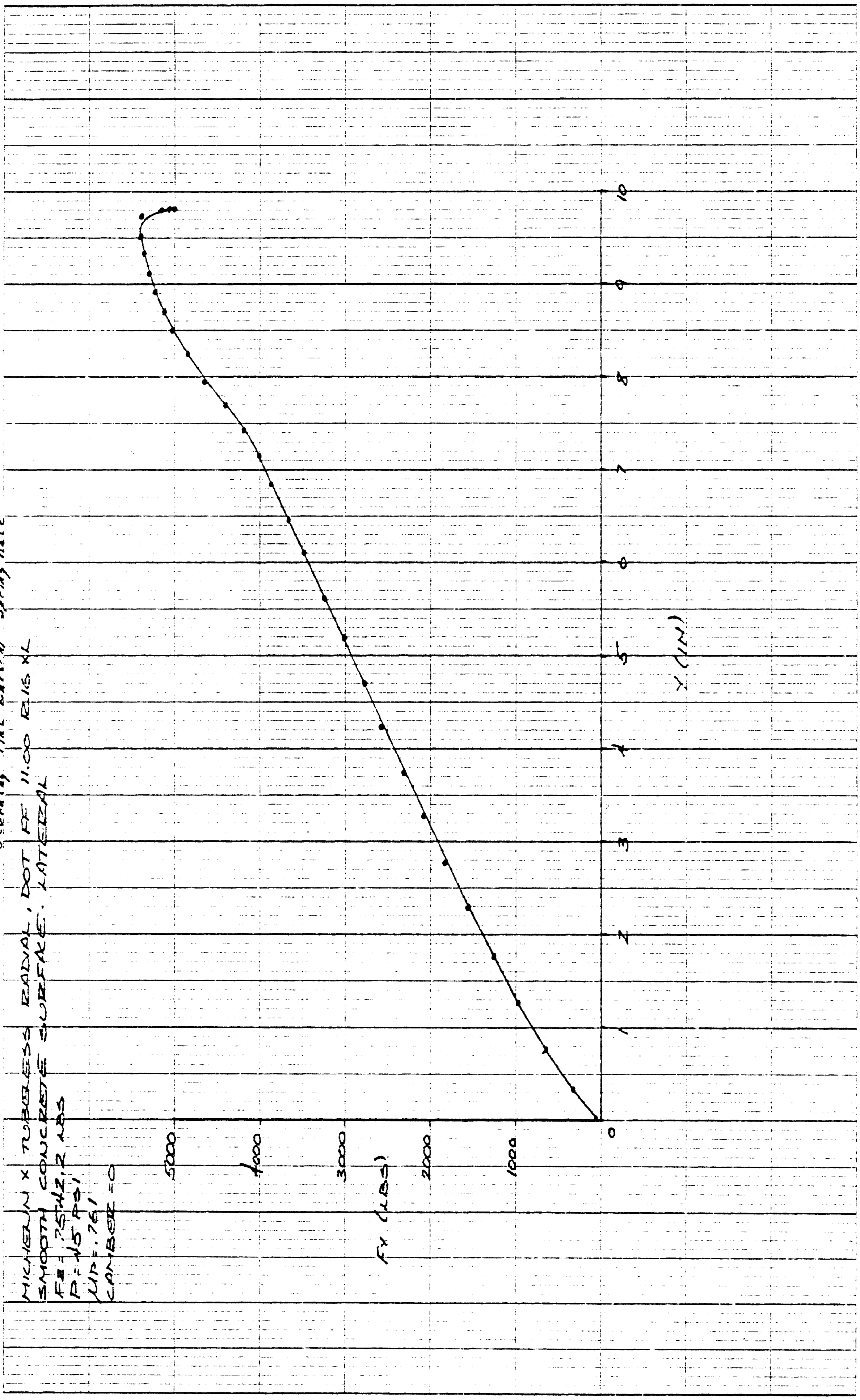

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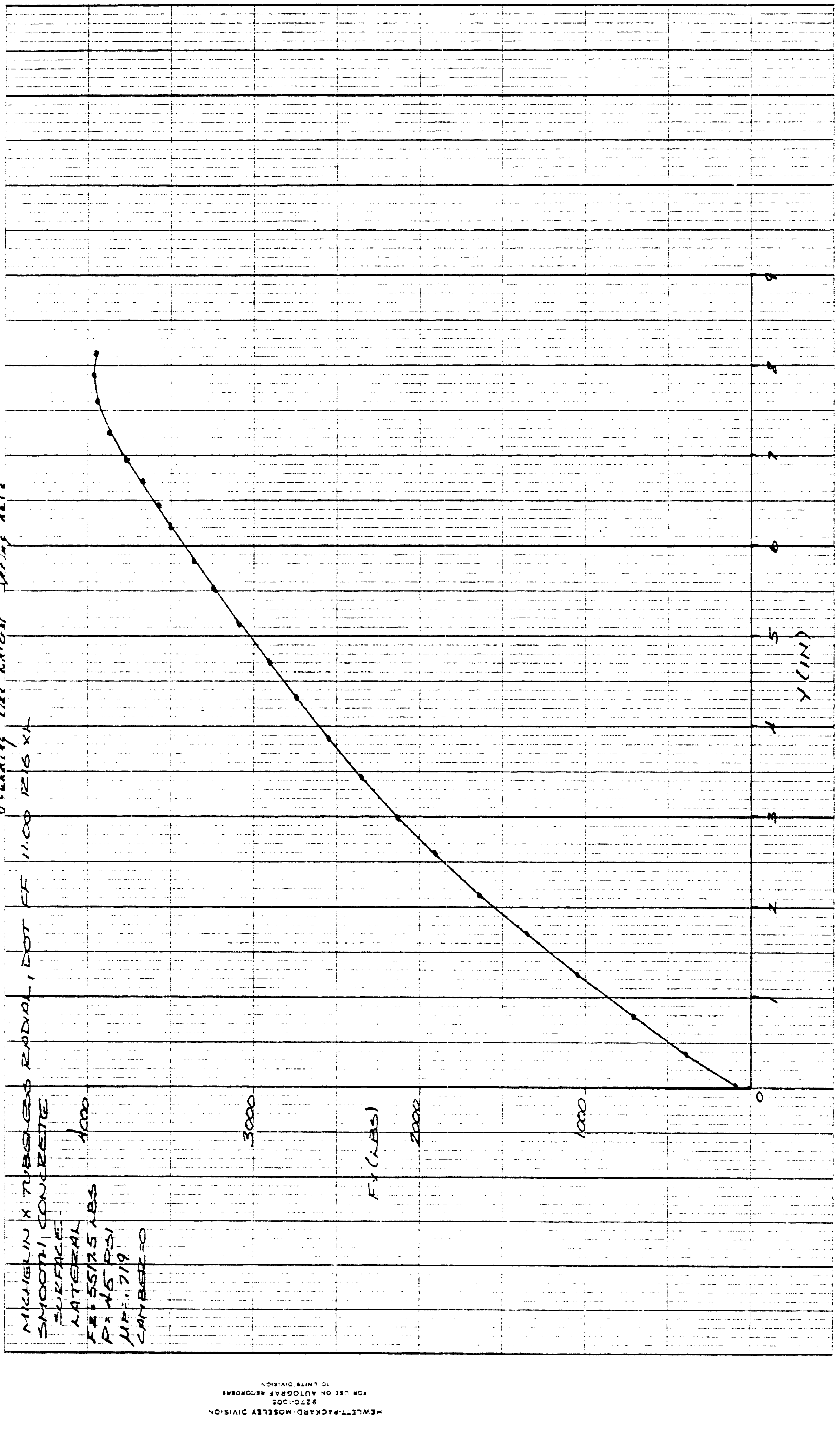

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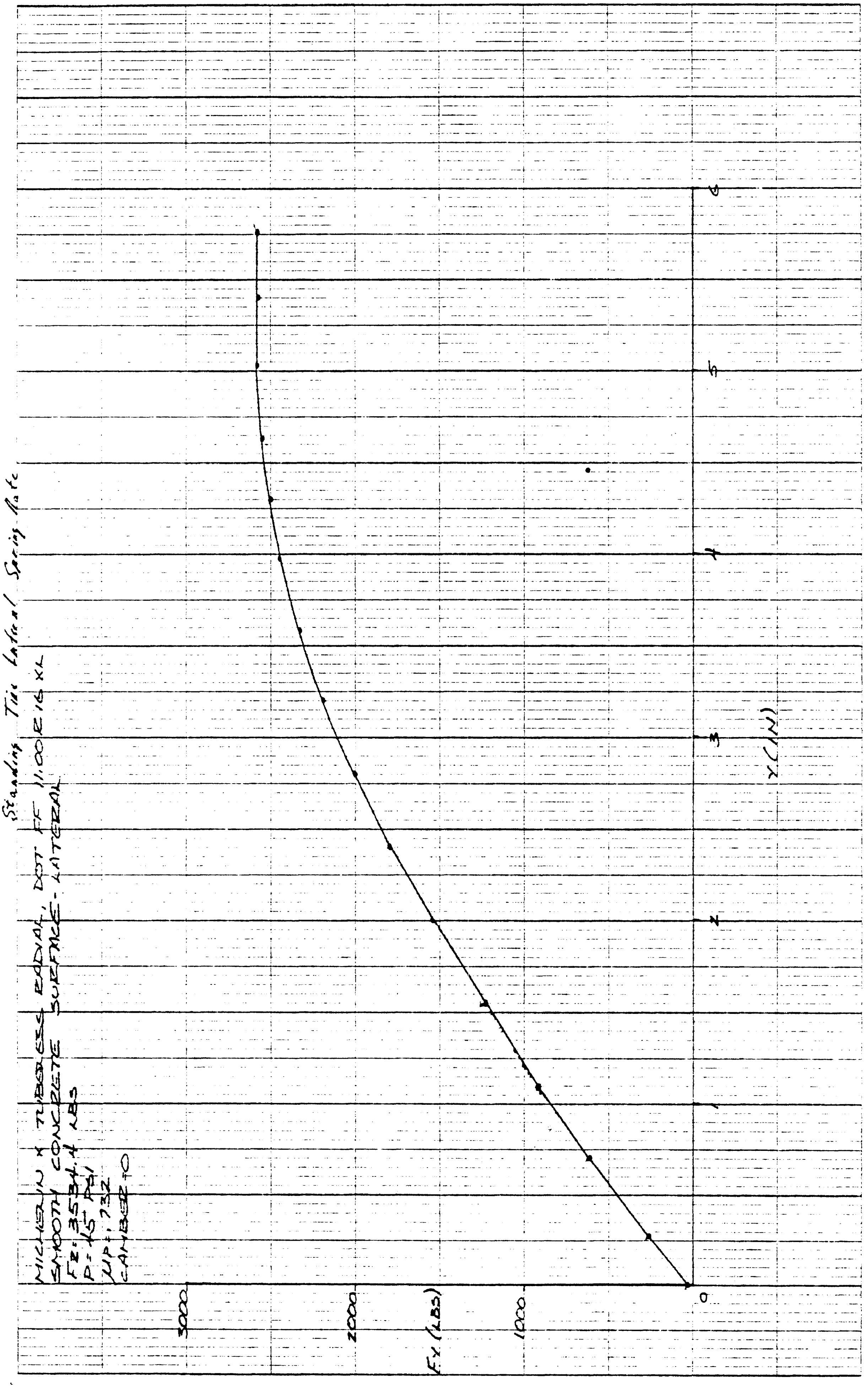

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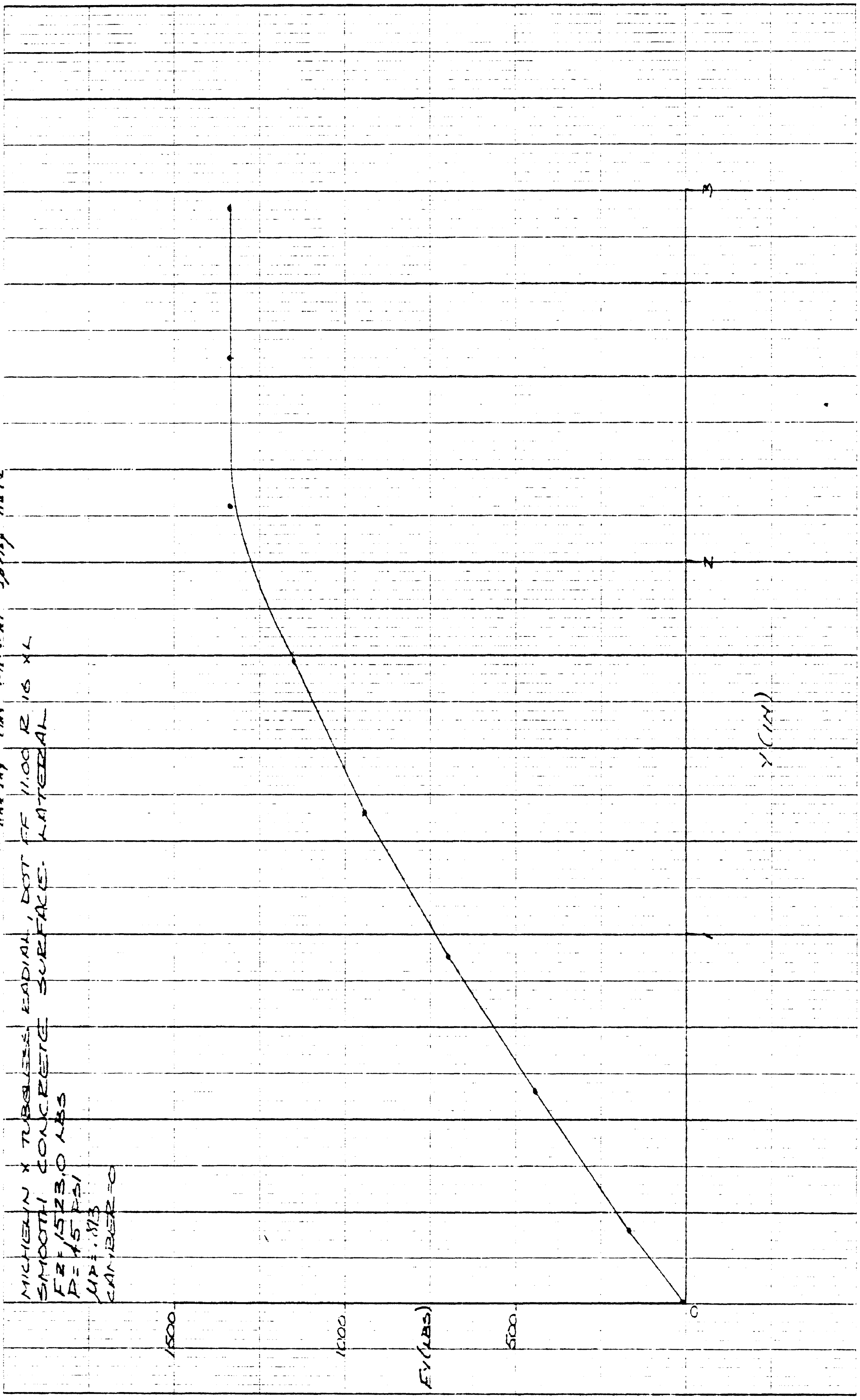

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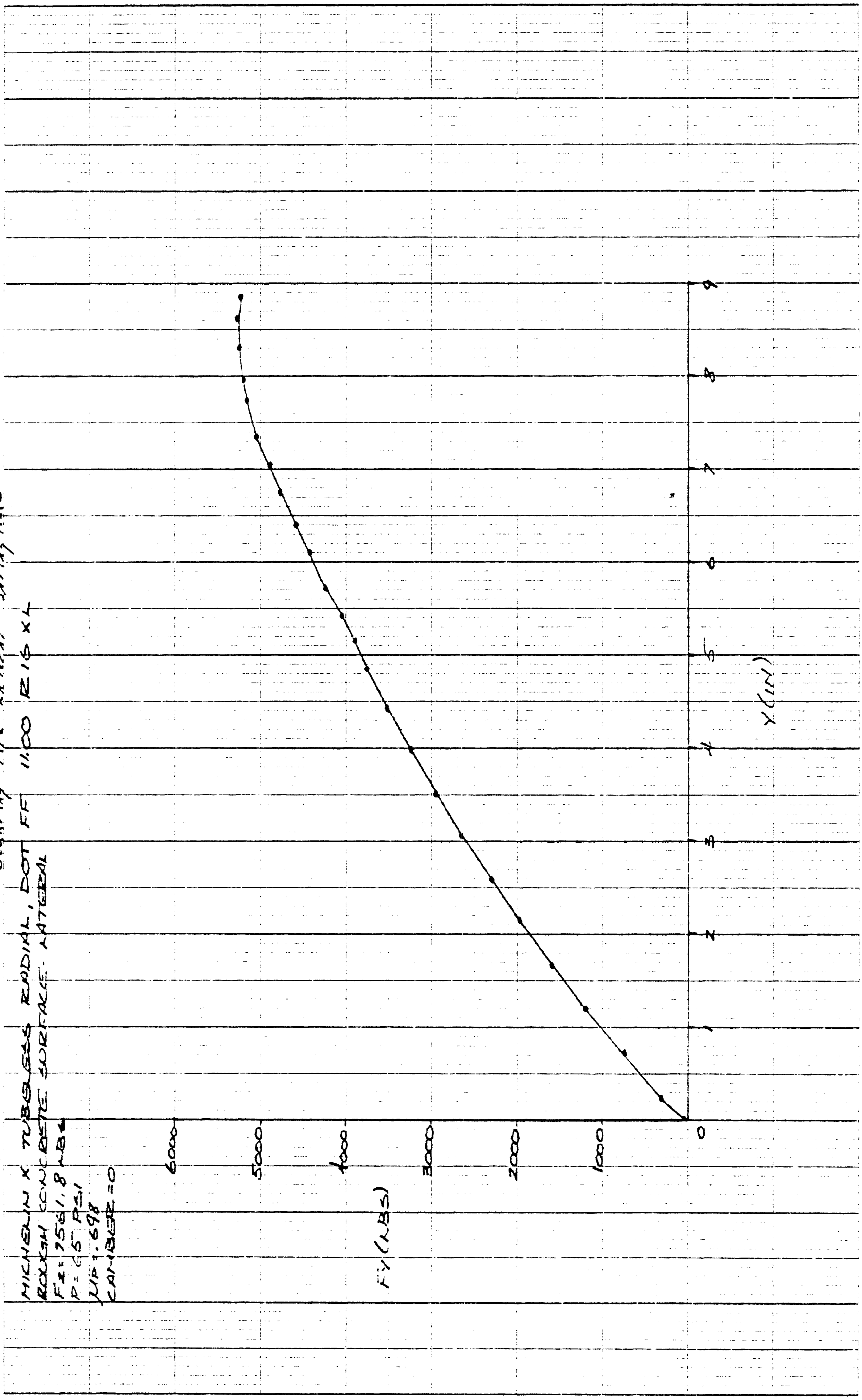

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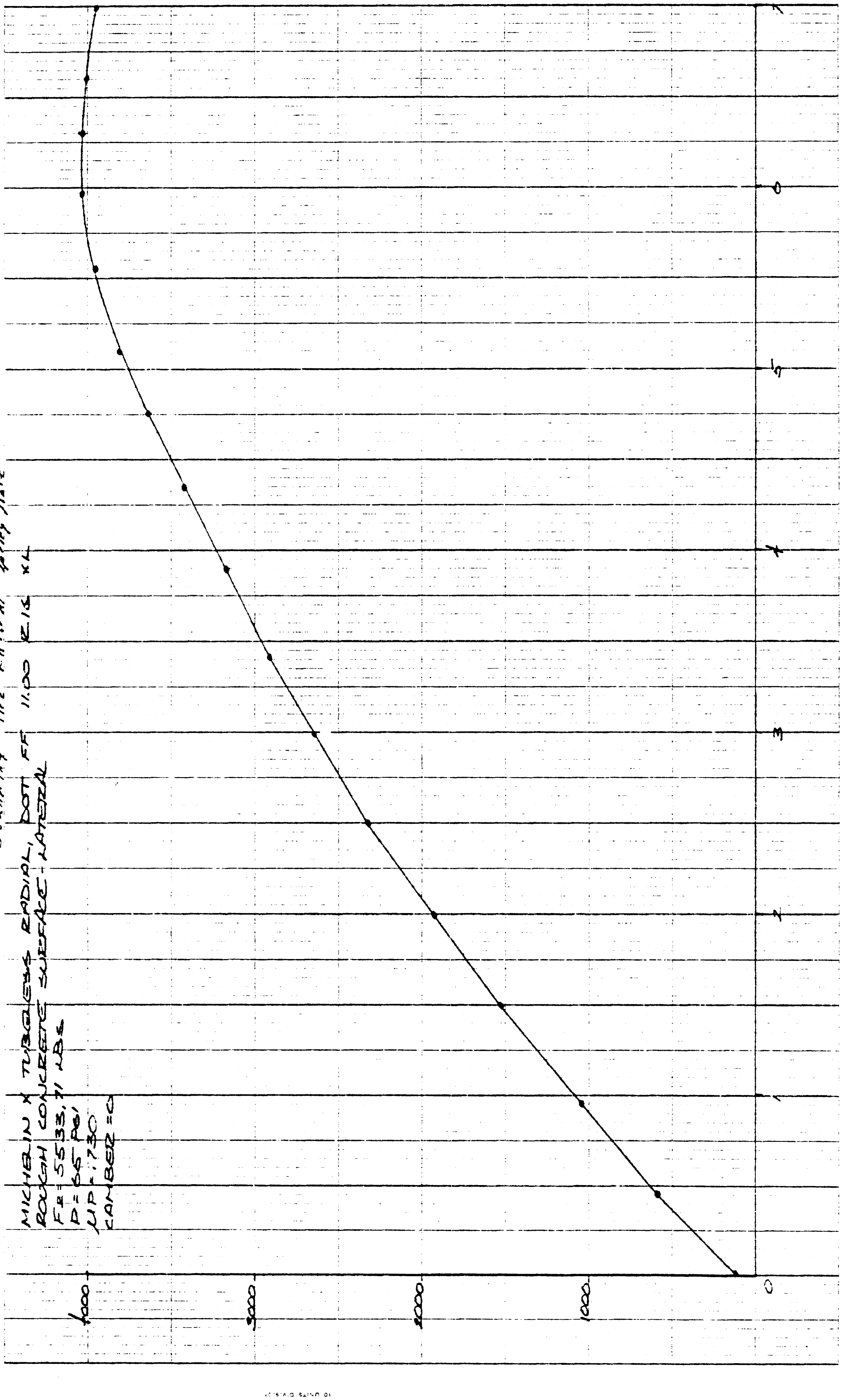
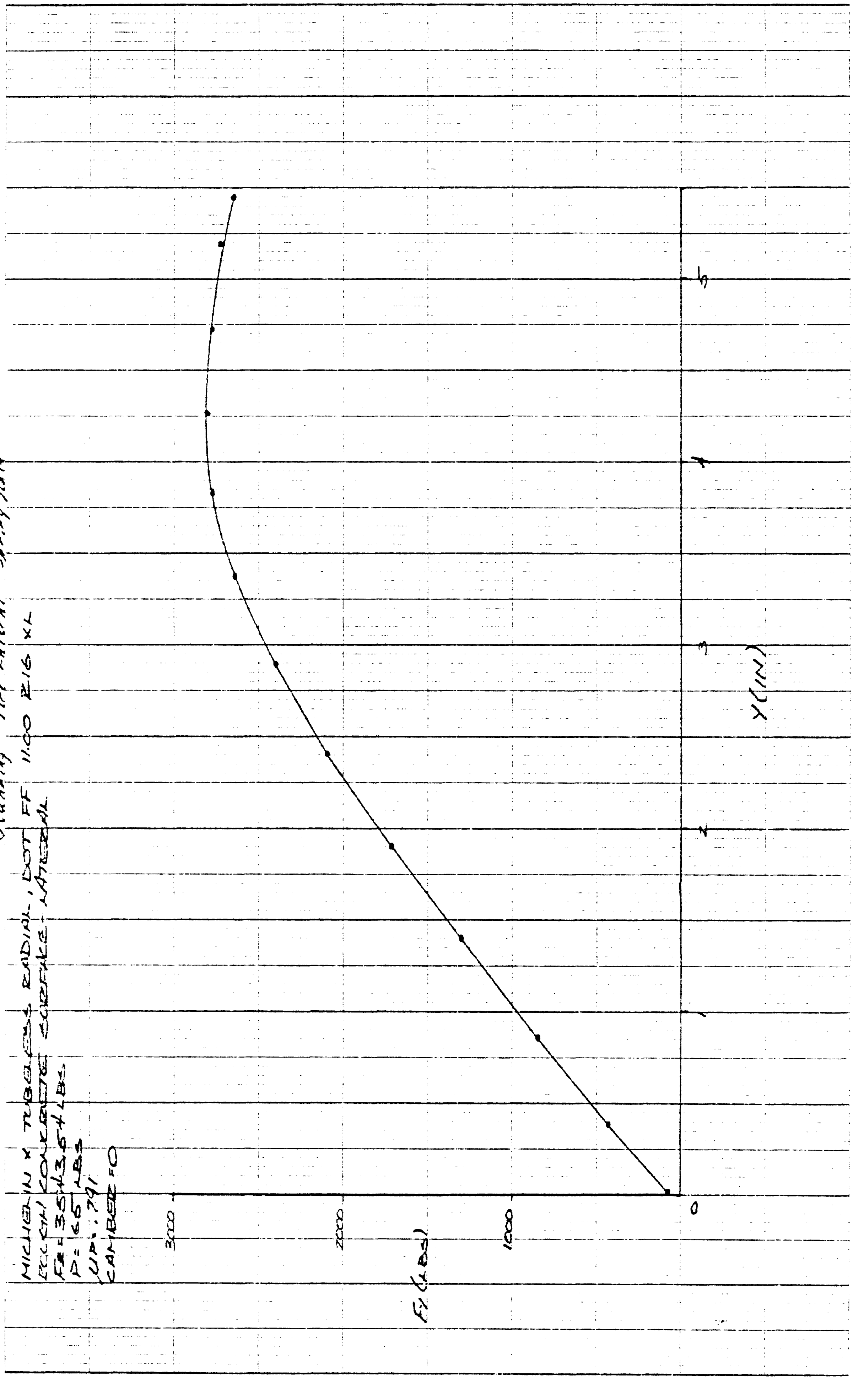
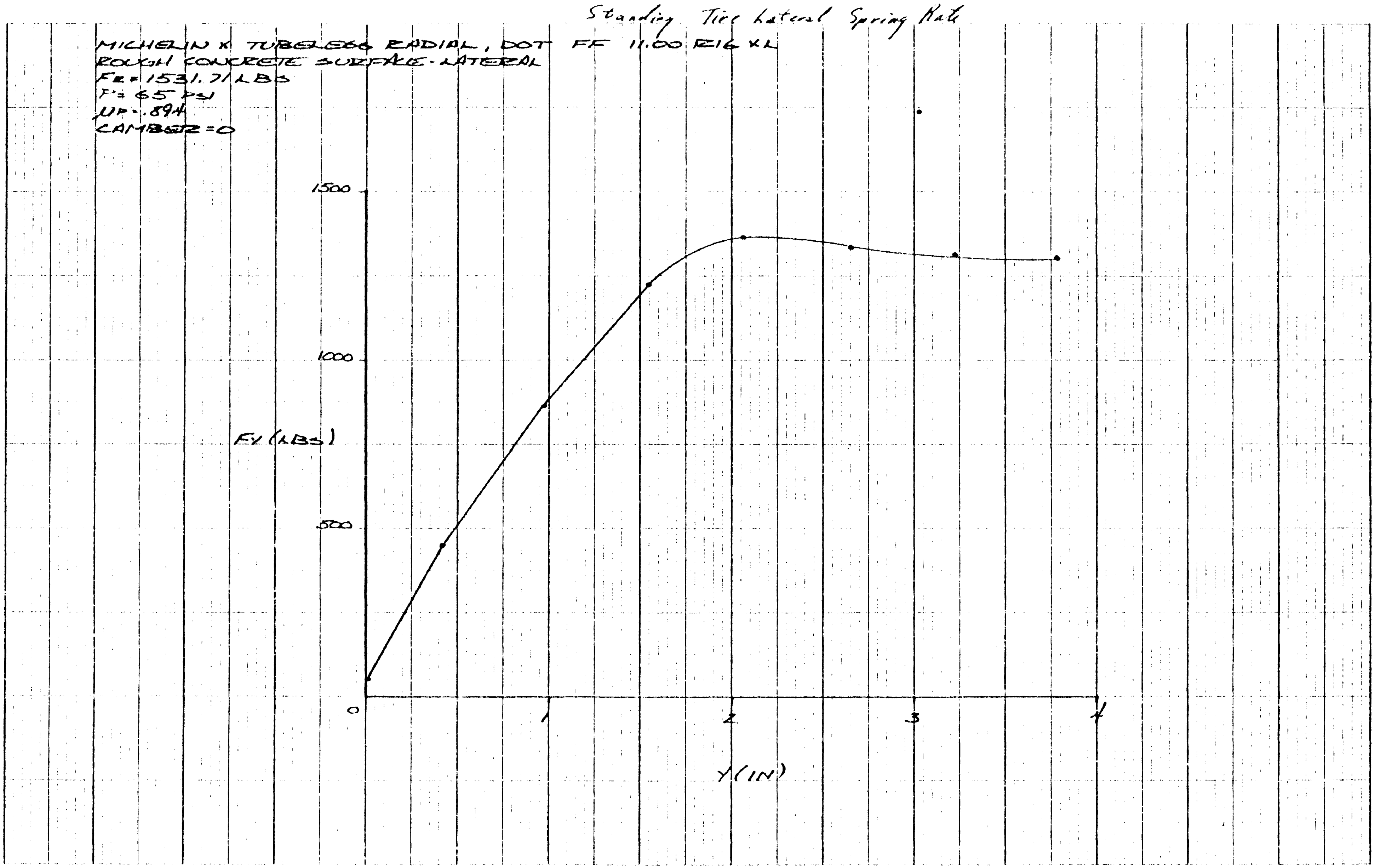

Standing Tire Lateral Spring Rate
MICHELIN X TUBELESS RADIAL, DOT FF 11.00 R 15 XL
ROUGH CONCRETE SURFACE-LATERAL
FZ=5533.71 LBS
P=65 PSI
μP=.730
CAMBER=0
4000
3000
2000
1000
0
1
2
3
4
5
6
7



Standing Tire Lateral Spring Rate
MICHELIN X TUBELESS RADIAL, DOT FF 11.00 R16 XL
CONCRETE SURFACE - LATERAL
P = 65 LBS
CAMBER = 0
3000
2000
1000
0
Fy (LBS)
Y (IN)



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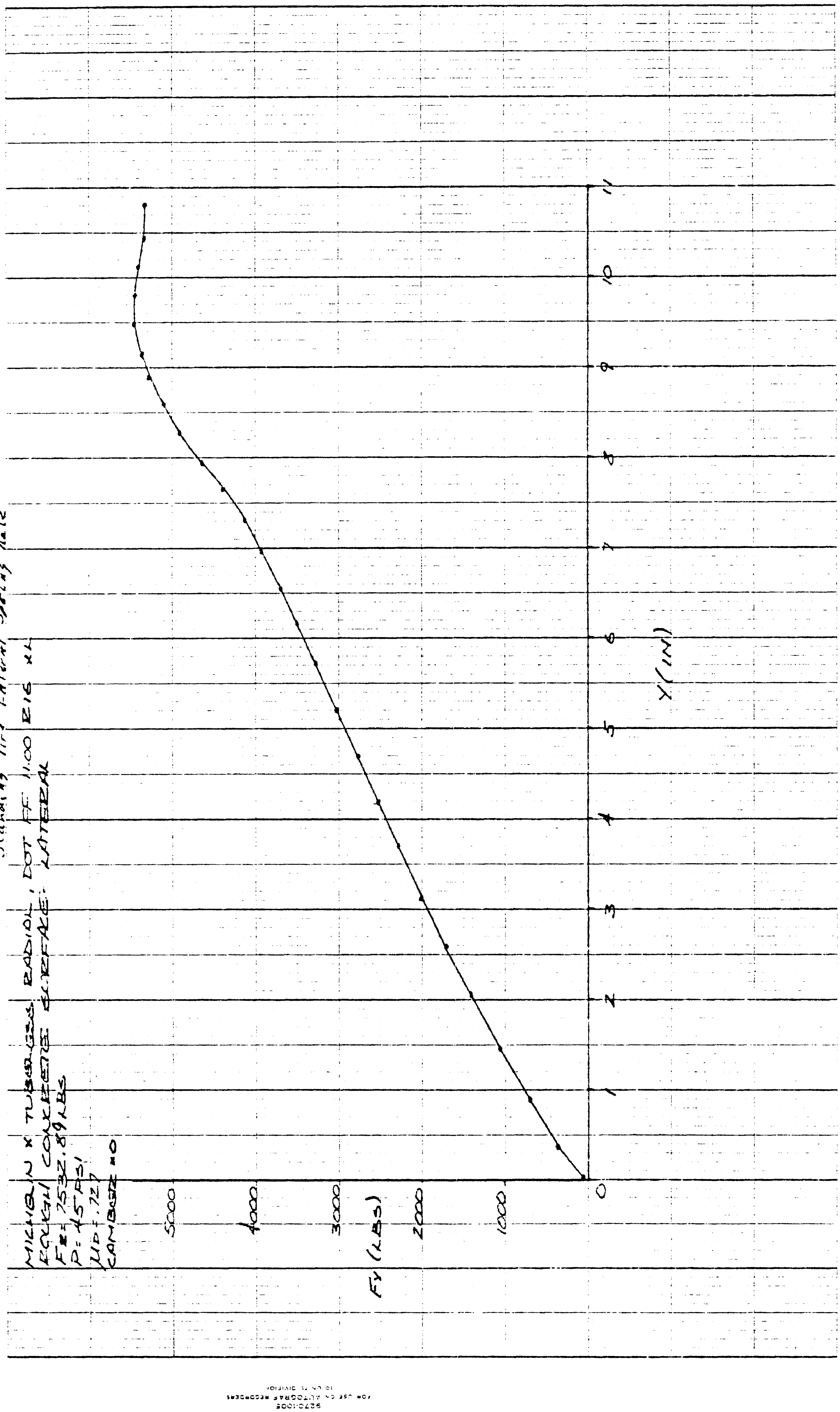

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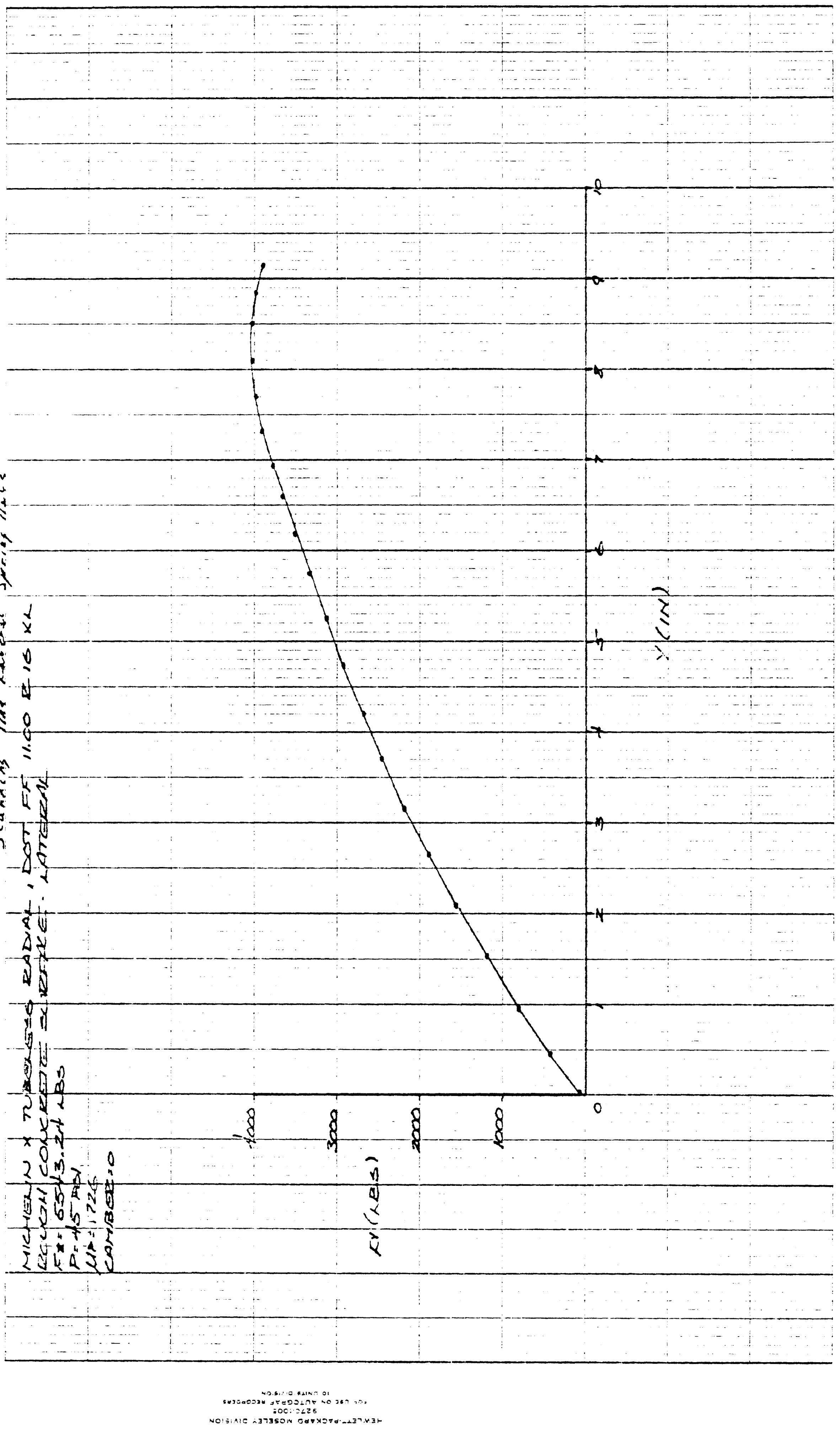
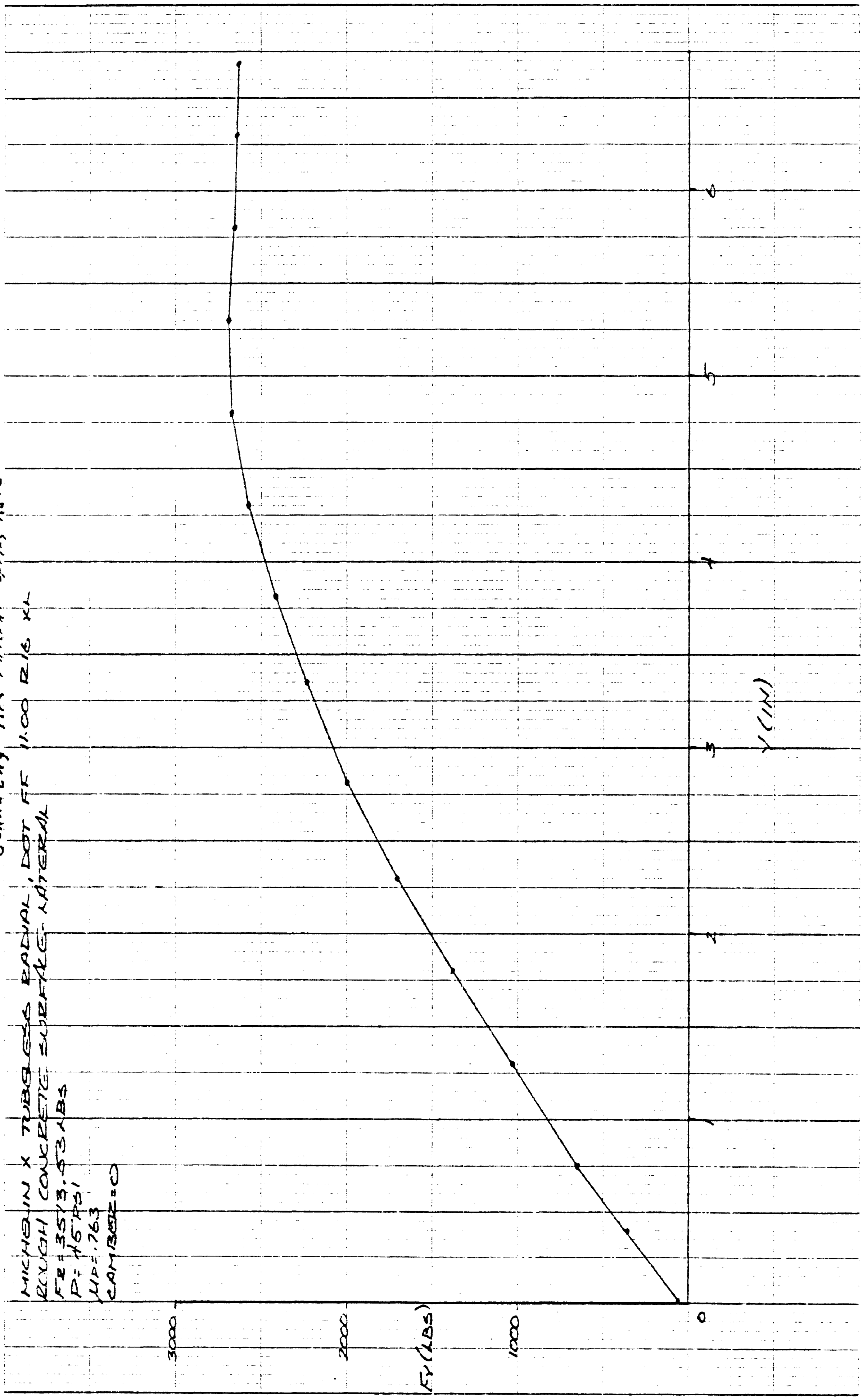

Standing Tire Lateral Spring Rate
MICHELIN X TUBELESS RADIAL, DOT FF 11.00 R 16 XL
ROUGH CONCRETE SURFACE: LATERAL
P=45 PSI
CAMBER=0
FY (LBS)
Y (IN)
0
1000
2000
3000
4000
HEWLETT-PACKARD MOSELEY DIVISION



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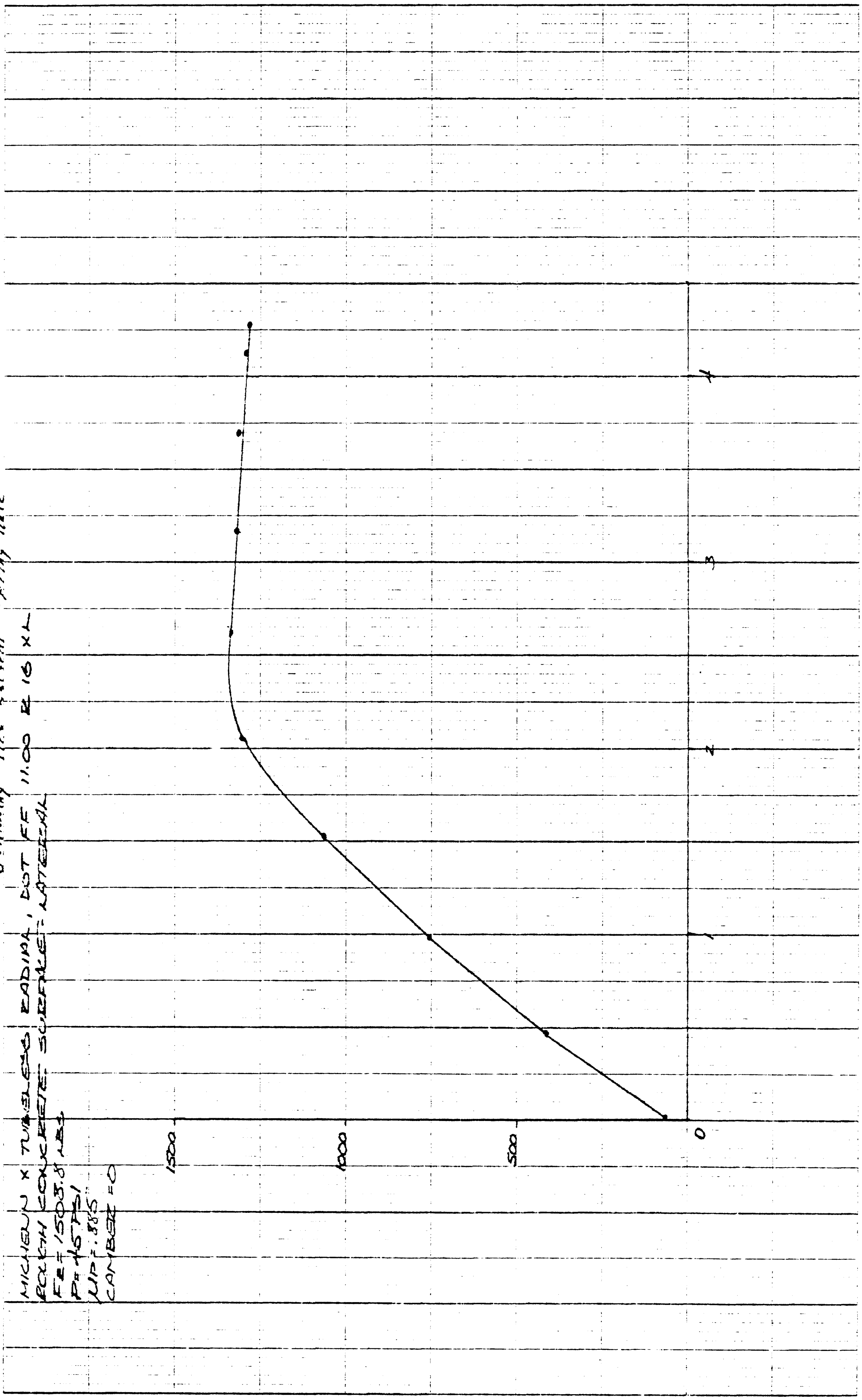
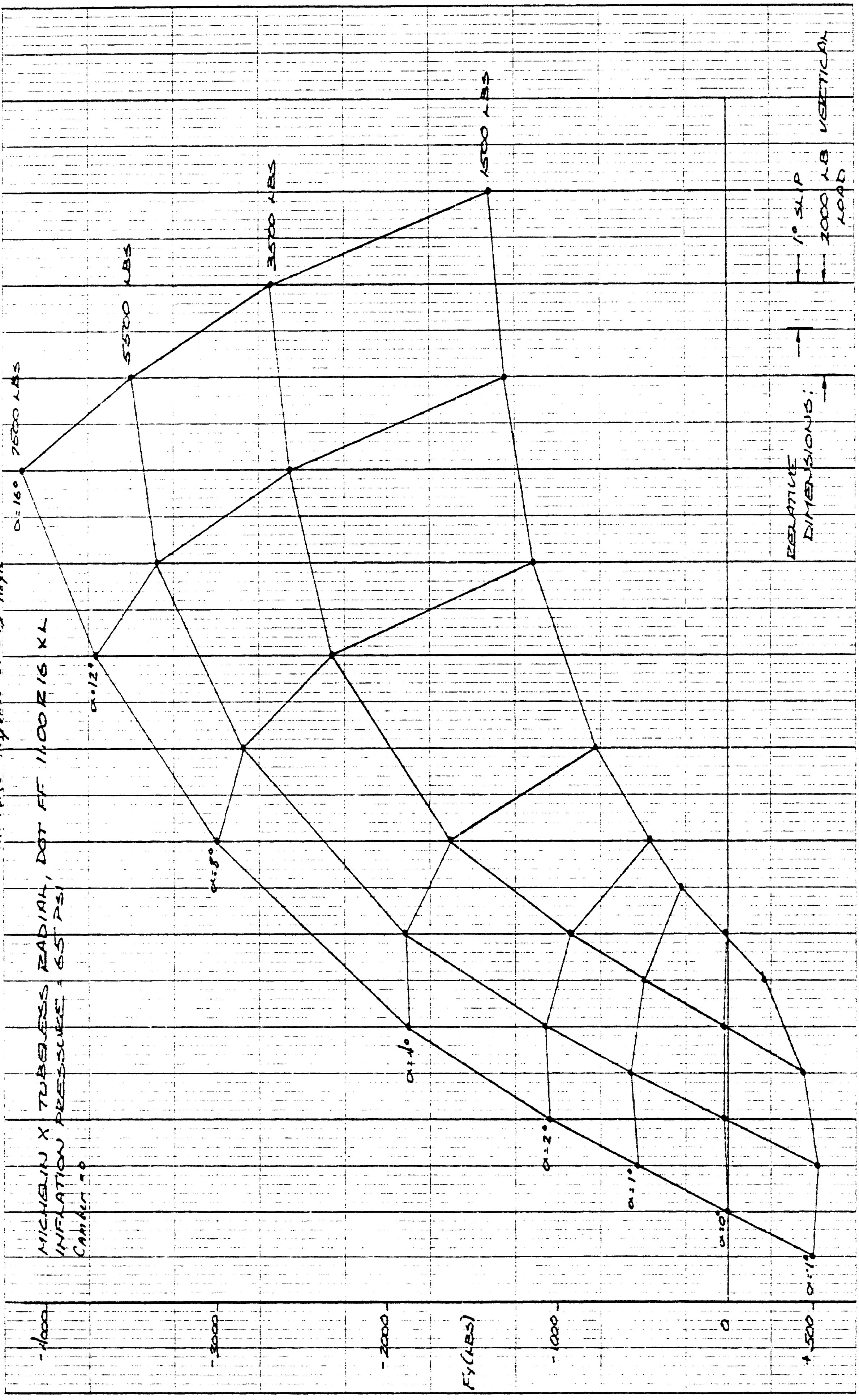

Standing Tire Lateral Spring Rate
MICHELIN X TUBELESS RADIAL, DOT FF 11.00 R 16 XL
ROUGH CONCRETE: SURFACE: LATERAL
FZ=1503.8 LBS
P=45 PSI
UP=.885"
CAMBER=0
1500
1000
500
0
1
2
3
4



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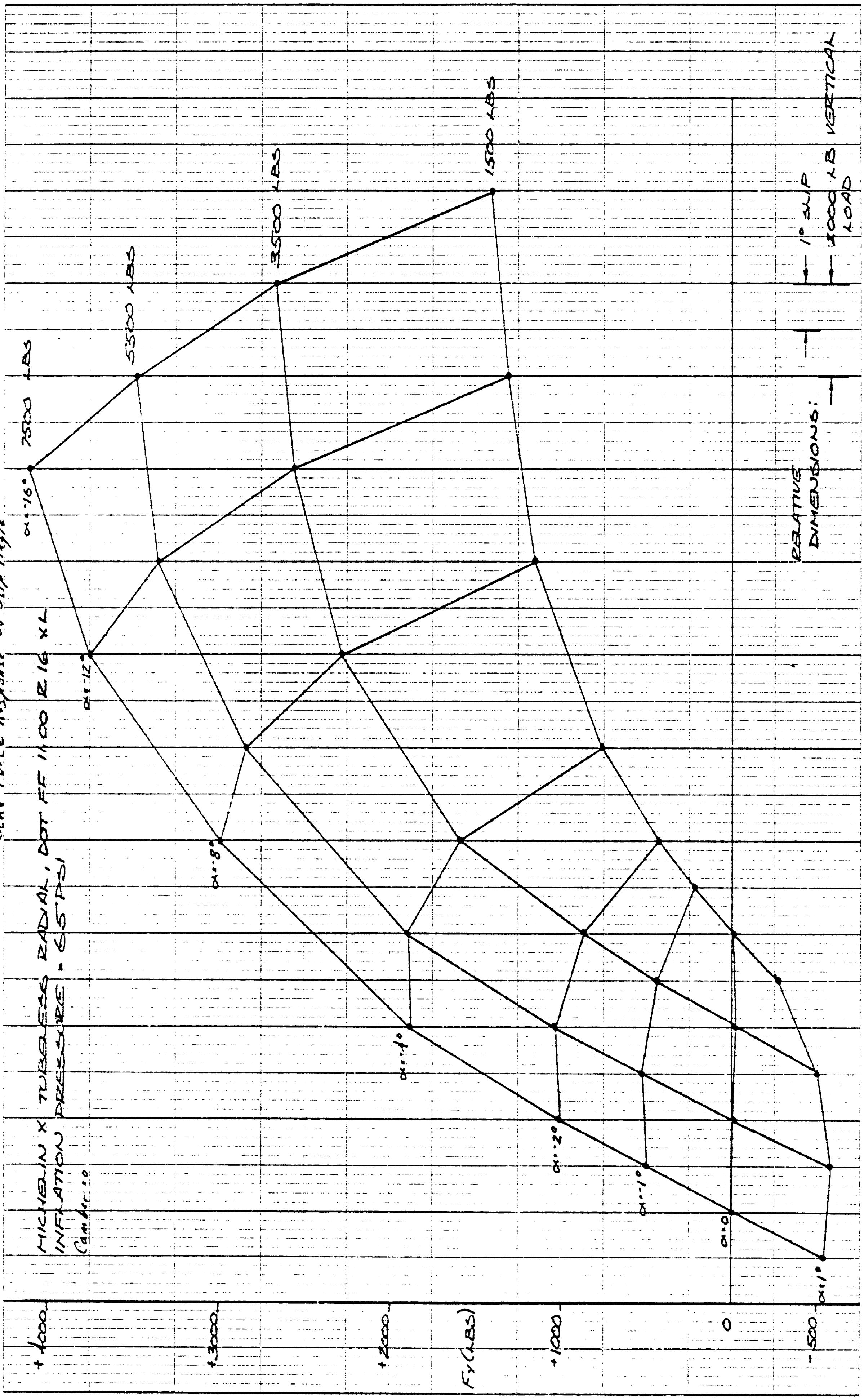

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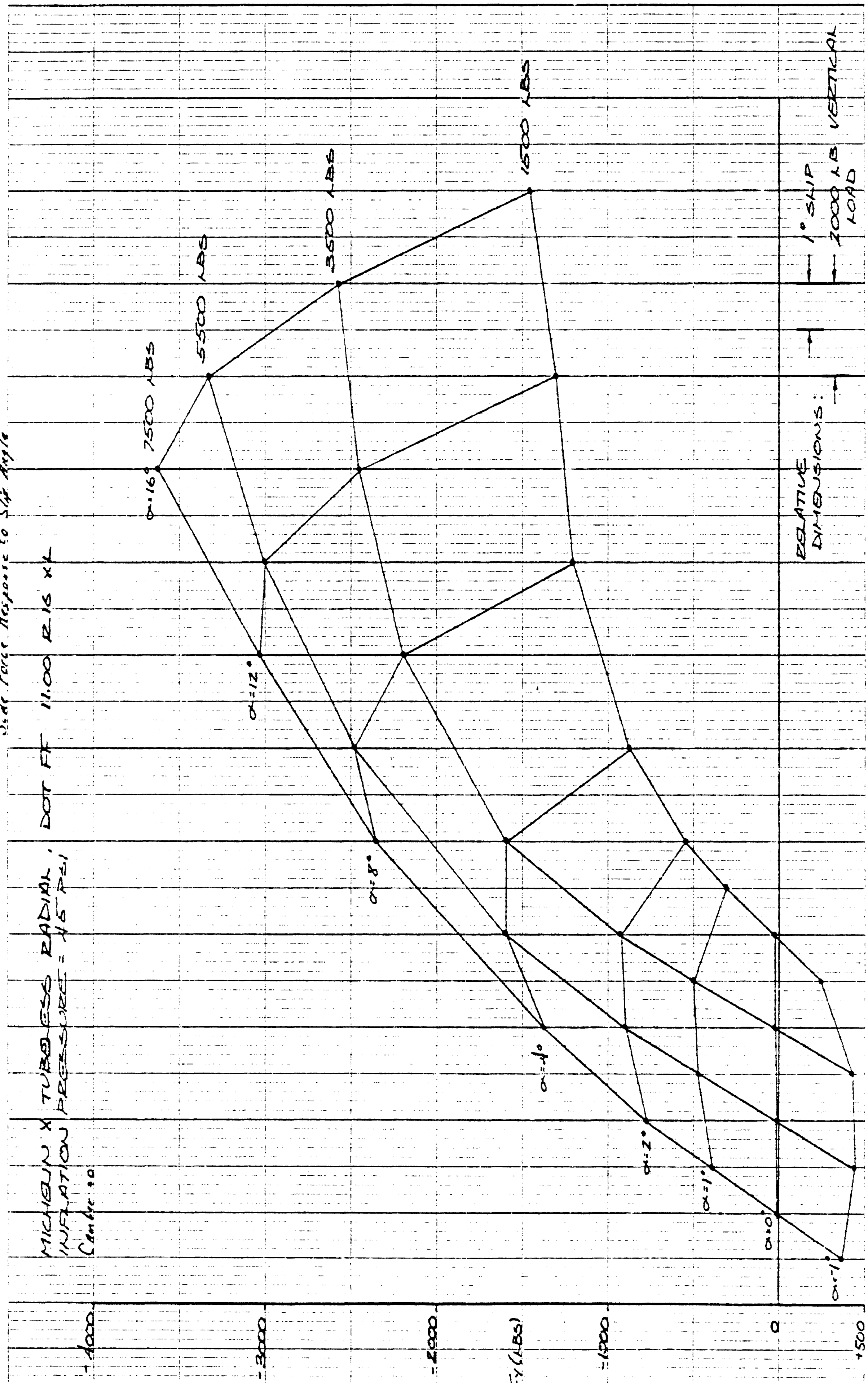

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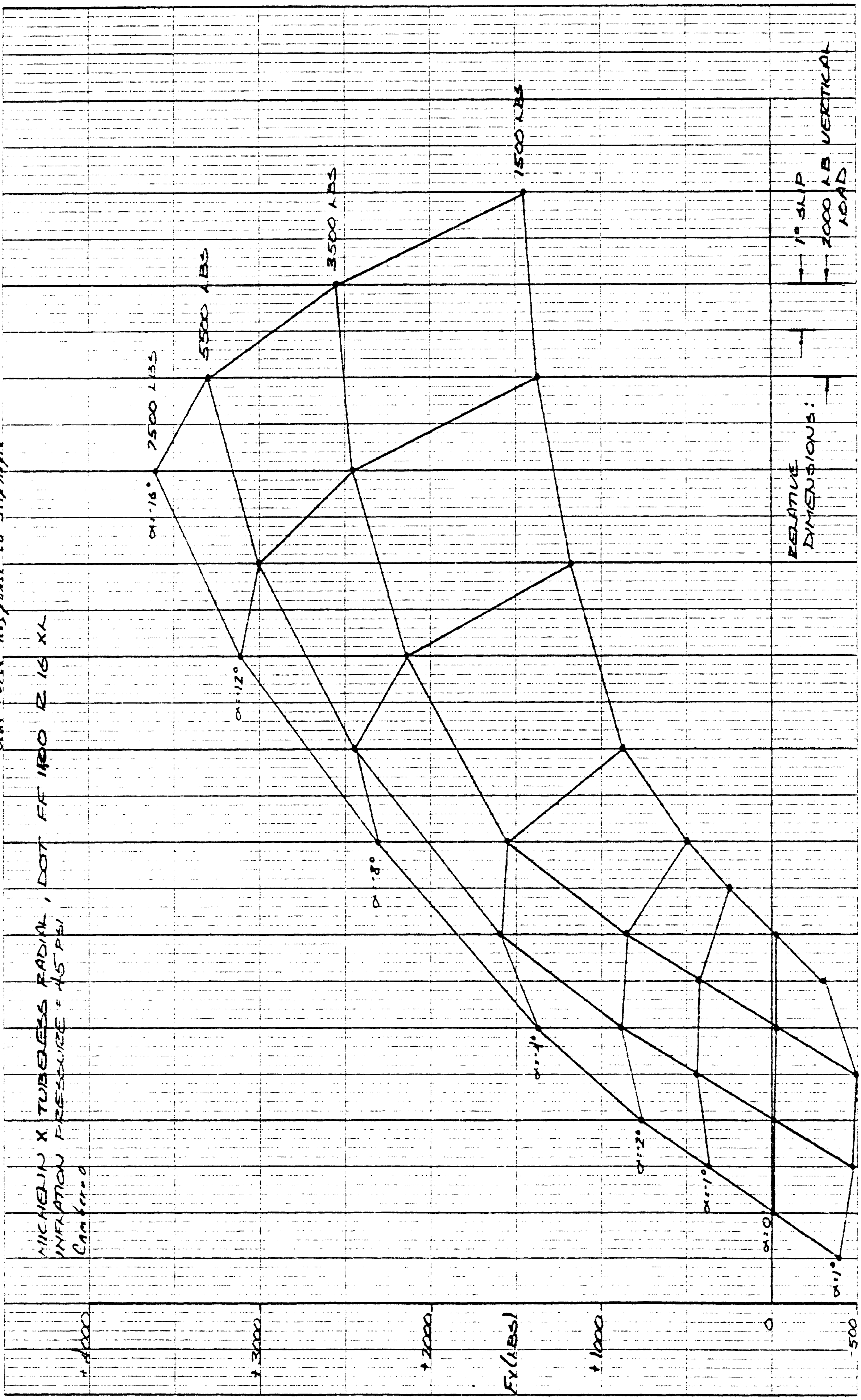

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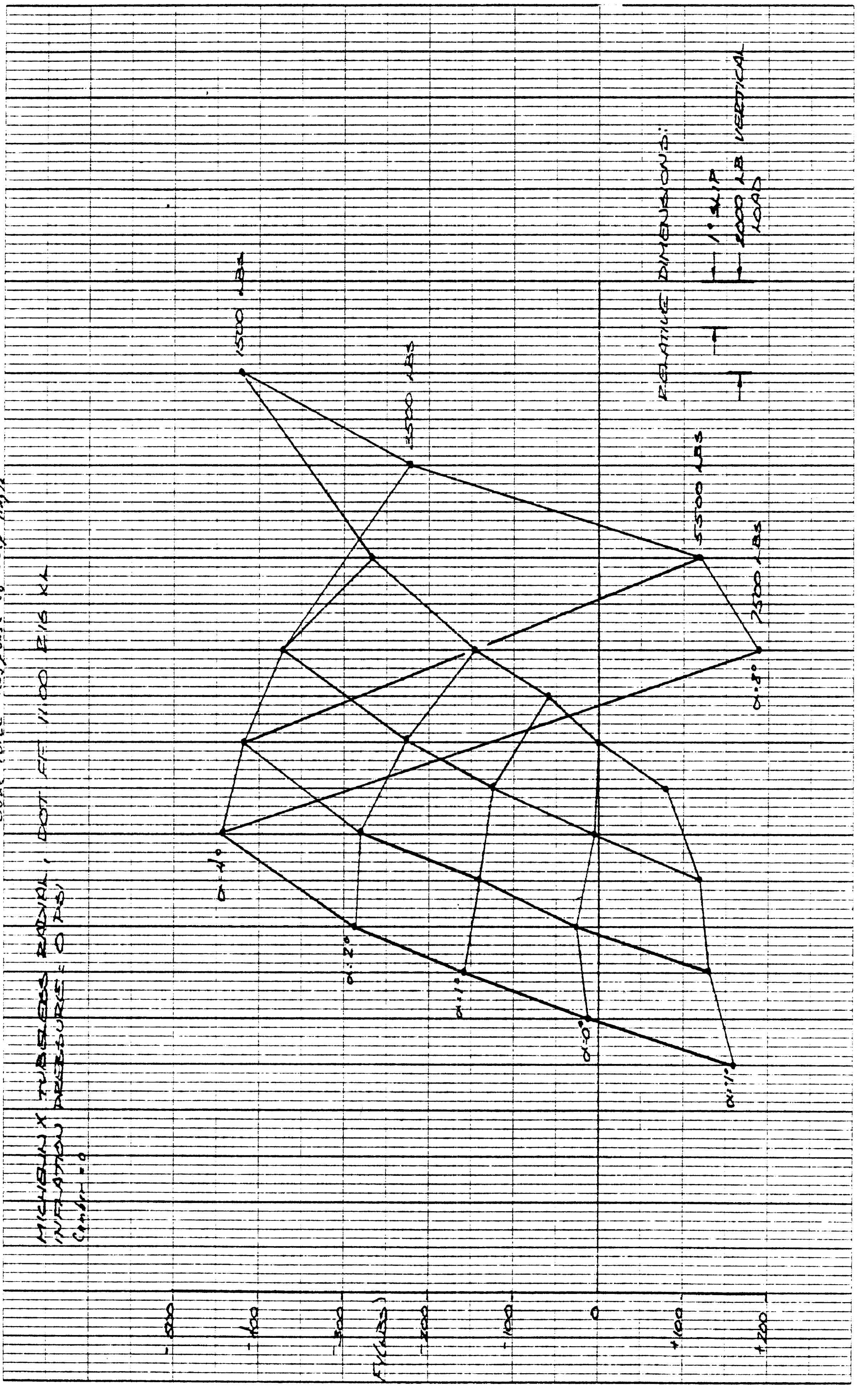

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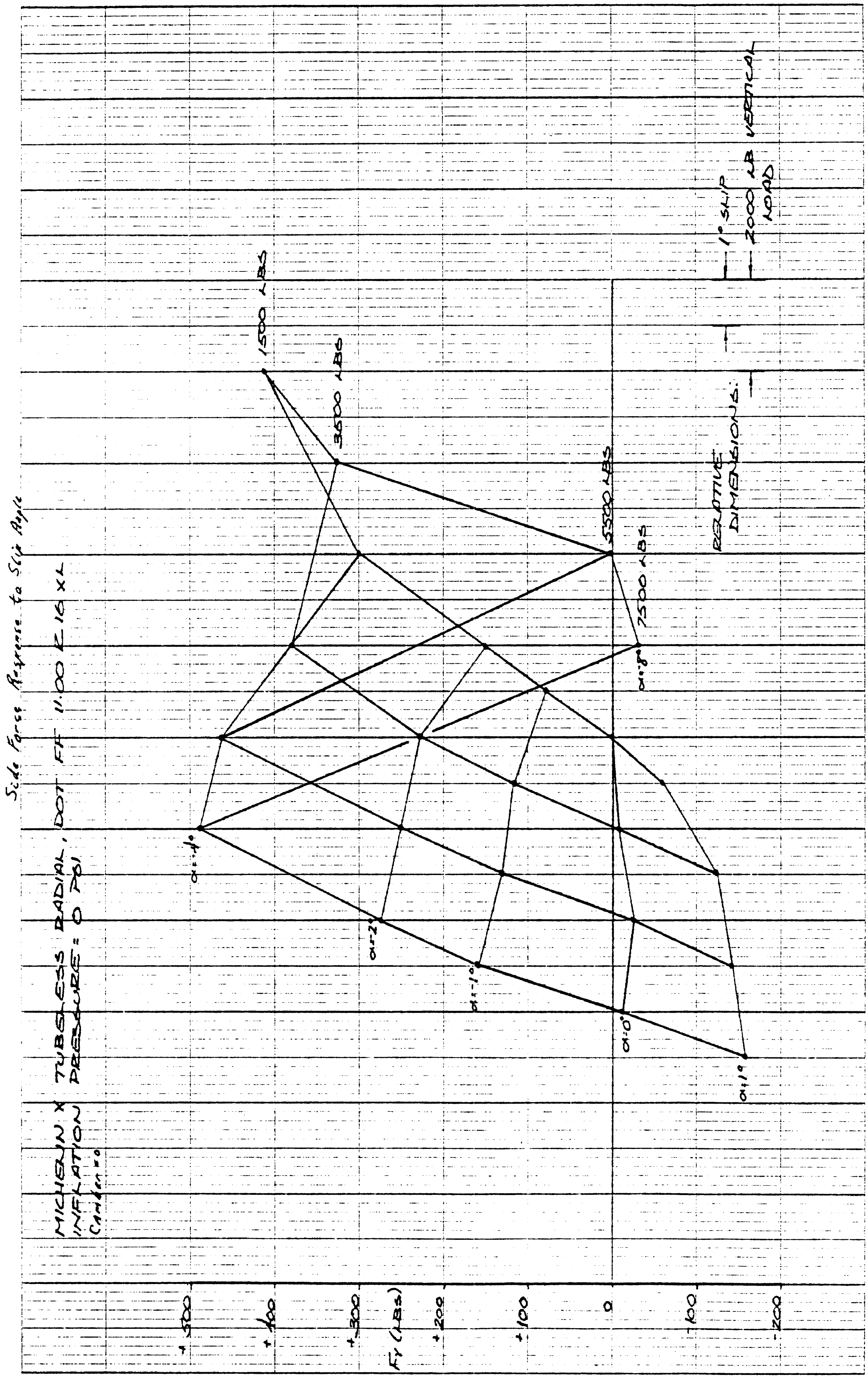

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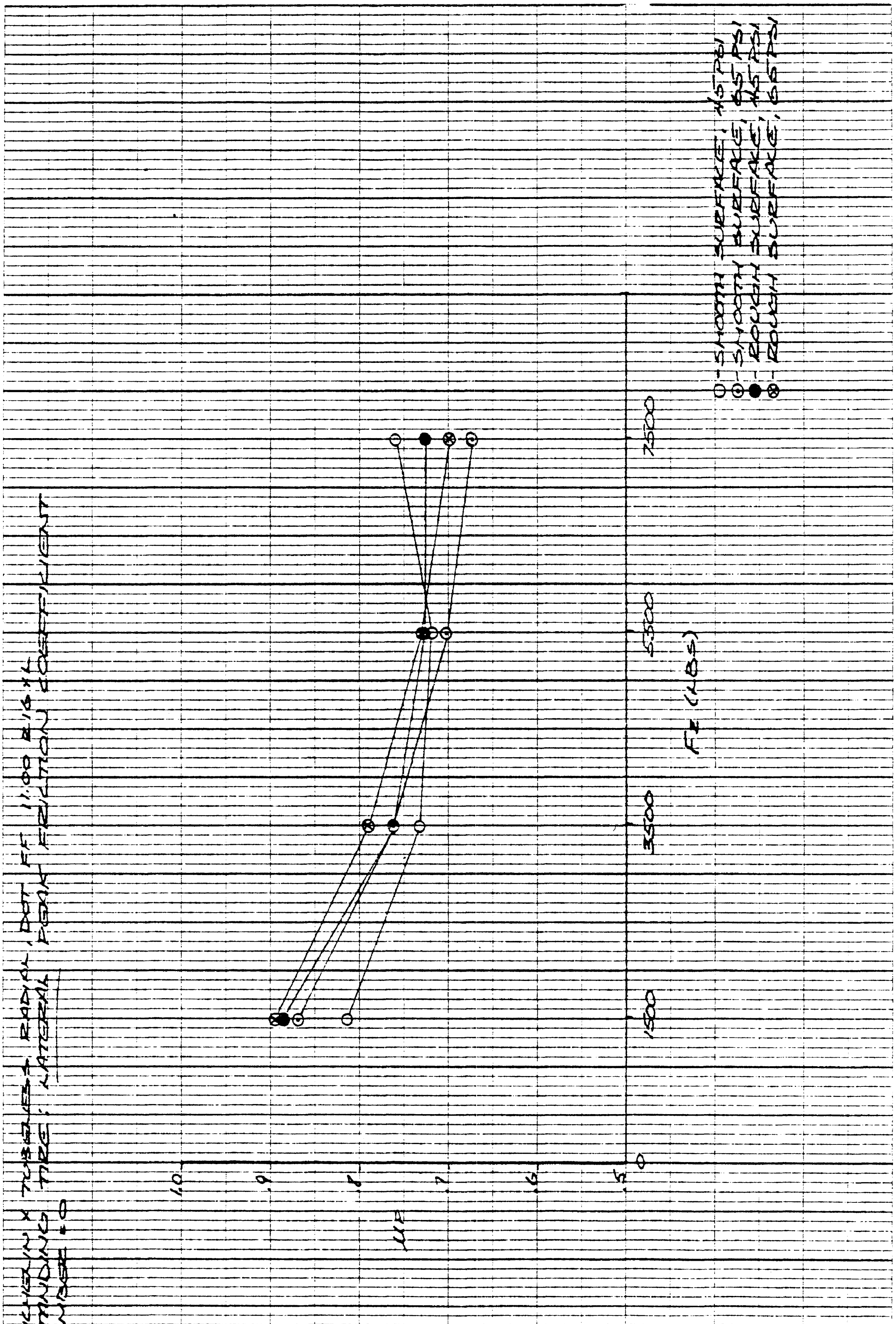

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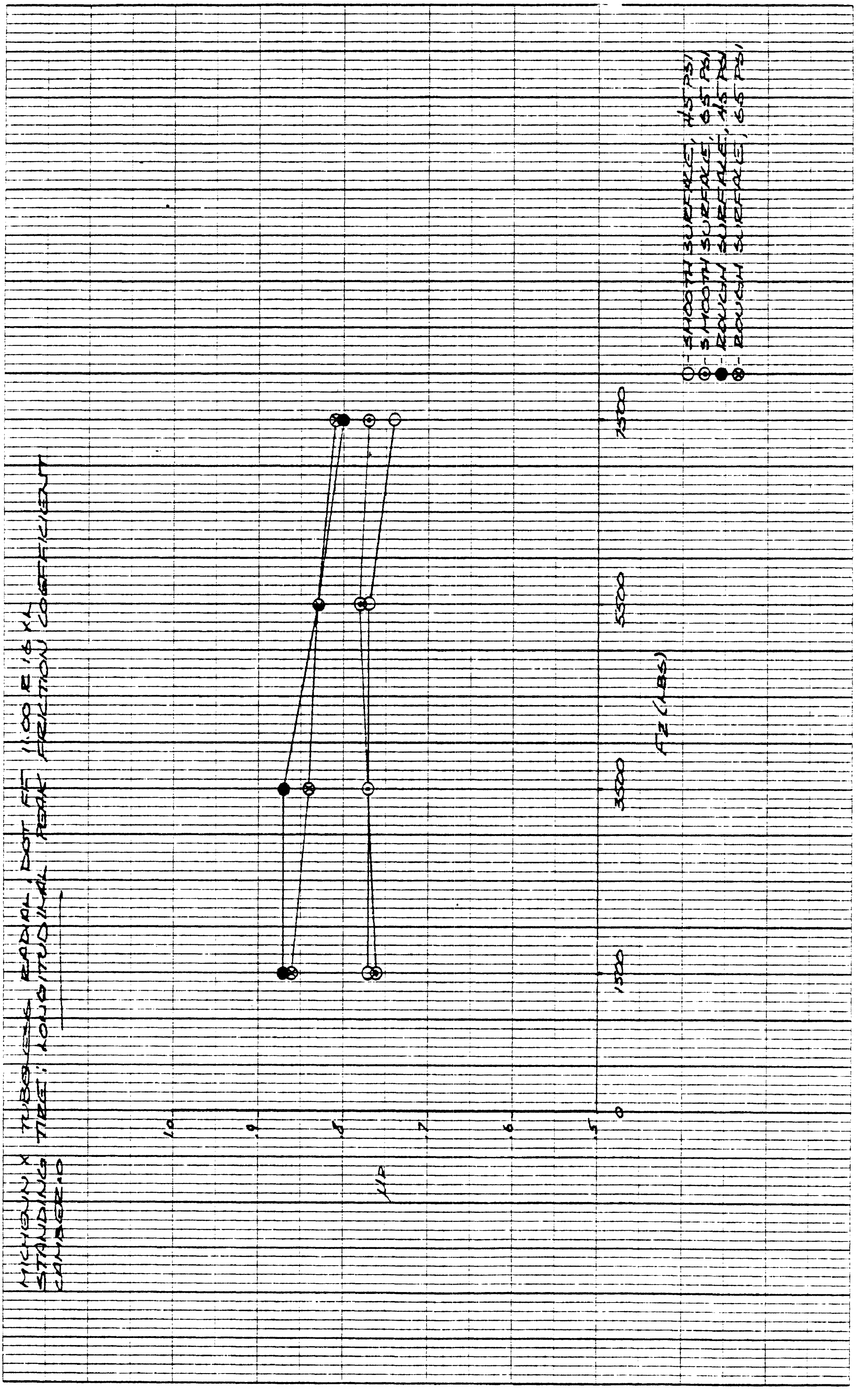

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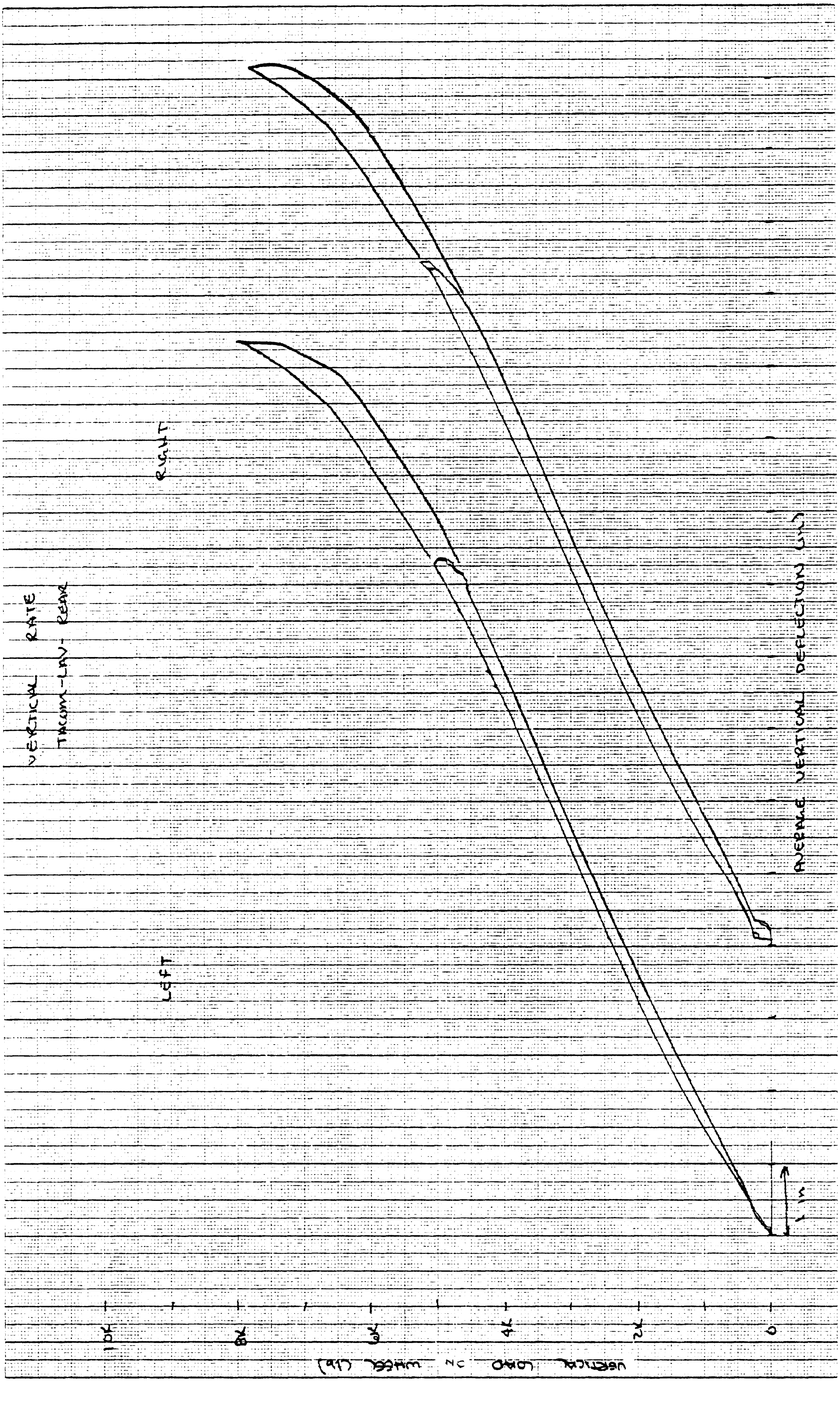
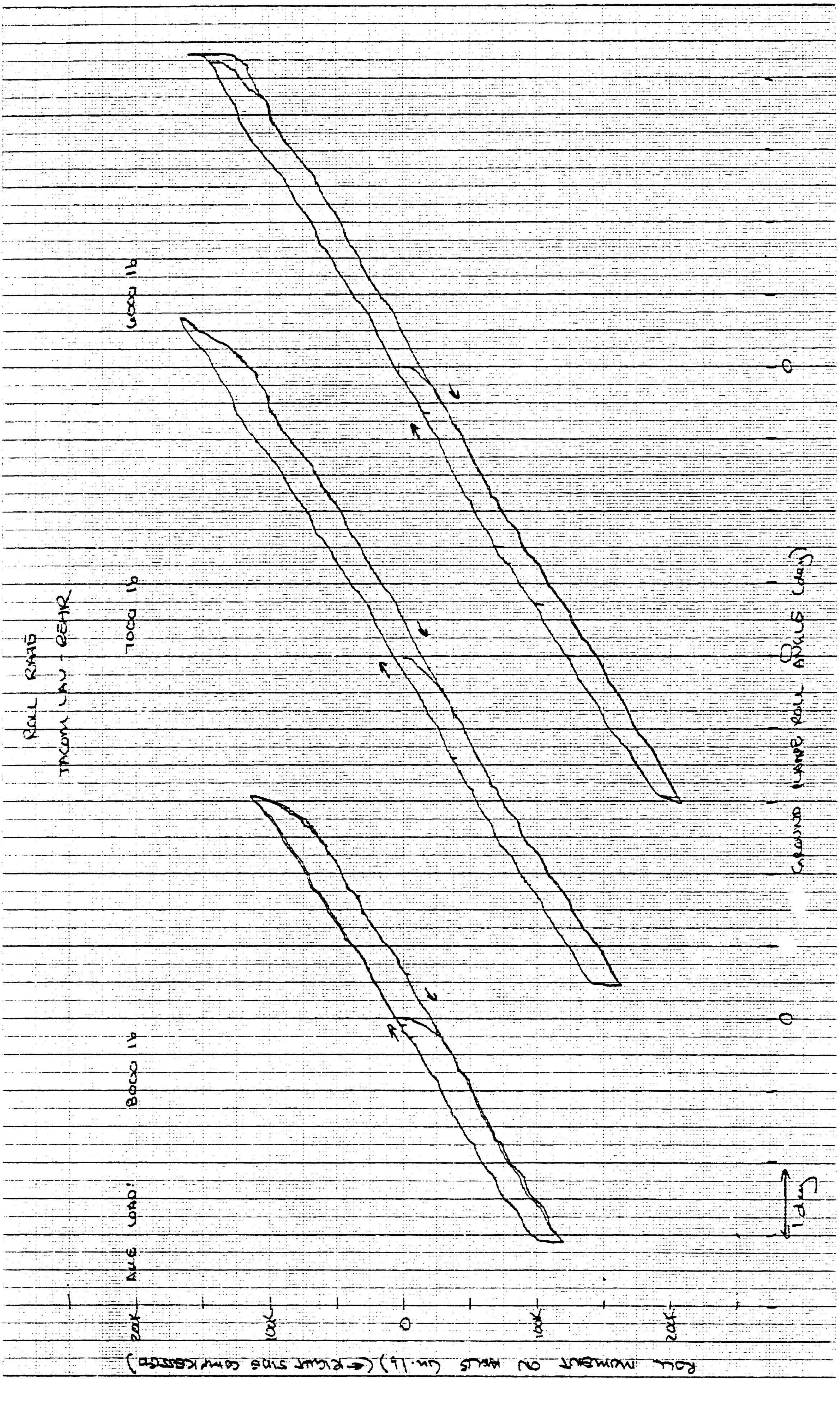
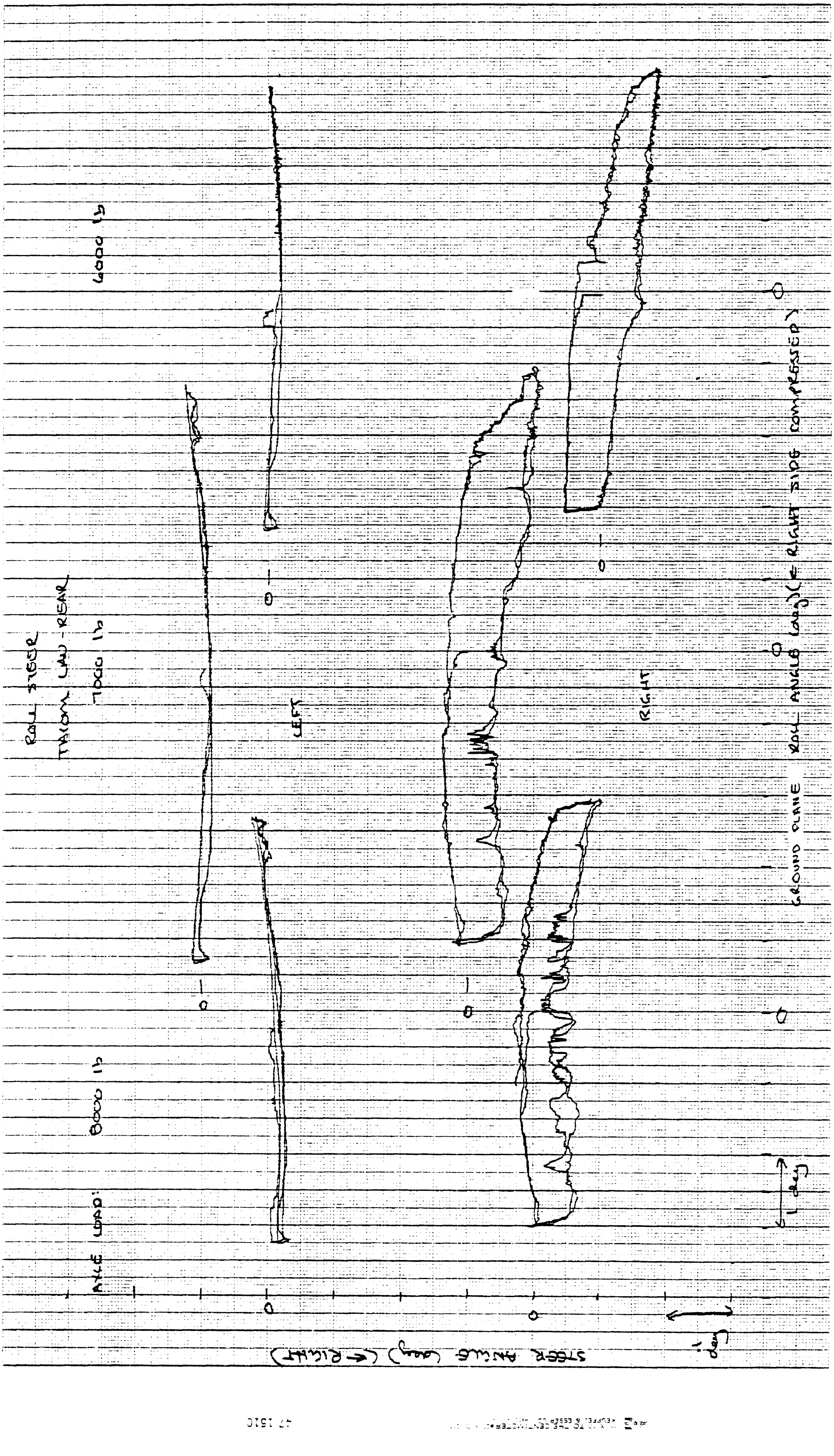
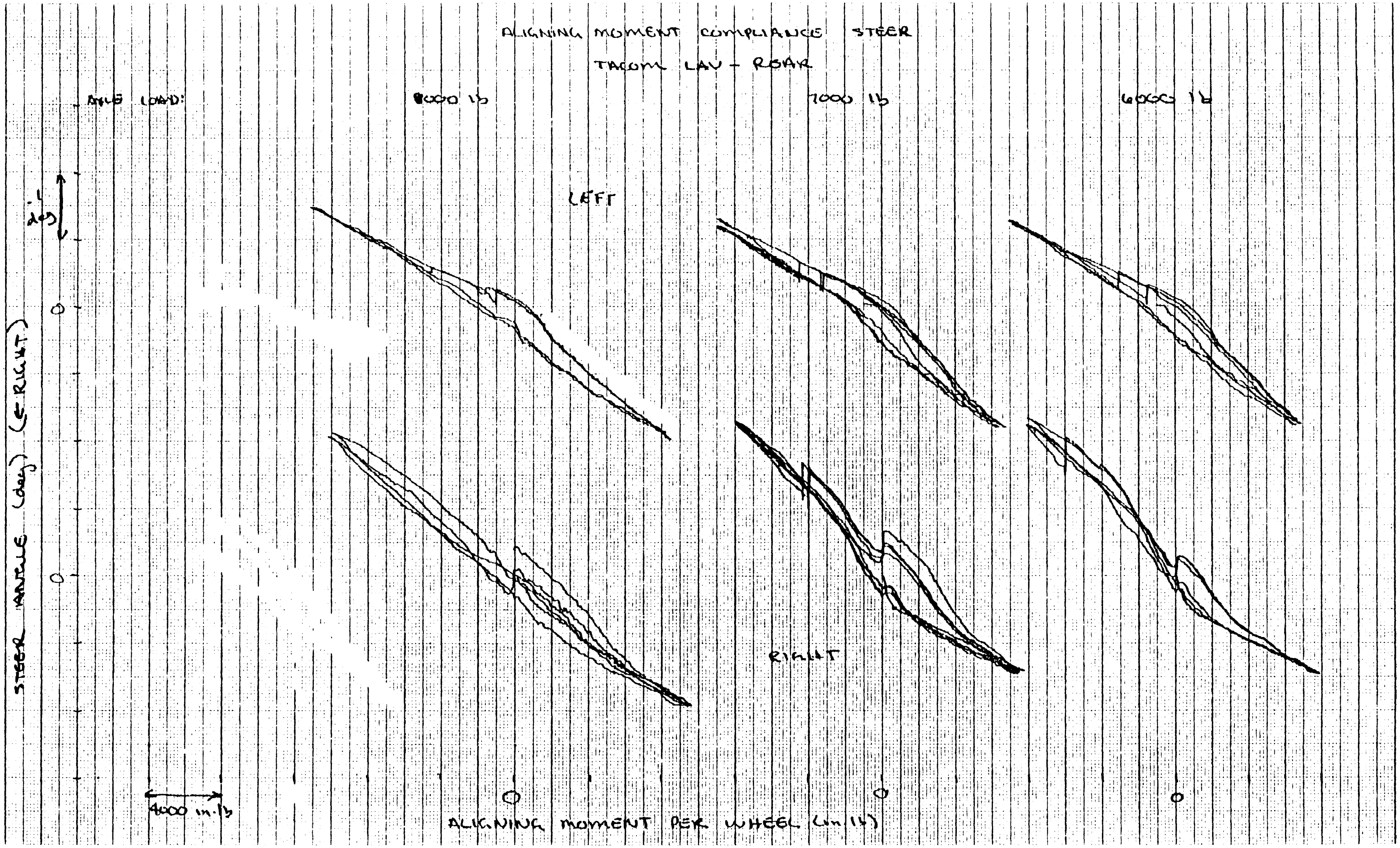
Suspension Properties Graphs

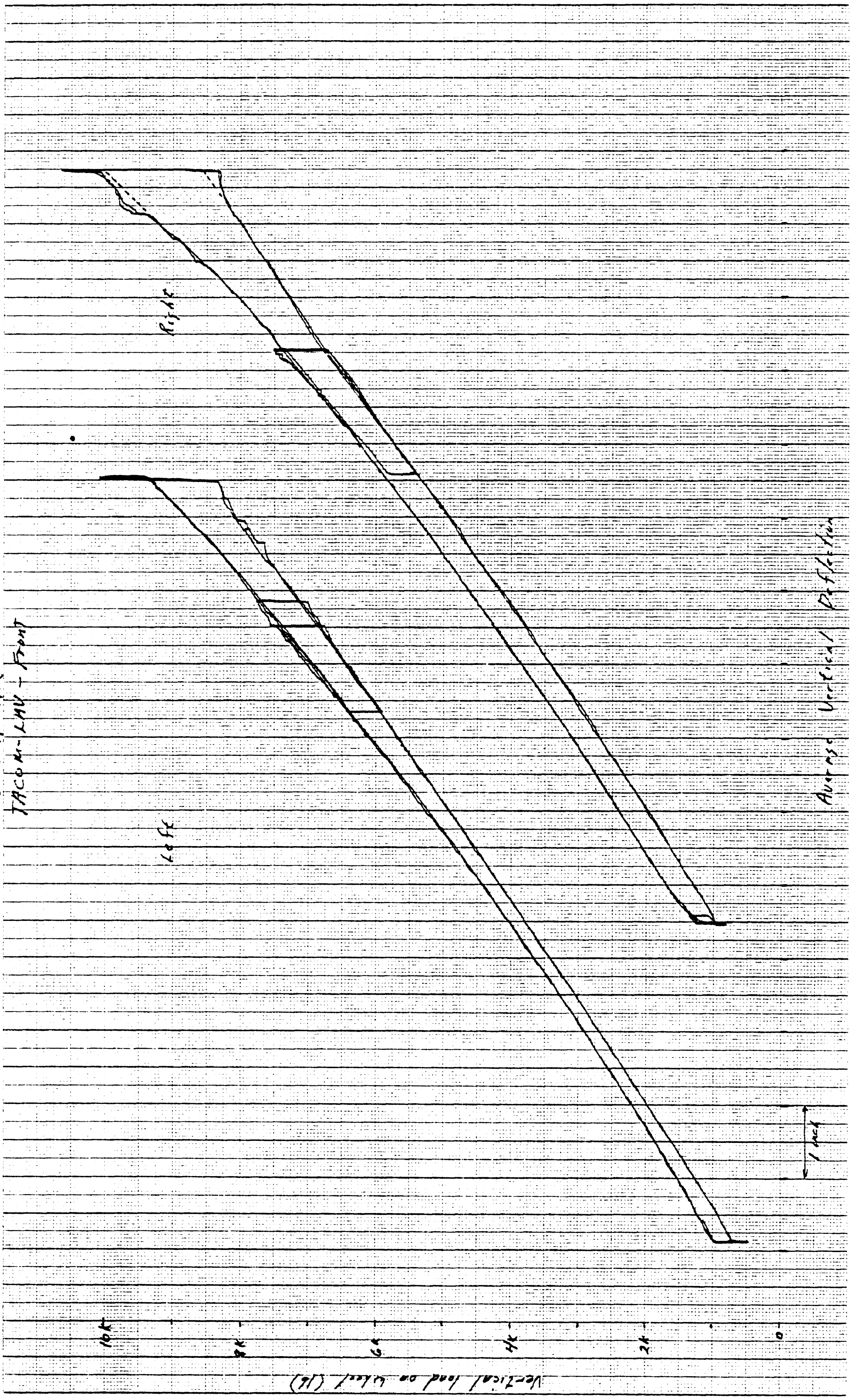

VERTICAL RATE
TACOM-LAV-REAR
RIGHT
LEFT
AVERAGE VERTICAL DEFLECTION (in)
1 in
10K
8K
6K
4K
2K
0
VERTICAL LOAD ON WHEEL (lb)

47 1510

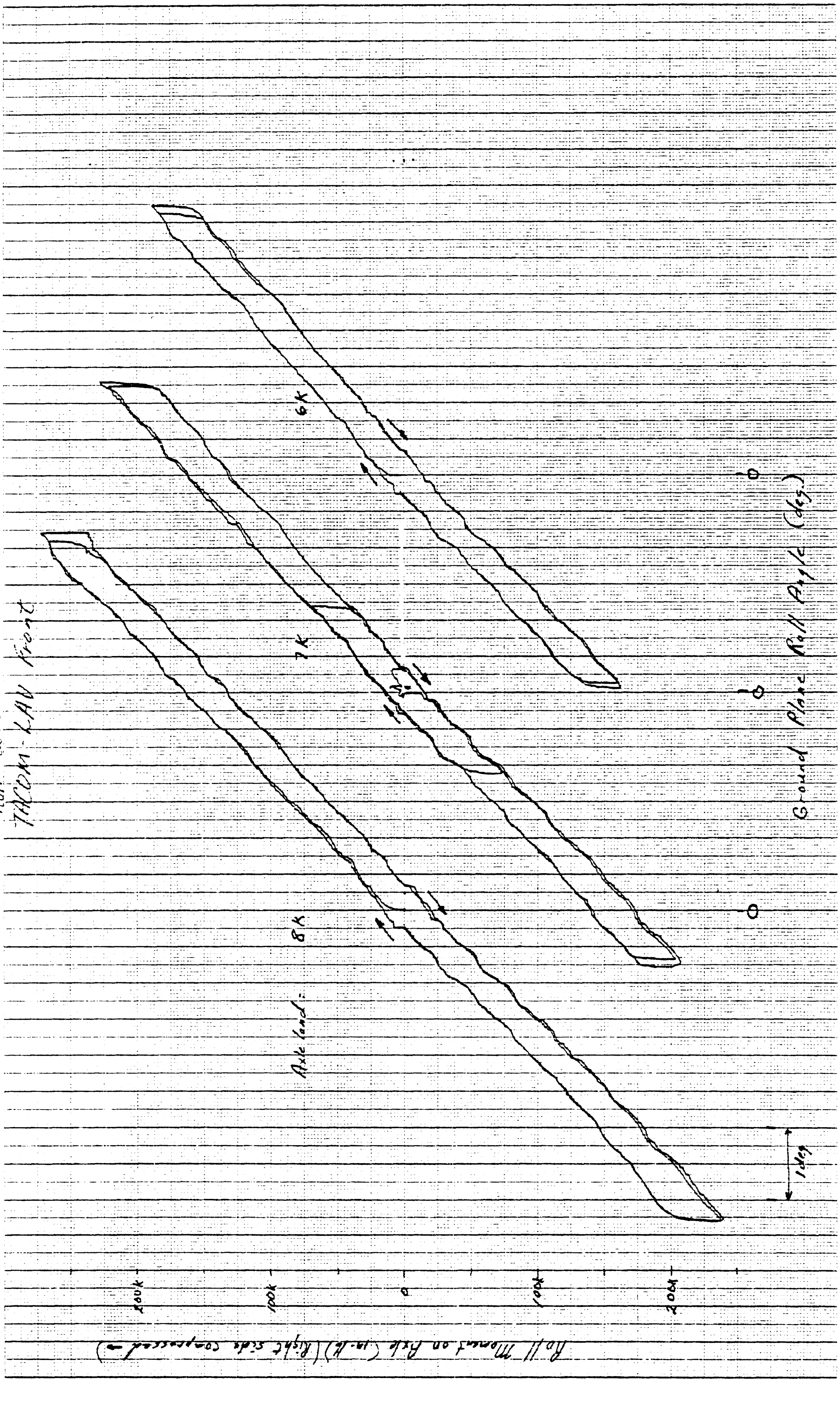

ROLL RATE
AXLE LOAD:
6000 lb
7000 lb
8000 lb
GROUND PLANE ROLL ANGLE (deg)
ROLL MOMENT ON AXLES (in-lb) (← RIGHT SIDE COMPRESSED)
200K
100K
0
100K
200K
1 deg

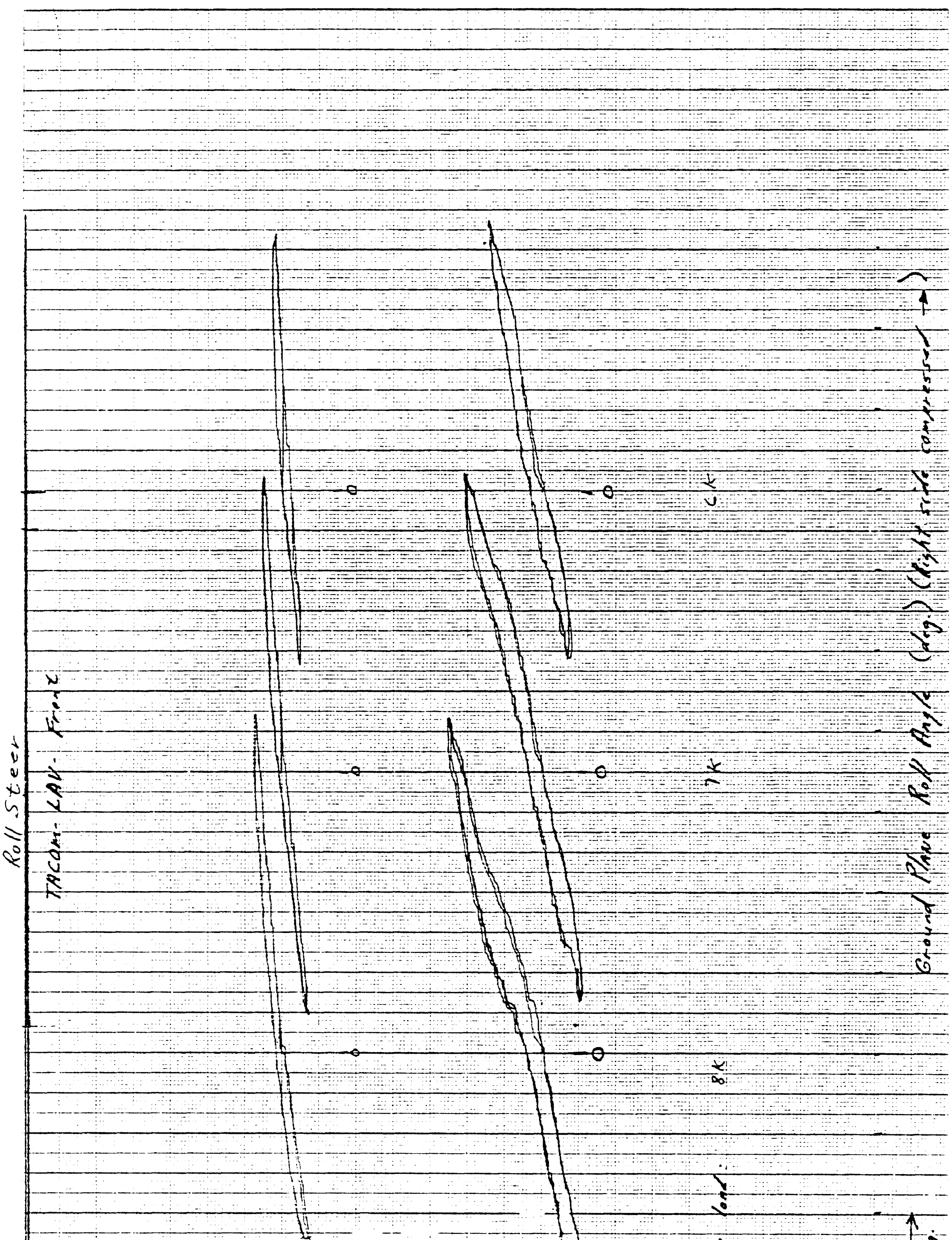

ROLL STEER
TALON LAV-REAR
AXLE LOAD: 8000 lb
7000 lb
6000 lb
LEFT
RIGHT
GROUND PLANE ROLL ANGLE (deg)(← RIGHT SIDE COMPRESSED)
STEER ANGLE (deg) (← RIGHT)
1 deg

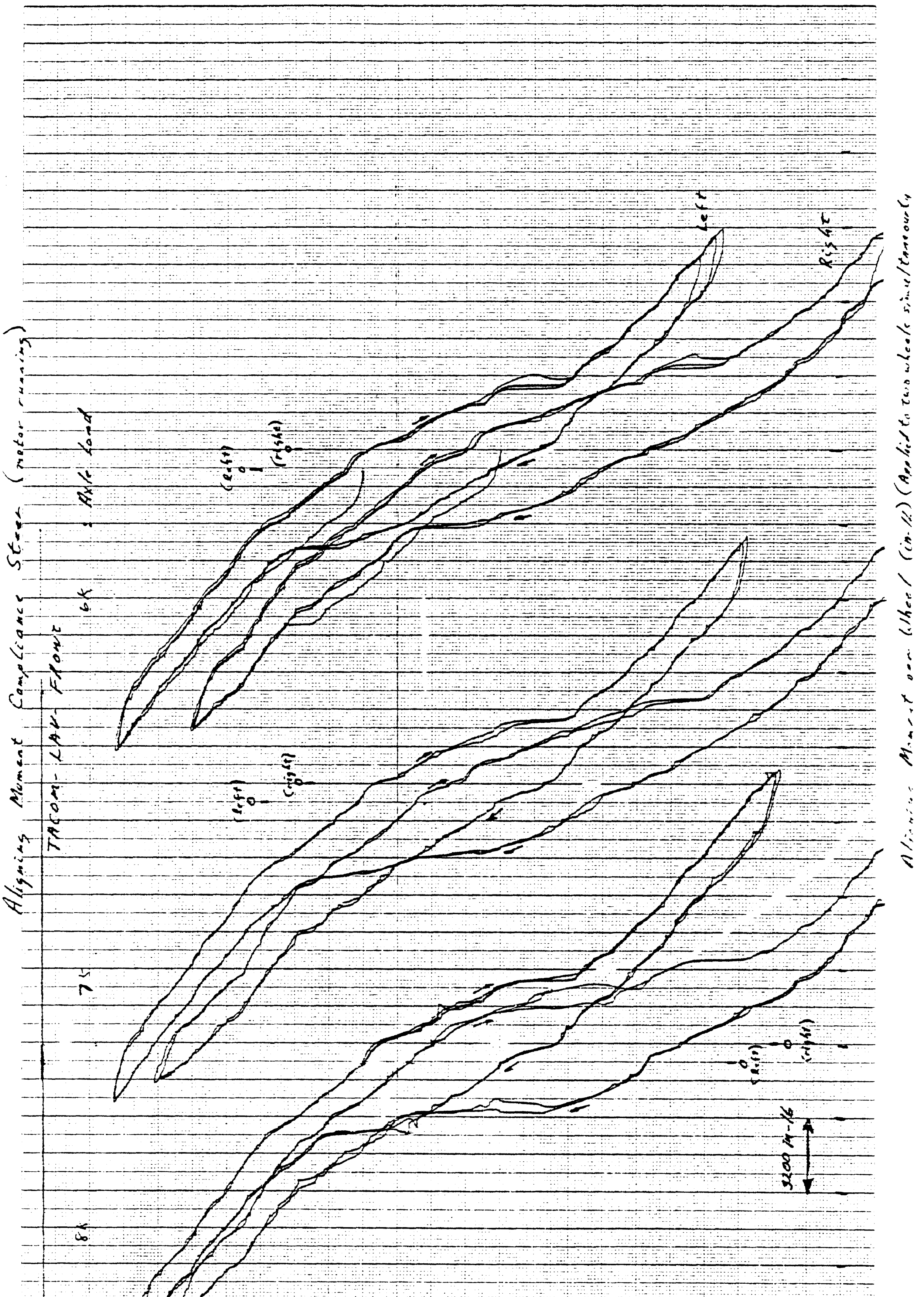

ALIGNING MOMENT COMPLIANCE STEER
TACOM LAV - R8AR
AXLE LOAD:
7000 lb
6000 lb
LEFT
RIGHT
1 deg
STEER ANGLE (deg) (← RIGHT)
0
0
4000 in.lb
0
0
0
ALIGNING MOMENT PER WHEEL (in.lb)


Vertical Rate
TACOM-LAV-Front
Right
Left
Average Vertical Deflection
1 inch
10K
8K
6K
4K
2K
0
Vertical load on wheel (lb)

47 1510


Roll Rate
TACOM-LAV Front
Axle load: 8K 7K 6K
200k
100k
0
100k
200k
Roll Moment on Axle (in-lb) (Right side compressed →)
0
0
0
1deg
Ground Plane Roll Angle (deg.)


Roll Steer
TACOM-LAV-Front
Ground Plane Roll Angle (deg.) (Right side compressed →)
Axle load: 6K 7K 8K
1 deg.
Left
Right
Steer Angle (deg) (← Steer to right)


Aligning Moment Compliance Steer (motor running)
TACOM-LAV Front
6K : Axle Load
7.5
8K
Left
Right
(left)
(right)
3200 in-lb
.5 deg
Steer Angle (deg.) (← steer to right)
Aligning Moment on Wheel / (in-lb) (Applied to two wheels simultaneously)