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IDENTIFICATION OF FLAWS BY USE OF THERMAL DIFFERENTIALS ON A TIRE UNDER MILD LOADING CONDITIONS

Transportation Systems Center
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Cambridge, Massachusetts 02142

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16. Abstract An experiment was conducted using a Monsanto Infrared Tire Flaw Detector (ITFD) to confirm the hypothesis that areas in tires having poor adhesion or separations tend to achieve a greater rate of temperature rise under conditions of moderate stress than unflawed areas. Three types of stress were tried: constant tire deflection; alteration of inflation pressure; alteration of wheel speed. Tire-to-wheel force in at least one case gave evidence of greater thermal rise rates than in other areas of the tire believed to be normal.				LIBRARY	
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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
INTRODUCTION.....	1
TEST PROCEDURE.....	1
CONSTANT DISTANCE TEST; VARY INFLATION PRESSURE.....	2
CONSTANT DISTANCE; VARY FORCE TEST.....	2
CONSTANT FORCE AND PRESSURE; VARY SPEED.....	4
CONCLUSION.....	4
APPENDIX: TFD PHOTOS OF MILD STIMULI EXPERIMENT.....	A-1

LIST OF ILLUSTRATIONS

<u>Figure</u>	
1. Constant Distance; Variation of Inflation Pressure..	3
2. Variation of Force; Constant Inflation Pressure at 40 mph.....	5

INTRODUCTION

An experiment was conducted to determine whether areas of known tire flaws increase in temperature at a rate substantially different from normal areas under lower than destructive wheel loads and speeds.

The test setup consisted of an 80 inch reliable test wheel with a speed capability of 20 mph to over 100 mph and a force capability of 375 lbs to over 2000 lbs in 70 pound increments by static loading. The sensor used was a Monsanto Tire Flaw Detector (TFD) using a dedicated PDP-12 computer. The writer was able to infer the following approximate radiometric specifications:

1. Sensitivity to temperature changes @ 200°F; 1°F
2. Spot size: half-power points at focus distance - 0.5"
3. Frequency response - 10Hz to 5KHz
4. Thermal range around 200°F
 - a. on normal setting: 60°F
 - b. on expanded range: 240°F
5. Estimated sensitivity of difference plot - 0.13°F
6. Estimated range of differential signals - ~6°F full scale

The tire utilized was a Uniroyal Serial AJVXDD511, 8-78-15, 2+2 FG/PE. This tire had at least one known flaw: a separation, caused by running in an overloaded condition.

TEST PROCEDURE

The tire was subjected to stimuli in the following three ways:

1. Constant roadwheel-to-tire spindle distance was maintained by use of a mechanical stop; inflation pressure

*The Monsanto TFD is described in detail in the information contained in the rear pocket of this memorandum.

was varied. It was hoped that this stimulus would approximate a constant deflection and therefore a consistent overall frictional pattern on the tire.

2. Tire pressure was kept constant and road wheel force was varied.
3. Force and pressure were kept constant and speed was altered. Little was expected from varying speed since the infrared system frequency response with a low frequency cutoff of 10 cycles causes phase shifts in the thermal differentials proportional to amplitude and speed. It would therefore be impossible to isolate true thermal changes.

CONSTANT DISTANCE TEST; VARY INFLATION PRESSURE

The tire was mounted, and tested at 40 mph. The TFD was allowed to take successive differences until no further temperature differences were observed in the readout. This set of amplitude values was then stored in the memory bank.

At this point, the road wheel was stopped with the tire still resting on it. The inflation pressure was increased; the wheel was tested at 40 mph again and allowed to stabilize for 15 minutes. Successive runs of this type were made until enough points were obtained to establish a curve.

Results

The following assumptions concerning the photographic data were made. (photographs are included in the appendix)

1. Noise amplitude in the difference trace was 0.13° RMS.
2. Full amplitude signal was assumed to be 6° F.

Note: (Monsanto estimates 0.1° and 2.5° for these parameters.) The results are shown on Figure 1.

CONSTANT DISTANCE; VARY FORCE TEST

The above procedure was repeated except that the mechanical stop was removed and the tire loaded in 70 pound increments from 385 lb to 700 lb. Speed was constant and tire pressure was

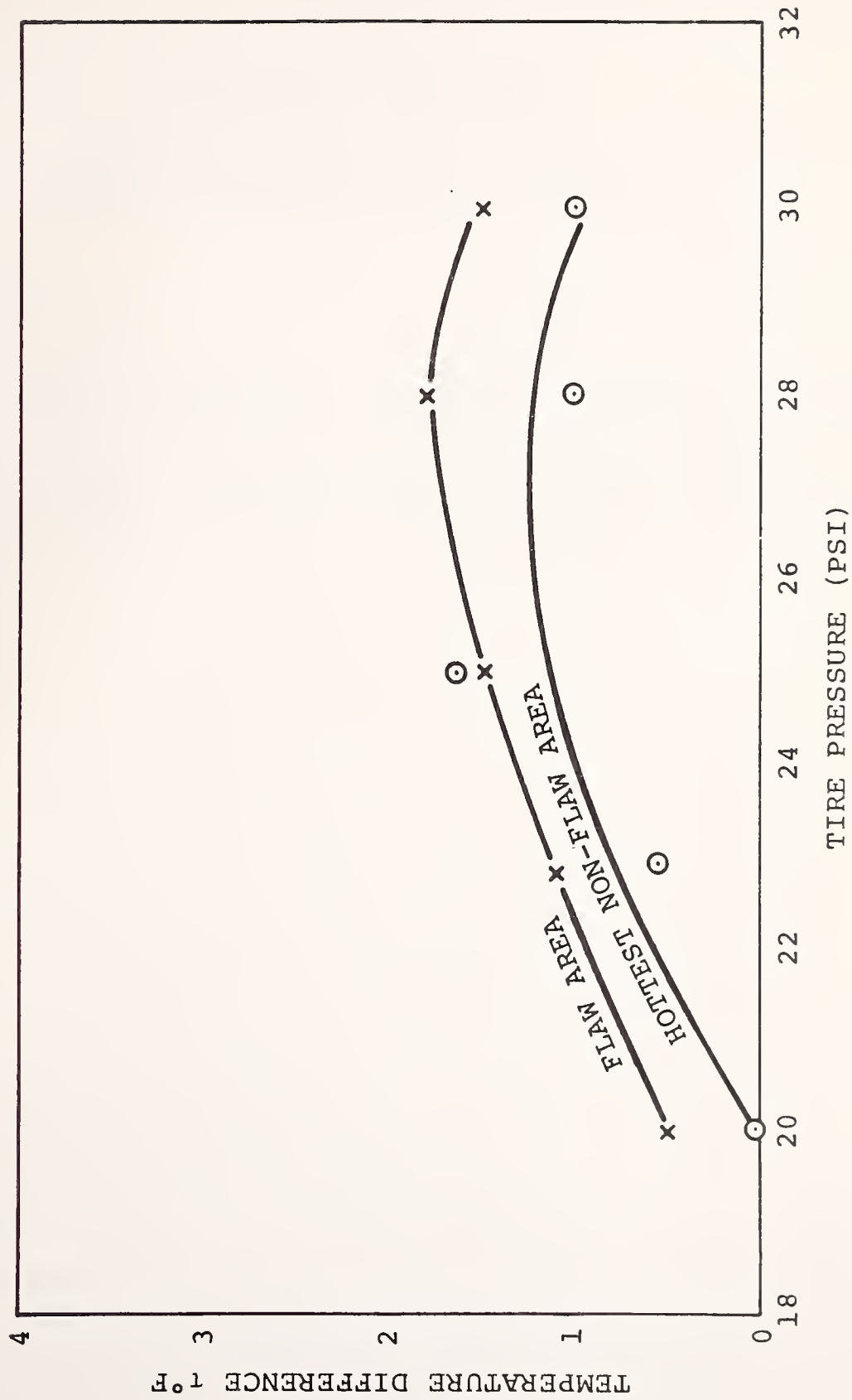


Figure 1. Constant Distance; Variation of Inflation Pressure

maintained at .20PSI. The results are shown in Figure 2. The last data point is assumed to be erroneous since a pointing problem was found in the setup causing an amplitude error.

CONSTANT FORCE AND PRESSURE; VARY SPEED

Little information was inferred from the data obtained by varying speed and performing the above tests.

CONCLUSION

There is some evidence to confirm that the area of a potential flaw is subject to a rate of thermal rise under mild stimuli which is different from that experienced from normal areas of a tire. The data are not conclusive however, and it is recommended that instrumentation be developed to confirm this on a sufficient number of tires having a variety of flaws.

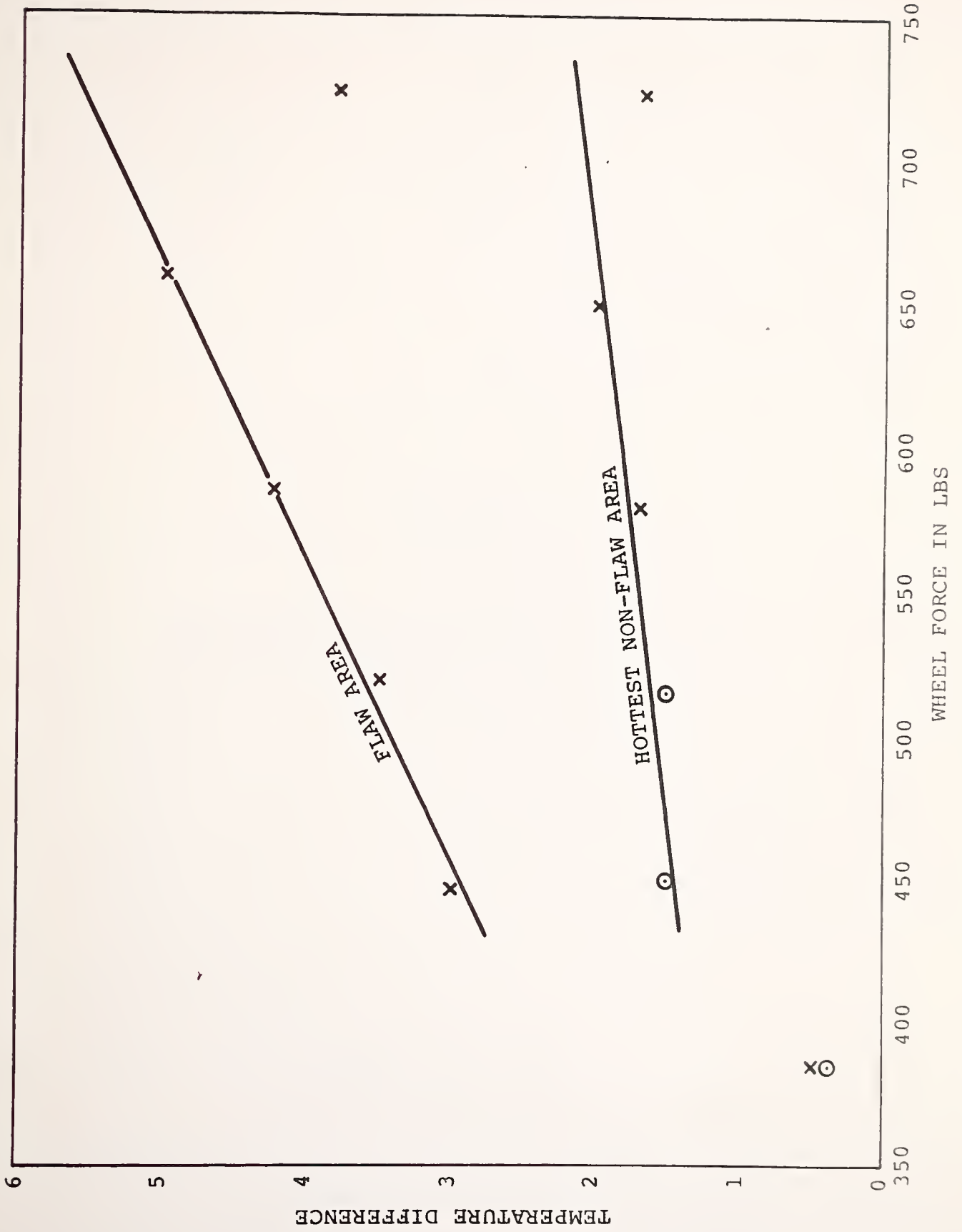


Figure 2. Variation of Force; Constant Inflation Pressure at 40 mph

APPENDIX

TFD PHOTOS OF MILD STIMULI EXPERIMENT

TIRE AJVX DD511 UNIROYAL SERIAL INDUCED FLAW

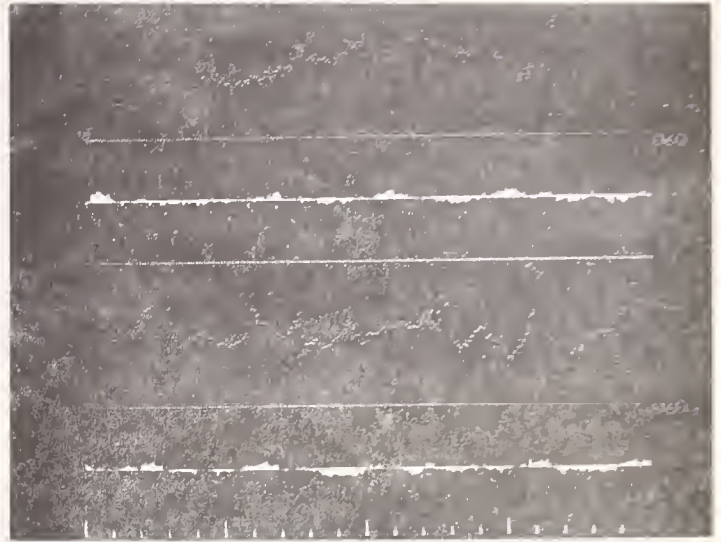
WHEEL SPEED 40 MPH
CONSTANT SPINDLE DISTANCE (A)

PRESSURE: 18 PSI

FORCE: 1040 LBS

TIME: 1015

A1

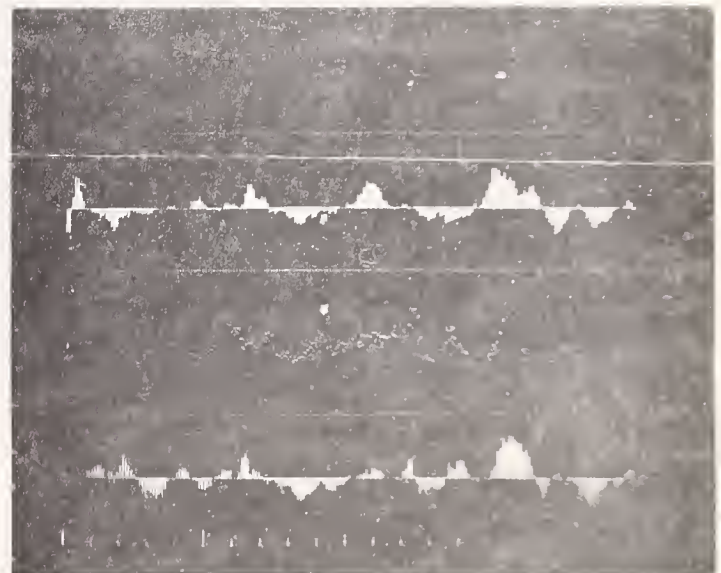


PRESSURE: 25 PSI

FORCE: 1070 LBS

TIME: 1032

A2

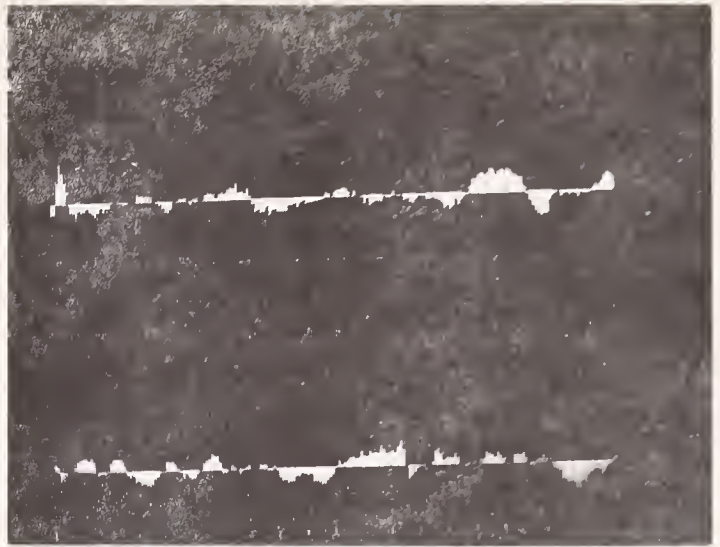


PRESSURE: 29 PSI

FORCE: 1250 LBS

TIME: 1046

T3

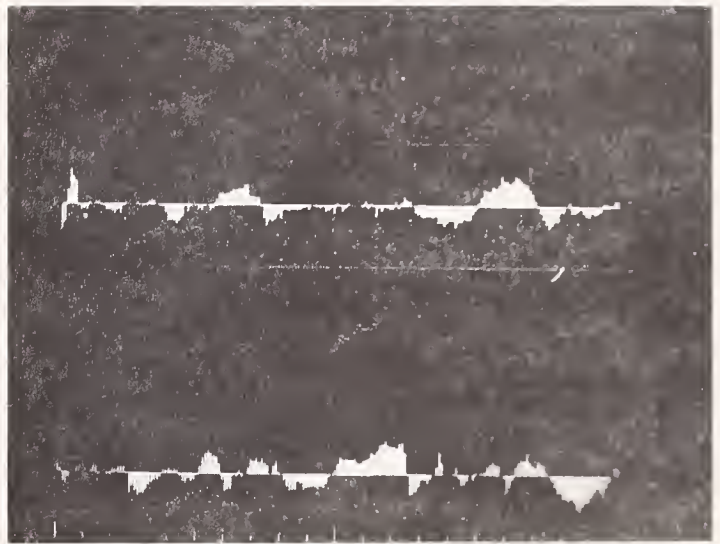


PRESSURE: 32 PSI

FORCE: 1400 LBS

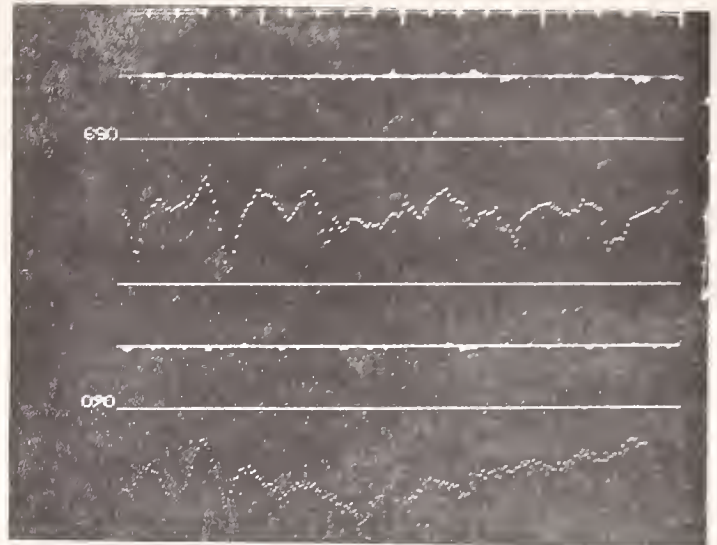
TIME: 1100

A4

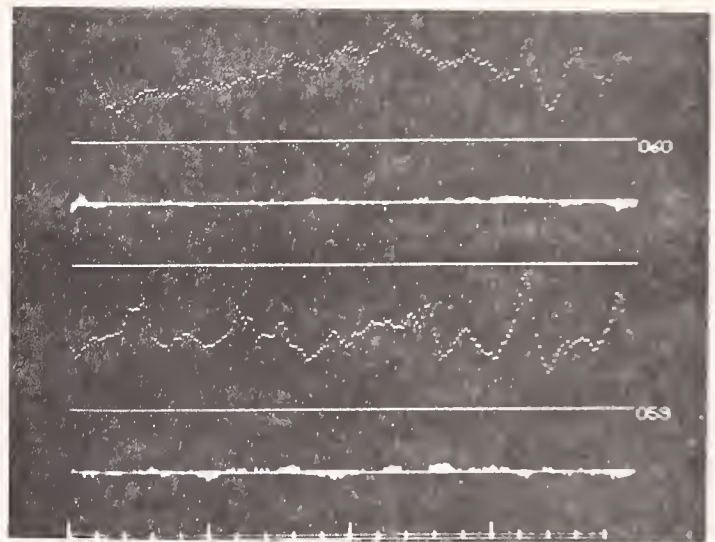


REPEAT EXPERIMENT

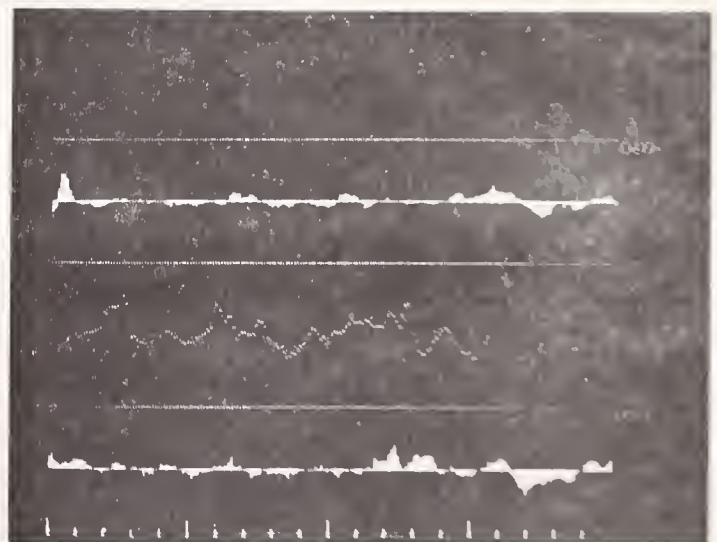
PRESSURE: 20 PSI



PRESSURE: 22 PSI

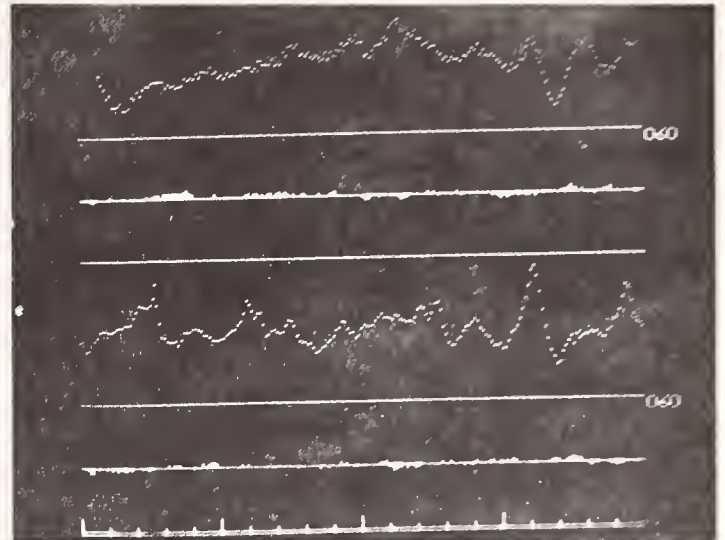


PRESSURE: 24 PSI



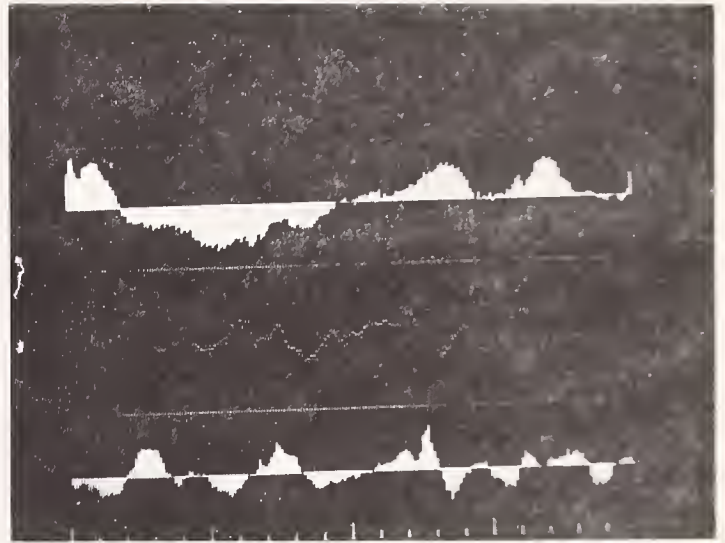
PRESSURE: 24 PSI
FORCE: 1180 LBS.
WHEEL SPEED: 35 MPH
TIME: 1540

B1



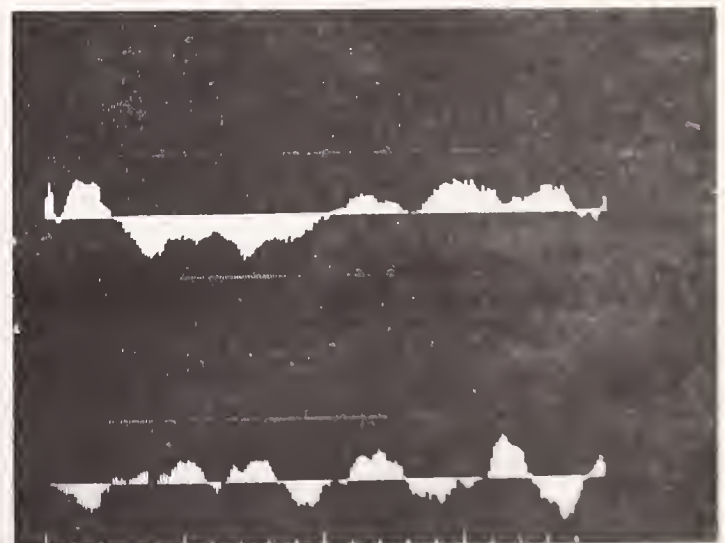
SPEED: 40 MPH
TIME: 1555

B2



SPEED: 45 MPH
TIME: 1610

B3



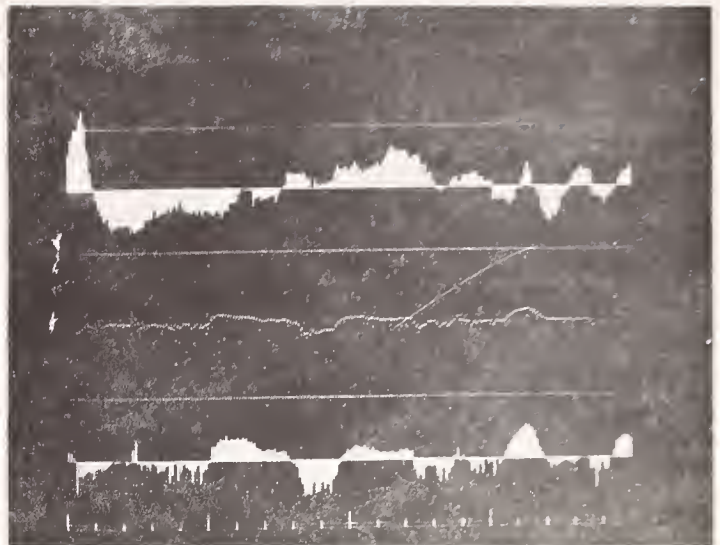
PRESSURE: 20 PSI

SPEED: 40 MPH

STARTING FORCE: 385 LBS

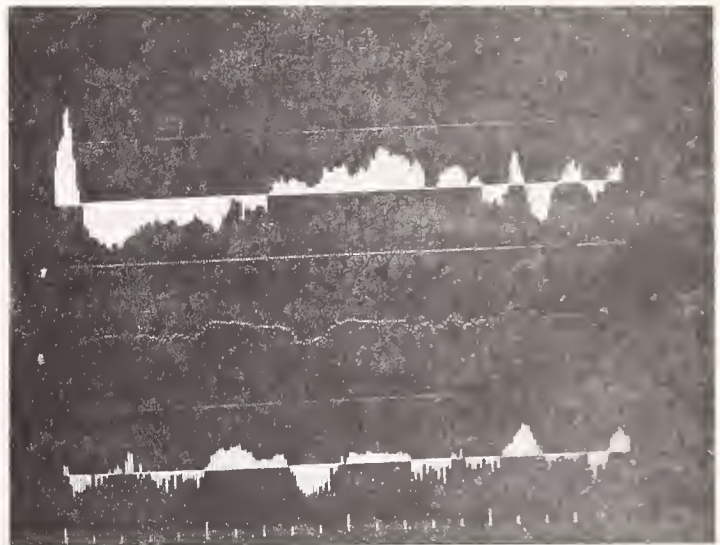
FORCE: 447 LBS

C1



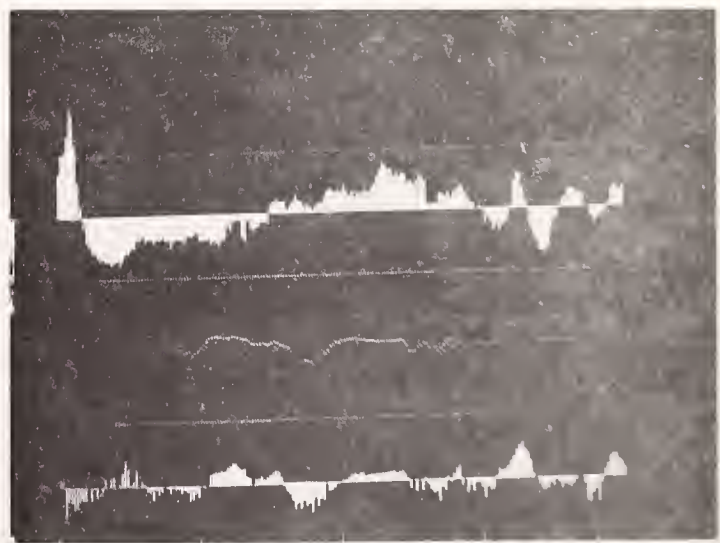
FORCE: 527 LBS

C2



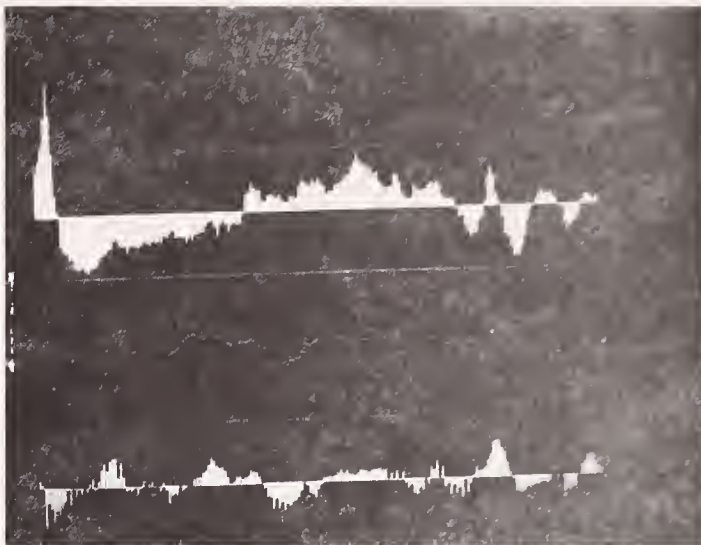
FORCE: 585 LBS

C3



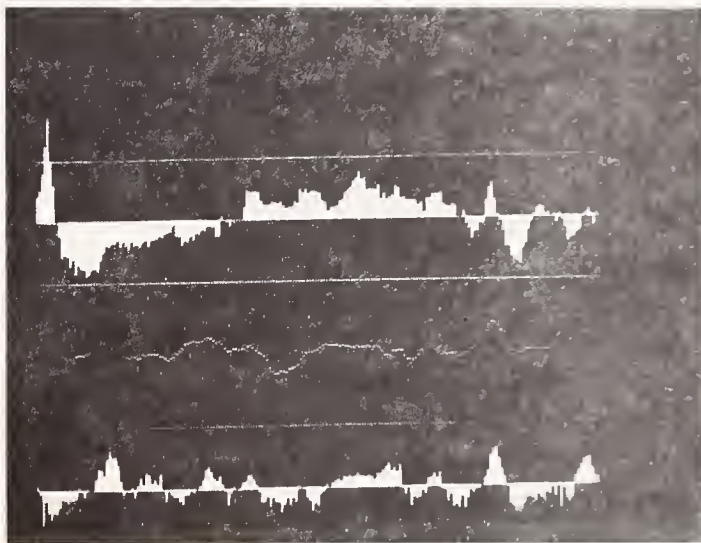
FORCE: 660 LBS

C4



FORCE: 729 LBS

C5



NOTE: OPTICAL ALIGNMENT
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