AD 701942

UNCLASSIFIED

DESIGN, DEVELOPMENT, AND TESTING OF TIRES FOR 16 TON GOER VEHICLES

FINAL REPORT

CONTRACT NO. DA-33-019-ORD-3478
(Including Modification 1 - 7)

THE FIRESTONE TIRE & RUBBER COMPANY

AKRON, OHIO

This project was performed under the technical supervision of Research & Engineering Directorate, Army Tank-Automotive Command.

Cleveland Ordnance District Office
Ordnance Project No. TW-510
D/A Project No. 546-09-036

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Compounder

Approved By:

November, 1963

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Contract No. DA-33-019-ORD-3478
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Earthmoving tires were specifically developed for use on the Goer vehicle. This development work included the design of various tread configurations and use of maximum feasible synthetic content. Tires were produced in three different tread designs, and two different levels of synthetic content. These tires were then tested for running temperature, traction, and mobility. Durability tests of 40% highway, 40% secondary roads, and 20% cross country were conducted. These tests showed that tires could be produced to provide at least 15,000 miles without any premature failures for this type of service.

OBJECT

The object of the original contract dated 30 September 1960 was to design and develop 29.5-25 16 ply rating tubeless tires to provide optimum performance when used on the Goer vehicle. It was also desired to attain these goals while using the maximum feasible synthetic content.

Subsequent modifications (1-7) from June, 1961 through January, 1963 called for:

1. Non-destructive drum testing.

2. Temperature testing in continuous highway service.

3. Traction testing in various soils.

4. Durability testing on paved (40%) and secondary (40%) roads and off-highway terrain (20%).

Conclusions:

1. We found that it was possible to produce tires more suited to the requirements of the Goer vehicle than any commercially available tire. The major areas of improvement includes the capacity for continuous highway operation and improved performance in mud. The three designs developed are shown in figures 1-4.

    Figure 1 - Super Ground Grip Goer
    Figure 2 - Super Ground Grip Goer (Grooved)
    Figure 3 - ND-CC Goer

2. Maximum synthetic content of the 29.5-25 SGG Goer was found to be 50% of the polymer used. The maximum synthetic content was determined by an evaluation of compound properties considering separation resistance and wear, cut, chip and tear resistance, as determined through the specific tests performed during the term of this contract and its modifications. However, certain inherent deficiencies from increasing synthetic (relative to natural rubber which is being replaced) in larger Off-The-Road type tires, should be recognized.
   These are:

   A. Higher Heat Build-Up

      To use synthetic in the tread of the tire, it was found necessary to incorporate a cooler-running, high-natural-rubber-content compound in the tread base under an all-synthetic tread cap compound, in order to lower the tire temperature in the critical separation area on top of the tire carcass.

   B. Poor Crack or Cut Initiation and Growth

      This deficiency manifested itself quite markedly during the durability testing. As a result of these tests, compound modifications were made in the all-synthetic tread cap stock to improve upon this property for future Goer tires.

   C. Lower Resistance to Chip and Tear

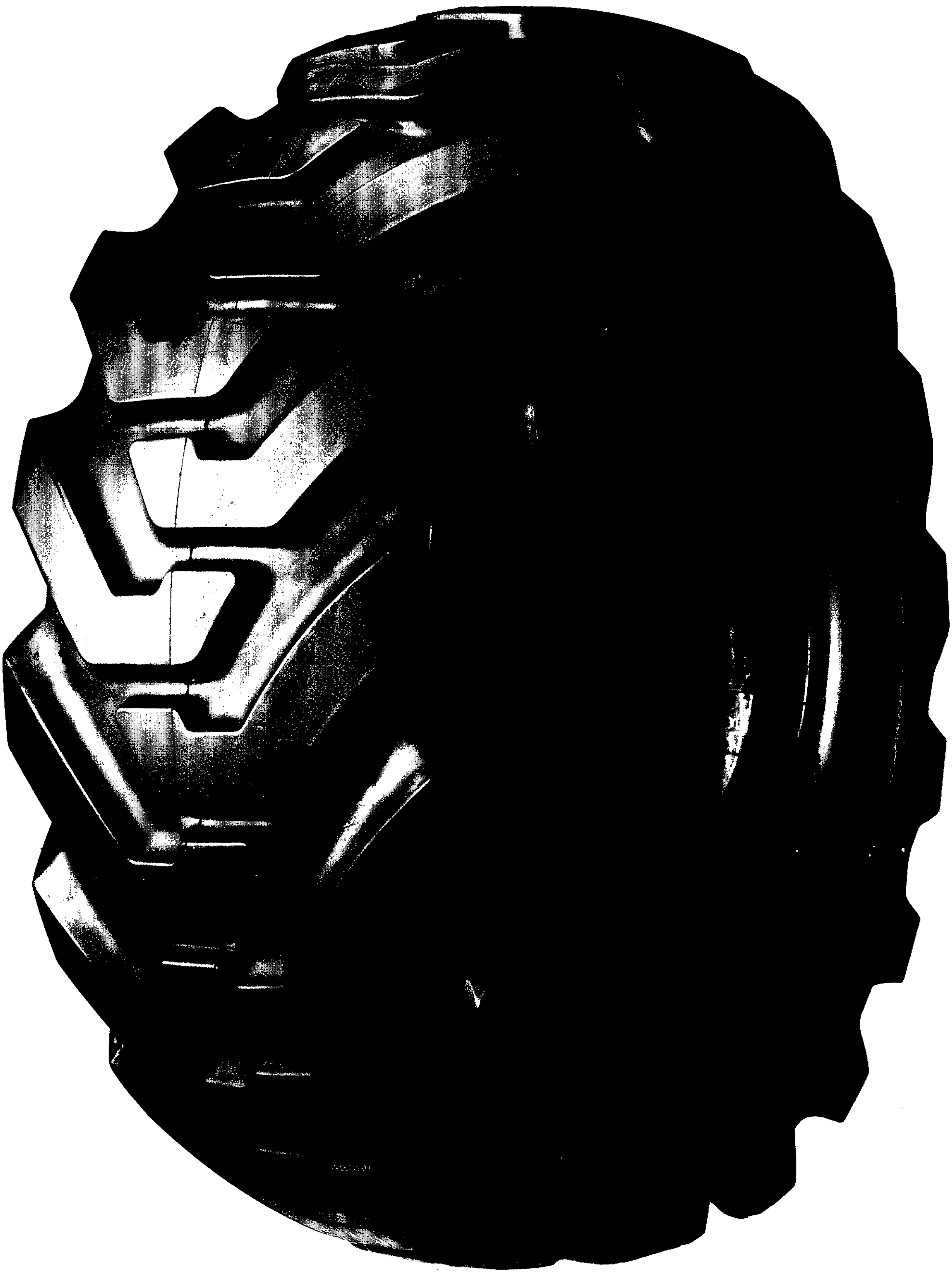
      Although the all-synthetic tread cap has been compounded to obtain the maximum cut, chip and tear resistance, without sacrificing other properties, there is an inherent lower resistance relative to natural rubber, for Off-The-Road type service, which compromises the overall performance of the tire. The exterior compounds of the tire (i.e. the tread and sidewall) have adequate protection against atmospheric deterioration and good low temperature

Firestone

Super Ground Grip Goer

Directional

Figure 1

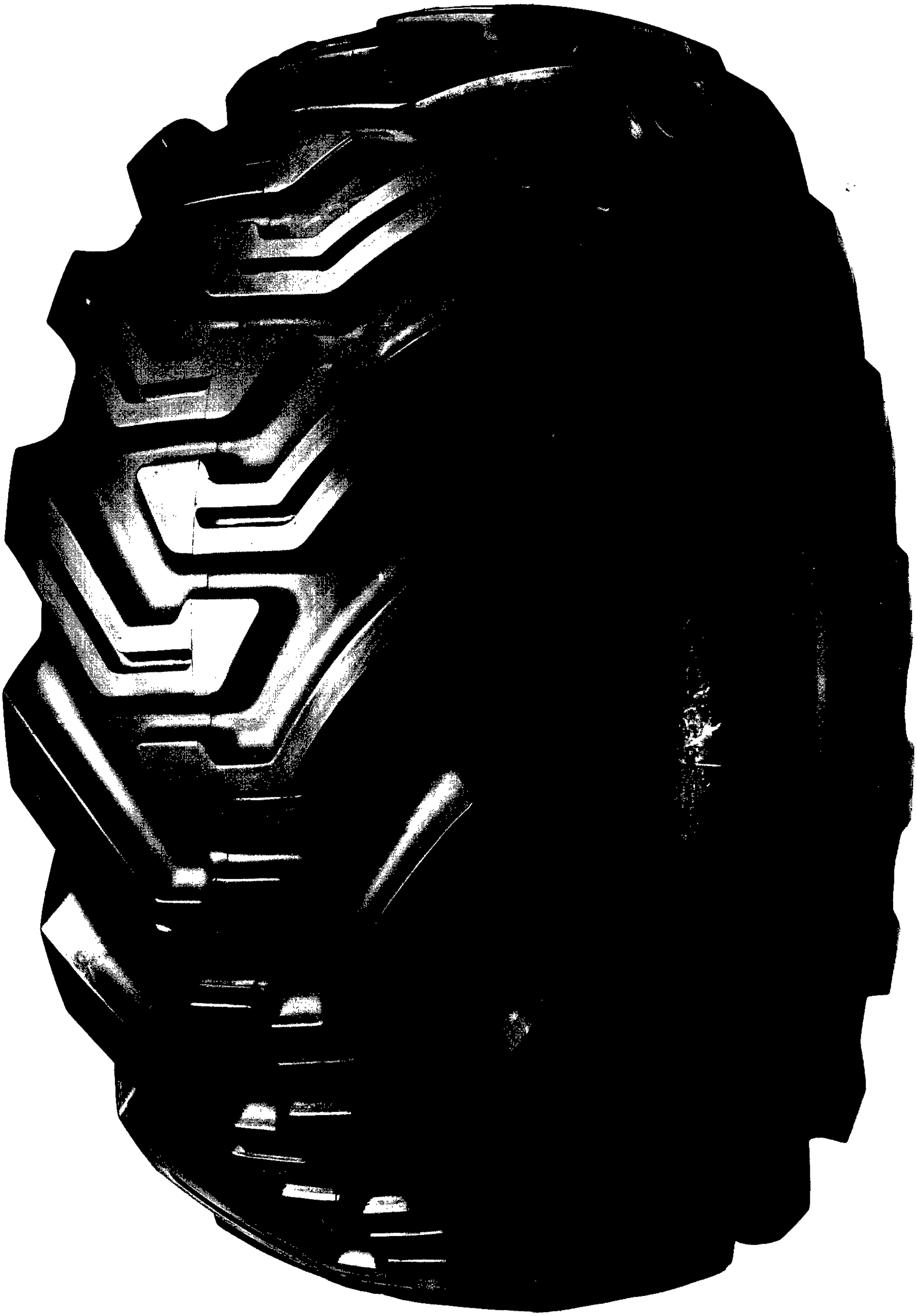


Firestone

Super Ground Grip Goer
(with grooves)

Directional

Figure 2

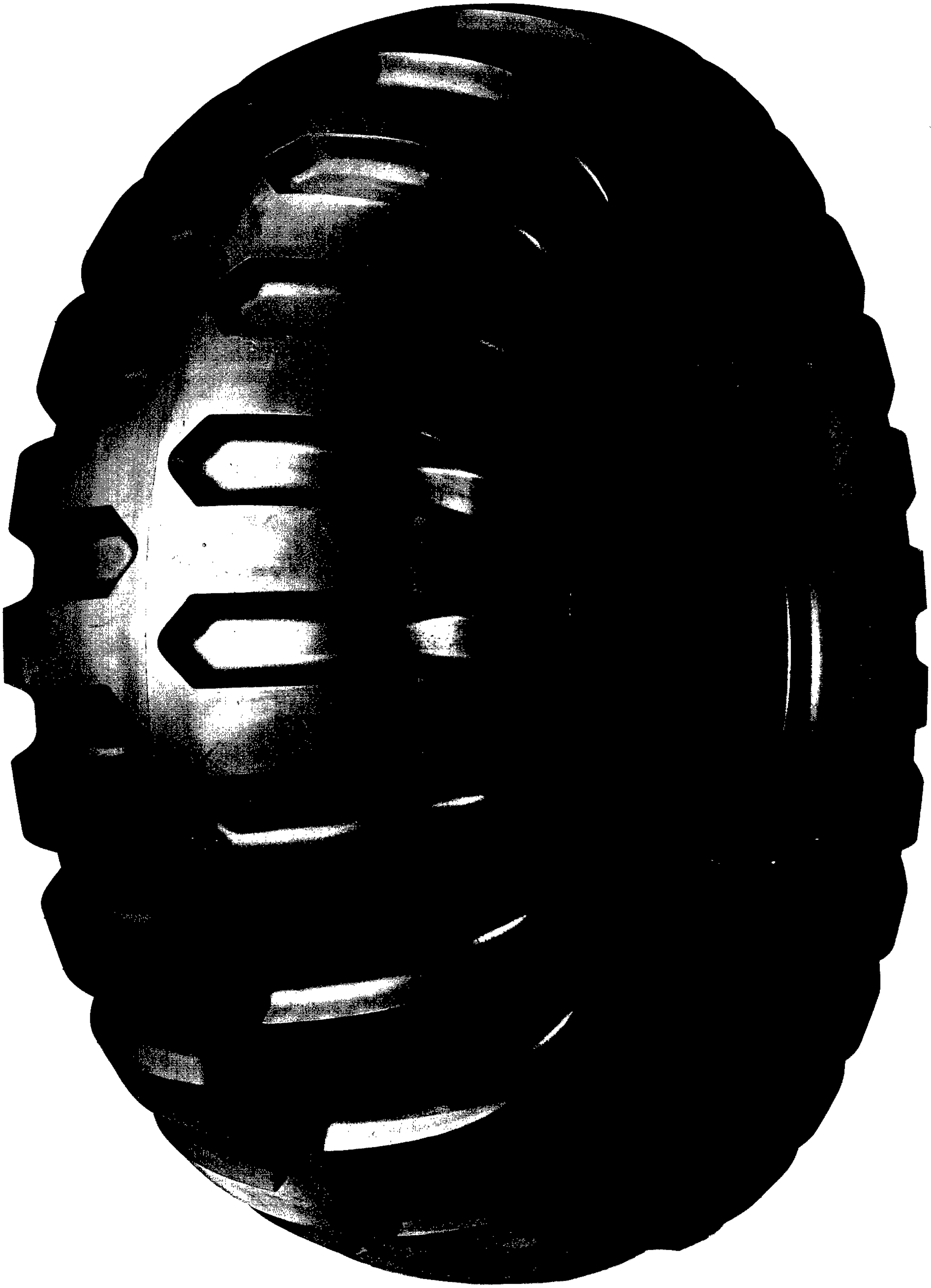


Firestone

ND-CC Goer

Non-directional

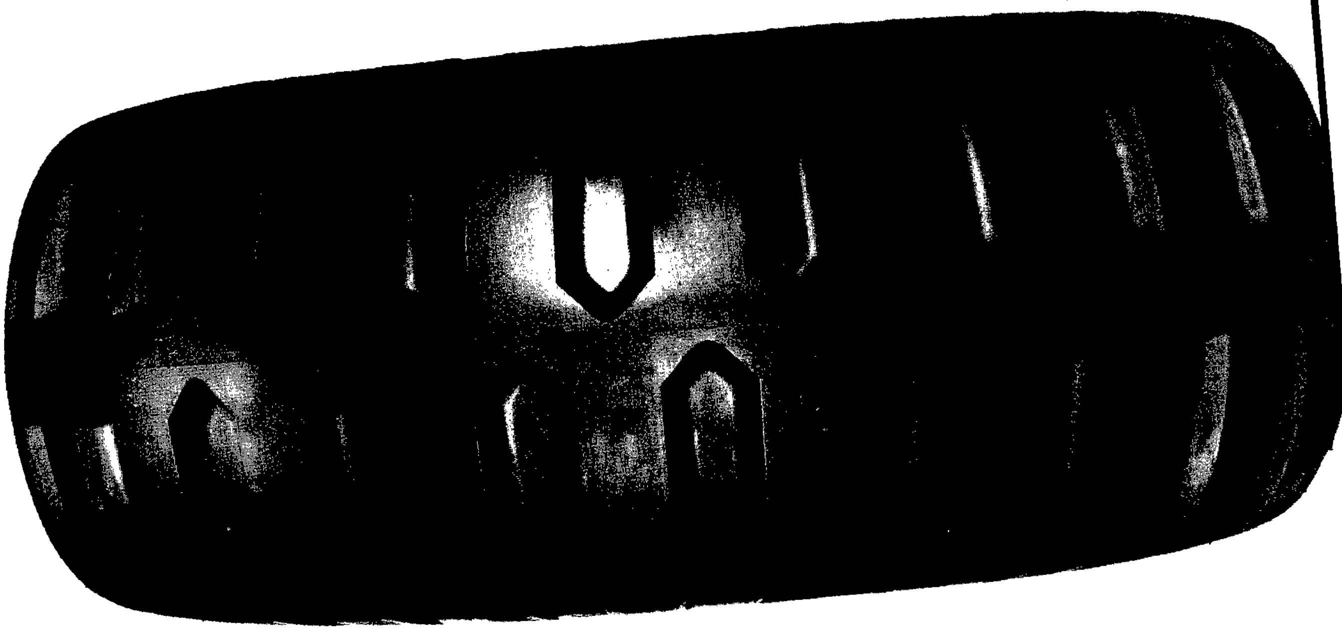
Figure 3

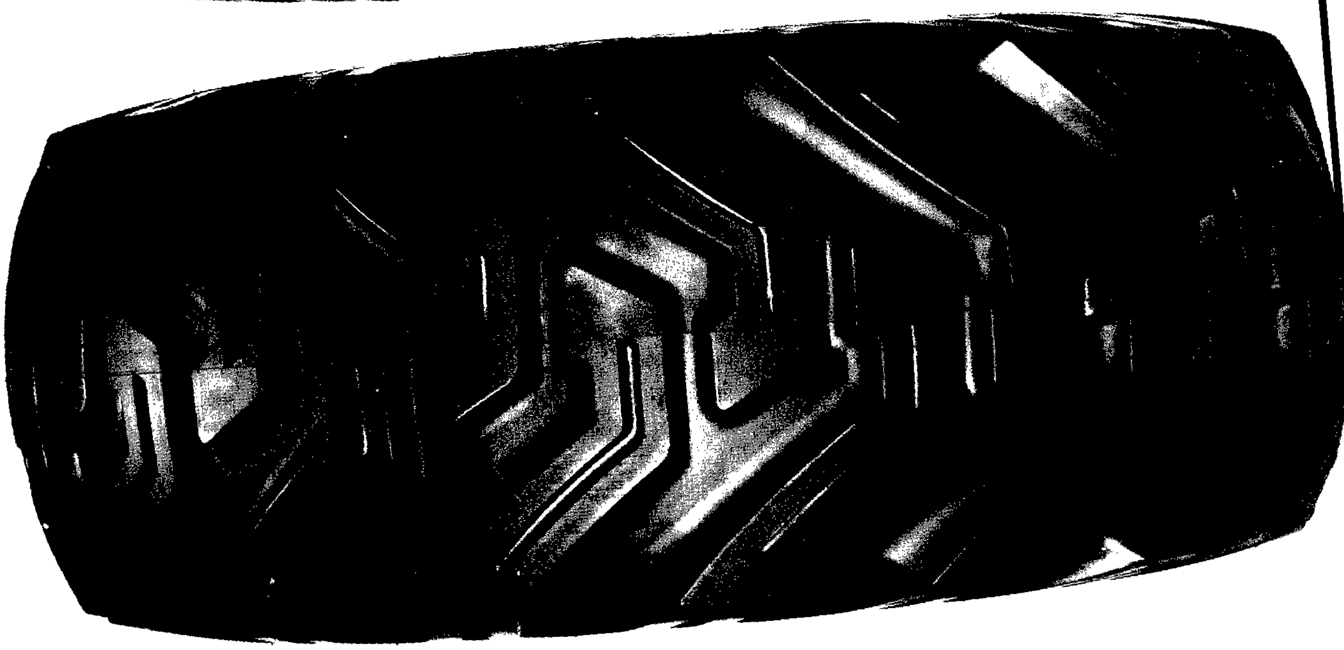


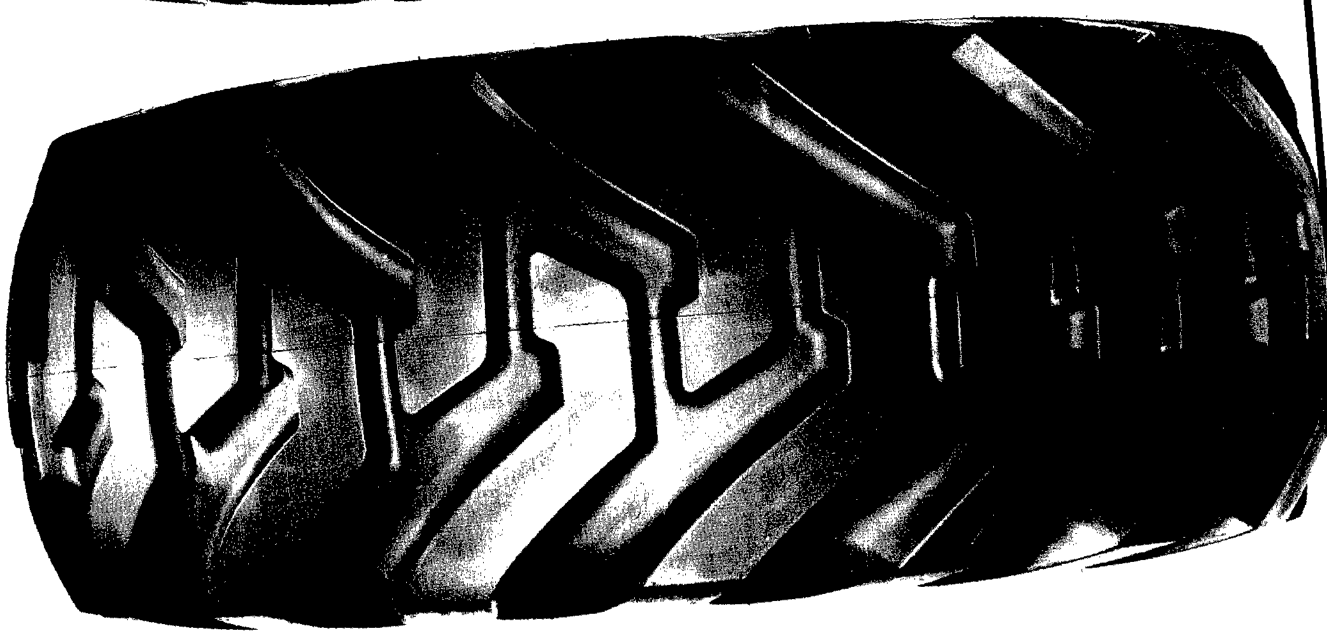
Head-on view of the three test designs
From left to right-

Super Ground Grip Goer
Super Ground Grip Goer (with grooves)
ND-CC Goer

Figure 4.







flexibility as a result of the particular blend of synthetic polymers used.

Use of the protective coatings described under Tire Compounding markedly enhances the tires' exterior compounds' resistance to atmospheric deterioration.

3. Of the three designs developed for this contract, the best design for optium performance, as determined by these tests, was the Super Ground Grip Goer tire with the grooved tread bars. This was the only tire of the three which would operate at a sufficiently low temperature to allow use of the maximum synthetic rubber construction and still permit continuous highway operation. This design, with or without the tread grooves, is approximately three times as effective in deep mud as the ND-CC Goer design. The ND-CC tire was approximately 10 to 15% more effective for drawbar pull on non-compressible surfaces and compressible soil. There was little difference in the sand performance of any of these designs. Our selection of the grooved Super Ground Grip Goer tire as the optimum was based on the premise that the prime requirement of these tires was the ability to operate continuously in highway service and provide maximum performance in mud.

4. Shown below is a table which summarizes the information obtained from the durability phase of the testing. The significant factors are that no tires were removed due to any type of premature failure. Also, the tires with the synthetic tread had a wear rating double that of the natural rubber tires.

TABLE - DURABILITY TEST SUMMARY

TYPE	SGG GOER (GROOVED)	SGG GOER (GROOVED)	ND-CC GOER
Compounding	Natural Rubber	Synthetic Rubber	Natural Rubber
Average Test Miles Per Tire Sample	10,022	15,040	7,509
Reason for Removal	Worn Smooth	Worn Smooth	Test Terminated
Durability Rating	100	150	Not Available
Tread Wear, Average Miles/mil. (1)	6.1	12.2	16.3
Tread Wear Rating	100	200	267

(1) See pp. 19-20 of Final Report, Durability Testing - Summary of Tire Tread Wear

It can be concluded from this testing that the Super Ground Grip Goer (grooved) tire with the natural rubber construction will not provide the desired 15,000 mile durability; however, through use of a synthetic construction, this level can be achieved. The ND-CC Goer design should provide approximately 20 to 25,000 miles with the natural rubber construction used, and could possibly double this figure by using the same synthetic compounds used in this test. It must be remembered that we are limited by the operating temperatures also.

Recommendations

1. Since no one design tested was clearly superior in all of the categories evaluated, it would seem that there is probably some design that would provide better overall performance than either of the three designs tested. It is our recommendation that additional testing be conducted to evaluate other design variations that would improve the mobility of the Goer vehicle.

2. This contract was limited to a tread design and compounding evaluation. It would also be beneficial to conduct tests in an attempt to evaluate the effects of various types of carcass constructions.

3. Use compound modifications to the all-synthetic tread cap compound referred to under conclusion #2 and under Tire Compounding, section B-1. These modifications were incorporated into the tires being fabricated for the European Troop Tests to be conducted in the spring of 1964.

4. Use tire protective Coating A referred to under Tire Compounding, section A-5. This coating has been used on all Goer tires manufactured by Firestone.

5. In view of the promising performance of the high-percentage-synthetic compounds in these tires, in service where natural rubber is normally used, continued compounding studies should be conducted to improve upon the overall performance characteristics of the high-synthetic-bearing compounds.

Background

Prior to this development contract, special tires were produced in existing commercial molds and supplied for use on the first four Goer vehicles. Design features of these tires were aimed primarily at maximum traction and continuous highway operation.

These tires performed fairly well, but a need was recognized for tires designed specifically for Goer vehicle-type service.

Subsequently, this contract called for production of four tires of each of three different designs. In addition, tires were to be produced with the maximum feasible synthetic content. In order to test these various characteristics, the following five tire specifications were issued and the corresponding tires produced:

Serial	Type	No. Tires	% Synthetic
K12500	SGG Goer	2	11%
K12600	SGG Goer	2	52%
K12700	SGG Goer with grooves	4	13%
K12800	ND-CC Goer	2	14%
K12900	ND-CC Goer	2	56%

Modification 1 dated 22 June 1961 called for one of each of these tires to be tested on an indoor laboratory drum to provide a temperature comparison.

Modification 3 dated 20 September added on-vehicle testing which would include an evaluation of these tires for continuous highway operation, mud, sand, drawbar pull, slopes, and maneuverability. These tests were subcontracted to Le-Tourneau-Westinghouse with ATAC approval. They conducted the highway temperature comparison and the mud tests but the drawbar pull tests in sand, non-compressible surface, and compressible soil were subcontracted by them to Nevada Automotive Test Center, Carson City, Nevada.

Modification No. 7 added a 20,000 mile durability test and twelve additional tires were supplied. Six of these were control tires in the Super Ground Grip Goer (with grooves) design with standard earthmover tire construction and compounding (natural rubber) features. The remaining six tires were the same except that the maximum possible synthetic rubber content was used.

In addition five tires in the ND-CC Goer design were purchased under contract number DA-20-089-ORD-40018. These tires were used as replacements for the durability test. Four of these tires attained 7500 miles before the 20,000 mile test limit was reached.

Mold Design and Tire Construction Development

The design of the tires for the 16 ton Goer vehicle requires consideration of the following criteria:

1. Gross Vehicle Weight - 64,000 Lbs.
   4 Tires
   58% of load on front axle
   42% of load on rear axle

2. Speed - Maximum over 30 MPH
   Cruise at 20 MPH
   Water at 4 MPH

3. Roadability - Capable of long sustained hauls.

4. Traction - Maximum in mud.

5. Flotation - Good in all soils (mud and sand).

6. Minimum vehicle.
   Ground Clearance - 30"

7. Ozone Resistance - Equivalent ot standard military specification requirements.

8. Compounding - Maximum feasible synthetic content.

9. Durability - 25,000 miles.

From the above data, the 29.5-25 size was selected as the optimum tire for use on this vehicle. This will provide the load carrying capacity and ground clearance required, and this wide base profile will provide maximum flotation and traction.

After the size selection was finalized, it was necessary to arrive at the best possible tread configurations. It was originally decided to bring in one tire mold with three separate tread rings; however, upon consideration of factory production engineers, it was decided to fabricate two unicast molds rather than one. Although this increased the cost over the original estimate, the advantages provided both the contractor and the customer decisively outweighed the additional cost to the contractor.

The three tread designs selected were:

1. Super Ground Grip Goer (maximum traction) See figure 1

2. Super Ground Grip Goer with grooves (modified maximum traction). See figure 2.

3. ND-CC Goer. See figure 3

The Super Ground Grip Goer design was similar to our own commercially proven Super Ground Grip WB tire. The purpose of the tread grooves in the modified tire was to reduce the tire operating temperature. Prior experience indicated that this would reduce tire operating temperatures by approximately 15°F.

Design dimensions for the ND-CC Goer were based on Tire and Rim Association limits and design criteria in MIL-T-12459A for cross country type tires.

Shown below is an evaluation of the performance characteristics which we felt could be expected from these three designs:

	Super Ground Grip Goer	Super Ground Grip Goer (with Grooves)	ND-CC Goer
Directional	Yes	Yes	No
Mud Traction	Excellent	Excellent	Good
Sand	Good	Good	Good
Highway Roadability	Fair	Fair	Fair
High Speed	Good	Excellent	Good
Continuous Operation			
Wear Resistance	Good	Good	Good
Cut Resistance	Fair	Fair	Fair

In order to carry the required load and yet have the lightest possible construction, a 16 ply rating construction was chosen as the optimum. The load rating for this tire is 17,190 pounds at 25 psi inflation for intermittent operation and 14,520 pounds at 30 psi for continuous highway operation. The weight of these tires is approximately 800 pounds.

The carcass construction utilized 840/2 nylon with a tensile of 30 pounds per cord. These twelve tires were of twin bead construction, 14 actual plies, and two tread plies. They also had an under base of .45". All other features were standard production items with the exception of the compounding.

TIRE COMPOUNDING

A. ORIGINAL CONTRACT

1. BASIC REQUIREMENTS FOR GOER TIRE COMPOUNDS

    1. COMPOUND STOCK WITH MAXIMUM SYNTHETIC CONTENT
    2. COMPOUND STOCKS FOR PROTECTION AGAINST ATMOSPHERIC DETERIORATION
    3. COMPOUND PROTECTIVE COATING TO COMPARE WITH (2)
    4. COMPOUND BEST COMPROMISE BETWEEN COOL RUNNING TIRE AND CUT, CHIP AND WEAR RESISTANT TREAD AND SIDEWALL

2. COMPOUNDS SELECTED FOR FABRICATION OF TIRES

TIRE IDENTIFICATION

29.5-25 16 PLY TUBELESS

	SERIAL IDENTIFICATION	COMPOUND LINE-UP	% OF POLYMER AS SYNTHETIC	NO. OF TIRES
SUPER GROUND GRIP GOER MAXIMUM TRACTION DESIGN	K12500	1	11	2
	K12600	II	52	2
SUPER GROUND GRIP GOER MODIFIED MAXIMUM TRACTION DESIGN	K12700	I	13	4
ND-CC GOER DESIGN	K12800	I	14	2
	K12900	III	56	2

2. COMPOUNDS SELECTED FOR FABRICATION OF TIRES

	COMPOUND DESCRIPTION		
	LINE UP I	LINE UP II	LINE UP III
Tire Serial Identification	K12500, K12700, K12800	K12600	K12900
Tread	NR	Isoprene	Oil Extended FR-S
Sidewall	½ Neoprene-½ NR	½ Isoprene-½ NR	Oil Extended FR-S
Outer Body	NR	NR	¼ Isoprene-3/4 NR
Inner Body	¼ Diene - 3/4 NR	Same as Line Up I	Same as Line Up I
Innerliner	7/10 Chlorobutyl-3/10 NR	" " " " "	" " " " "
Bead Insulation	FRS	" " " " "	" " " " "
Other Bead Compounds	NR	" " " " "	" " " " "

3. COMPOUND DESIGN

COMPOUND LINE UP I

Compound Line Up I with 11 to 14% of the polymer as synthetic (depending on weight distribution of tire components) is the least deviation from standard Off-The-Road Tire Compounding.

This Line Up features an all natural rubber tread with superior cut and tear resistance. The tread is specially compounded for cool running and resistance to atmospheric deterioration.

The sidewall is compounded from a polymer blend of 50% Neoprene and 50% natural rubber, and is extremely resistant to atmospheric deterioration.

The outer body is compounded from all natural rubber. It is cool running and furnishes maximum tear and heat resistance.

25% of the polymer as Diene and 75% natural rubber is the feature of the inner body. It is cool running and heat resistant.

The innerliner is compounded with 70% of the polymer as chlorobutyl and 30% natural rubber. Excellent heat resistance and impermeability to air are its features. One-half as much air is transmitted at 176°F and 75 psi through this type innerliner than through an all natural rubber innerliner.

COMPOUND LINE UP II

Compound Line Up II with 52% of the polymer as synthetic is a greater departure from standard compounding. Its tread polymer is 100% Isoprene specially compounded for best compromise between cool running and resistance to wear, tear and atmospheric deterioration.

The sidewall, compounded from 50% Isoprene and 50% natural rubber, is tear, cut and atmospheric deterioration resistant.

The same compound features as Line Up I are used in the remainder of the tire.

COMPOUND LINE UP III

Compound Line Up III, with 56% of the polymer as synthetic, features tread and sidewall compounds with all of the polymer as oil extended FRS, specially compounded for resistance to atmospheric deterioration.

The tread and sidewall are also compounded for cool running and cut and tear resistance.

Isoprene as 25% and natural rubber as 75% of the polymer is the feature of the outer body. The outer body is compounded for cool running, and heat and tear resistance.

The remaining compounds are the same as Line Up II and III.

4. COMPOUND PROPERTIES

TREAD

Compound Line Up:	I	II	III
Tire Identification Serial:	K12500,K12700 K12800	K12600	K12900
Formulation:	100 NR	100 Isoprene	131 FR-S 123
Normal (70°F) Stress-Strain			
Tensile, psi	4175	3025	3075
300% Modulus, psi	1750	1625	825
Elongation, %	540	480	675
Tensile @ 275°F			
Tensile, psi	1100	625	700
Elongation, %	320	210	340
Normal (70°F) Tensile After 2 Days @ 212°F			
Tensile, psi	2250	1275	2675
Elongation, %	250	185	465
Firestone Flexometer			
Running Temp., °F	226	240	275
Deflection, %	15.3	16.7	20.7
Shore "A" Hardness	64	63	62
Ring Tear			
Normal-70°F, lb/in	800	500	525
-212°F, lb/in	300	200	275
Brittle Point			
ASTM D746-57T, °F	-63	-60	-45

4. COMPOUND PROPERTIES

SIDEWALL

Compound Line Up:	I	II	III
Tire Identification Serial:	K12500,K12700, K12800	K12600	K12900
Formulation:	50 NR	50 NR	131 FR-S 123
	50 Neoprene	50 Isoprene	
Normal (70°F) Stress-Strain			
Tensile, psi	3175	3725	3000
300% Modulus, psi	900	975	500
Elongation, %	640	635	765
Tensile @ 275°F.			
Tensile, psi	700	700	400
Elongation, %	350	360	270
Normal (70°F) Tensile After 2 Days @ 212°F			
Tensile, psi	1975	1025	2575
Elongation, %	405	265	570
Firestone Flexometer			
Running Temp., °F	203	201	246
Deflection, %	26.7	20.0	24.7
Shore "A" Hardness	50	57	57
Ring Tear			
Normal-70°F, lb/in	325	575	400
-212°F, lb/in	100	225	175
Brittle Point			
ASTM D746-57T, °F	-71	-53	-45

4. COMPOUND PROPERTIES

BODY

Compound Line Up:	I	II	III	I,II,III
Formulation:	Outer Body	Outer Body	Outer Body	Inner Body
	100 NR	100 NR	75 NR	75 NR
			25 Isoprene	25 Diene
Normal (70°F) Stress-Strain				
Tensile, psi	4125	4100	3975	2900
300% Modulus, psi	1200	925	875	800
Elongation, %	600	670	685	580
Tensile @ 275°F.				
Tensile, psi	1250	1250	1025	475
Elongation, %	520	630	540	220
Normal (70°F) Tensile After 2 Days @ 212°F				
Tensile, psi	2050	1675	1925	1525
Elongation, %	375	390	425	405
Firestone Flexometer				
Running Temp., °F	189	184	188	132
Deflection, %	23.3	24.7	26.0	20.7
Shore "A" Hardness	52	51	49	54
Ring Tear				
Normal-70°F, lb/in	550	850	550	200
-212°F, lb/in	300	350	325	125
Brittle Point				
ASTM D746-57T, °F	-69	-67	-63	-66

4. COMPOUND PROPERTIES

REMAINDER OF COMPOUNDS

Innerliner, Bead Insulation, Bead Cover, Bead Filler, Chafer and Abrasion Gum Strip compounds are all standard Firestone compounds.

5. PROTECTION FROM ATMOSPHERIC DETERIORATION

COMPOUND PROTECTION

Tread and sidewall compounds feature standard Firestone Off-The-Road antiozonants for maximum resistance to atmospheric deterioration.

The oil extended FR-S tread and sidewall, and the Neoprene/natural rubber sidewall are superior to the Standard Military Control for accelerated weathering in the Firestone Weatherometer.

The natural rubber and Isoprene treads, and the natural rubber/ Isoprene sidewall, while somewhat inferior to the Standard Military Control for accelerated conditions, are expected to be well protected for normal operations.

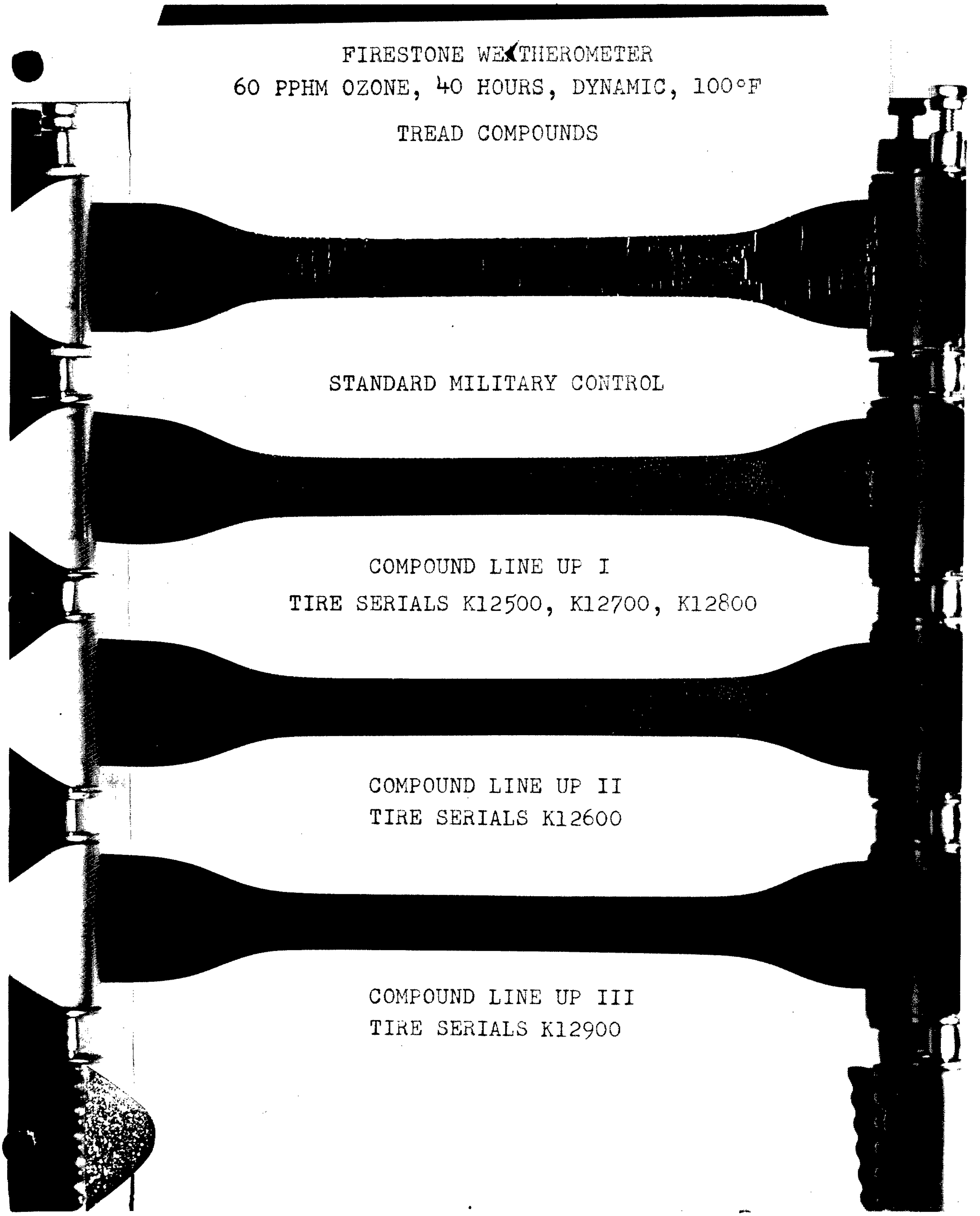
Comparisons of tread and sidewall compounds and the Standard Military Control were made in the Firestone Weatherometer under the following conditions:

1. 60 parts per 100 million of Ozone - 40 hrs. exposure-static - 100°F. - pre-aged 3 days at 158°F - 12½% elongation

2. Same as above except dynamic (10 min. flex - 50 min. static per hour) and strips not pre-aged

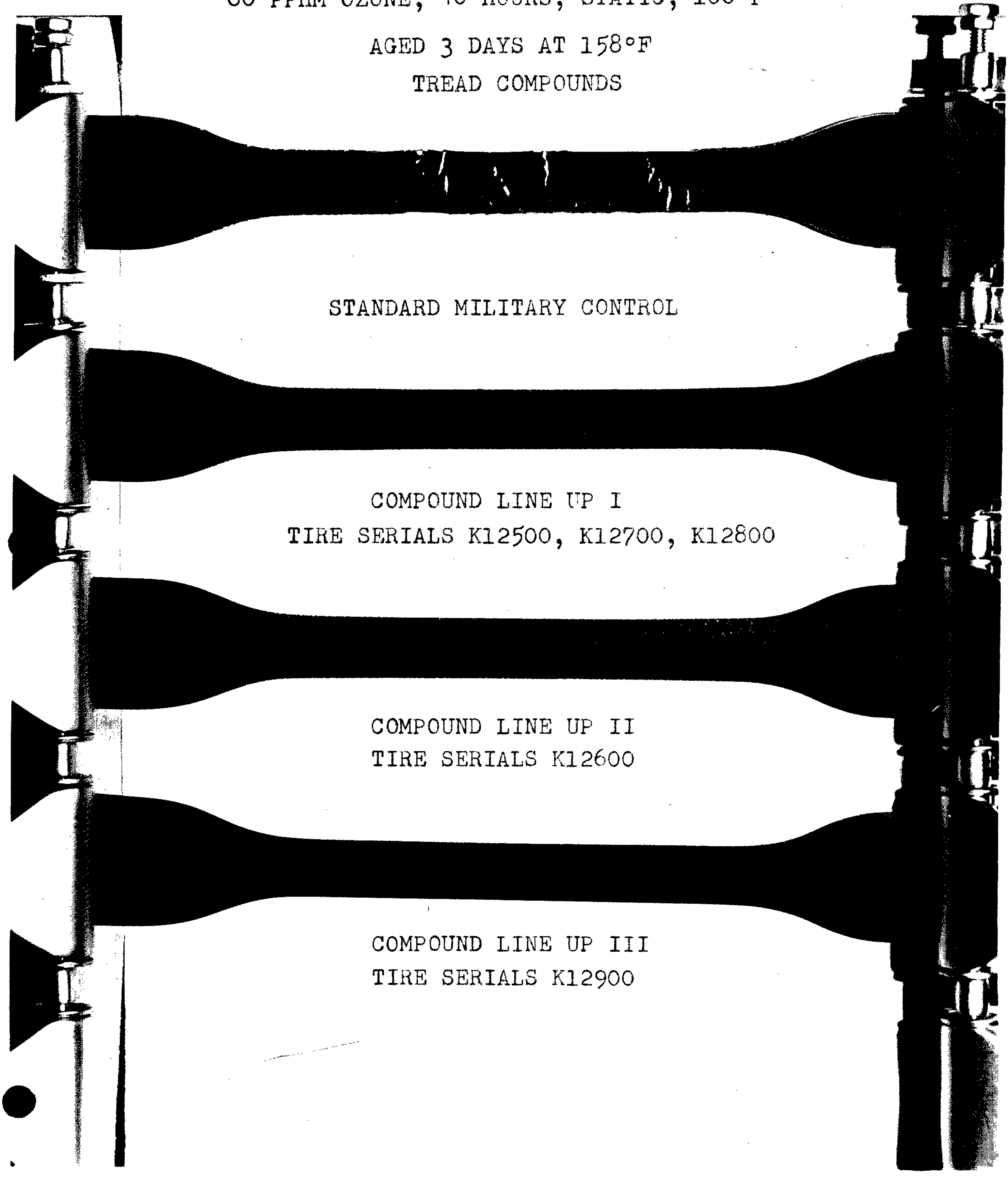
3. Same as (1) above except exposure at 40°F.

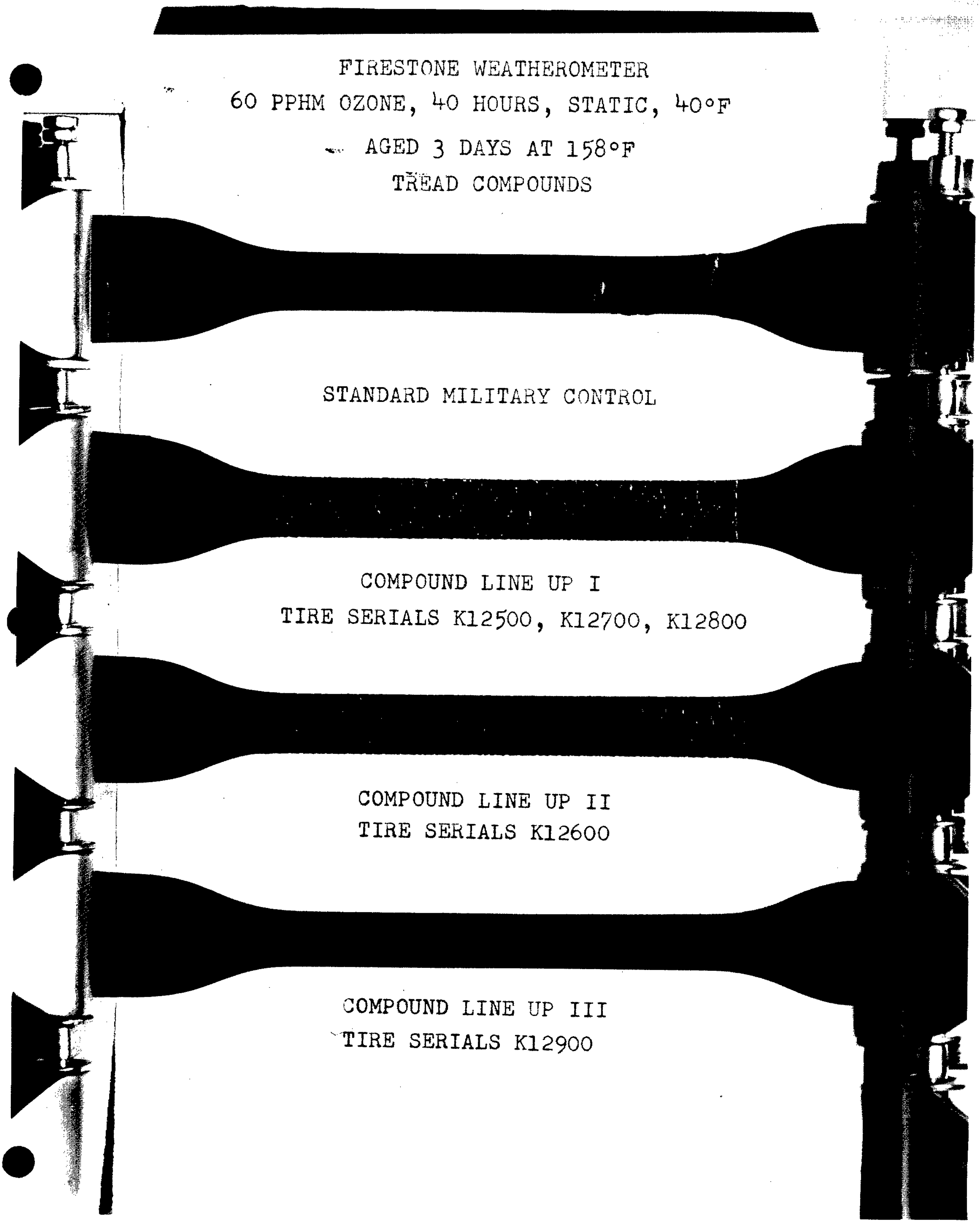
Photographs of results are on the following pages.

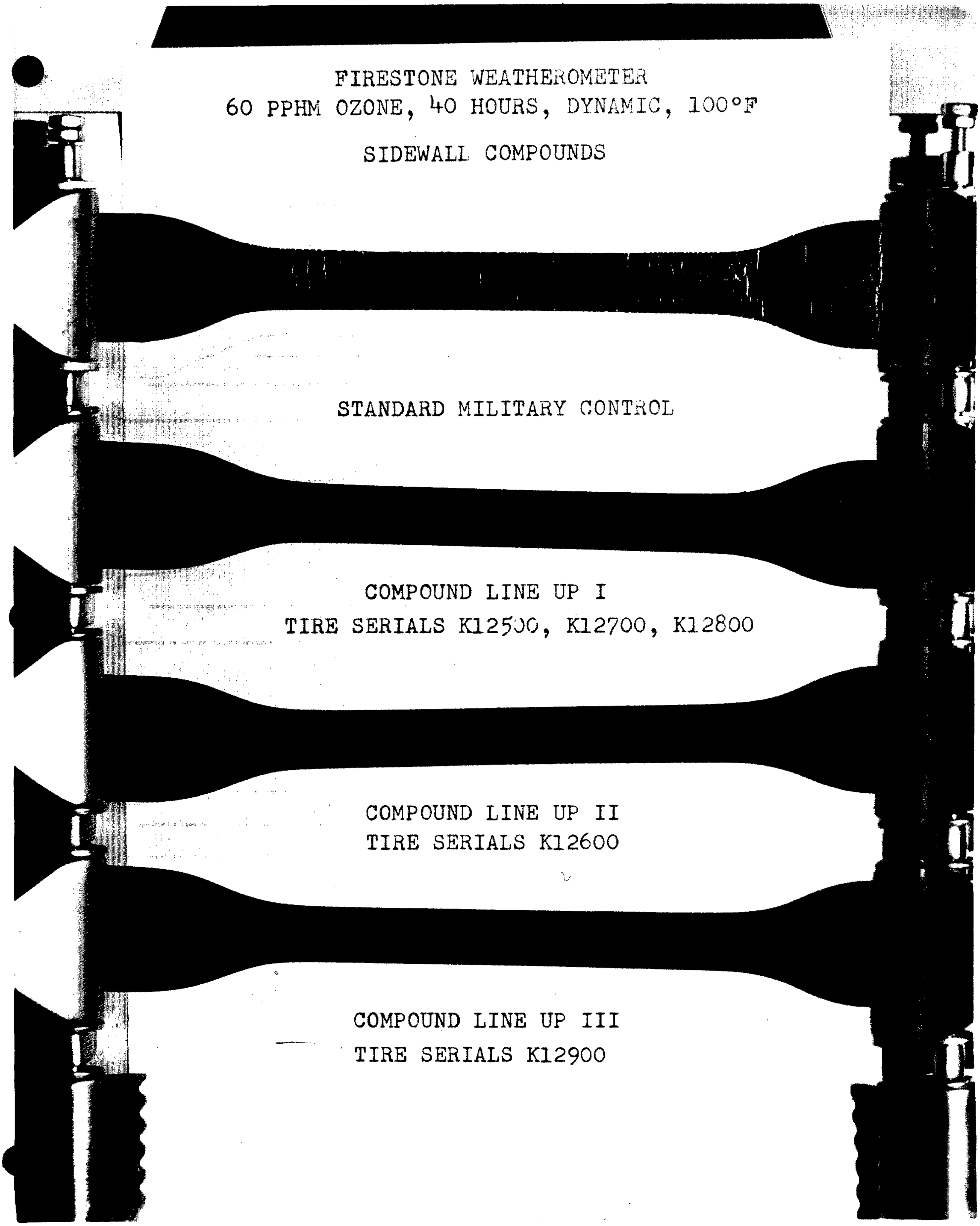

FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, DYNAMIC, 100°F
TREAD COMPOUNDS
STANDARD MILITARY CONTROL
COMPOUND LINE UP I
TIRE SERIALS K12500, K12700, K12800
COMPOUND LINE UP II
TIRE SERIALS K12600
COMPOUND LINE UP III
TIRE SERIALS K12900

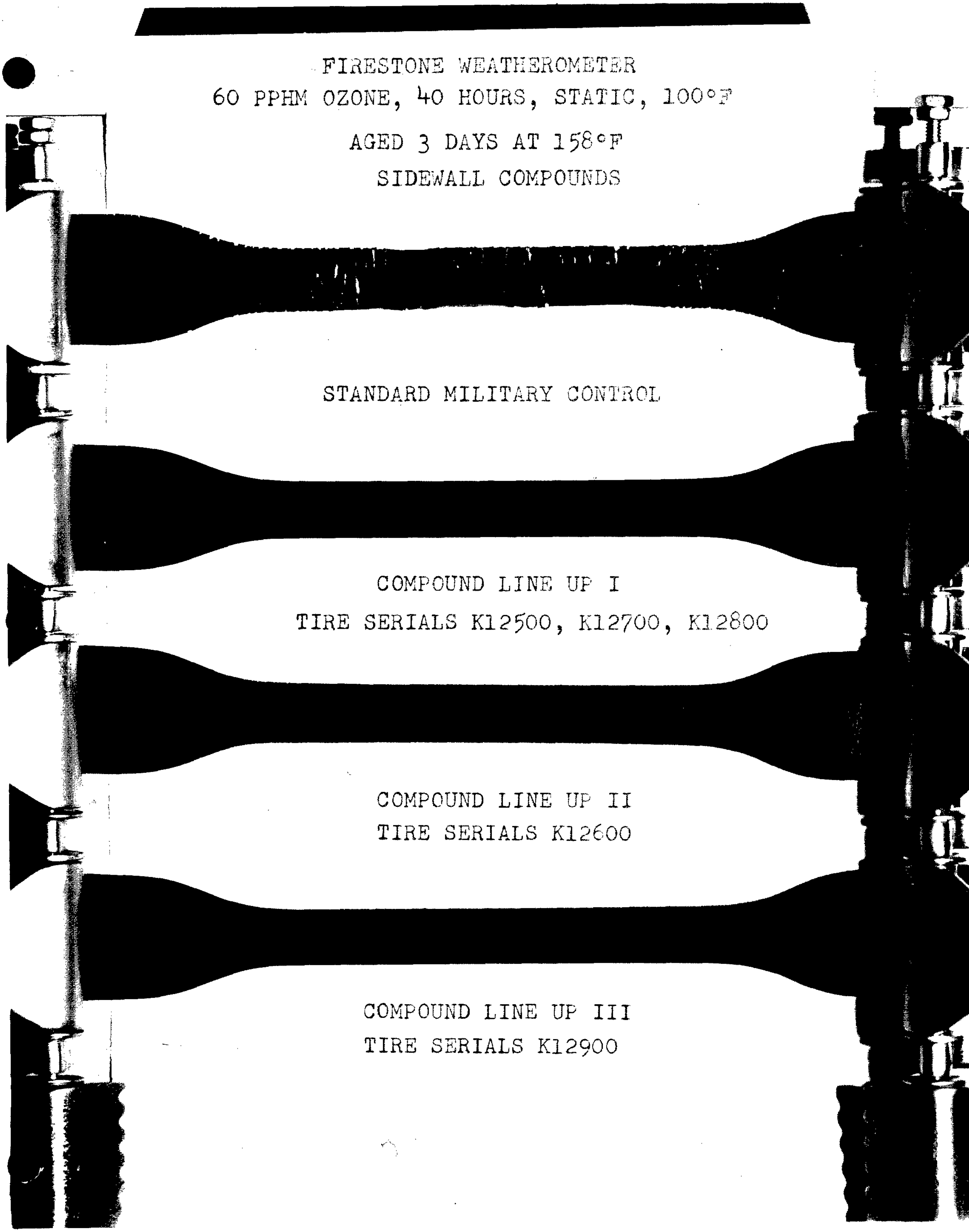
FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, STATIC, 100°F

AGED 3 DAYS AT 158°F
TREAD COMPOUNDS



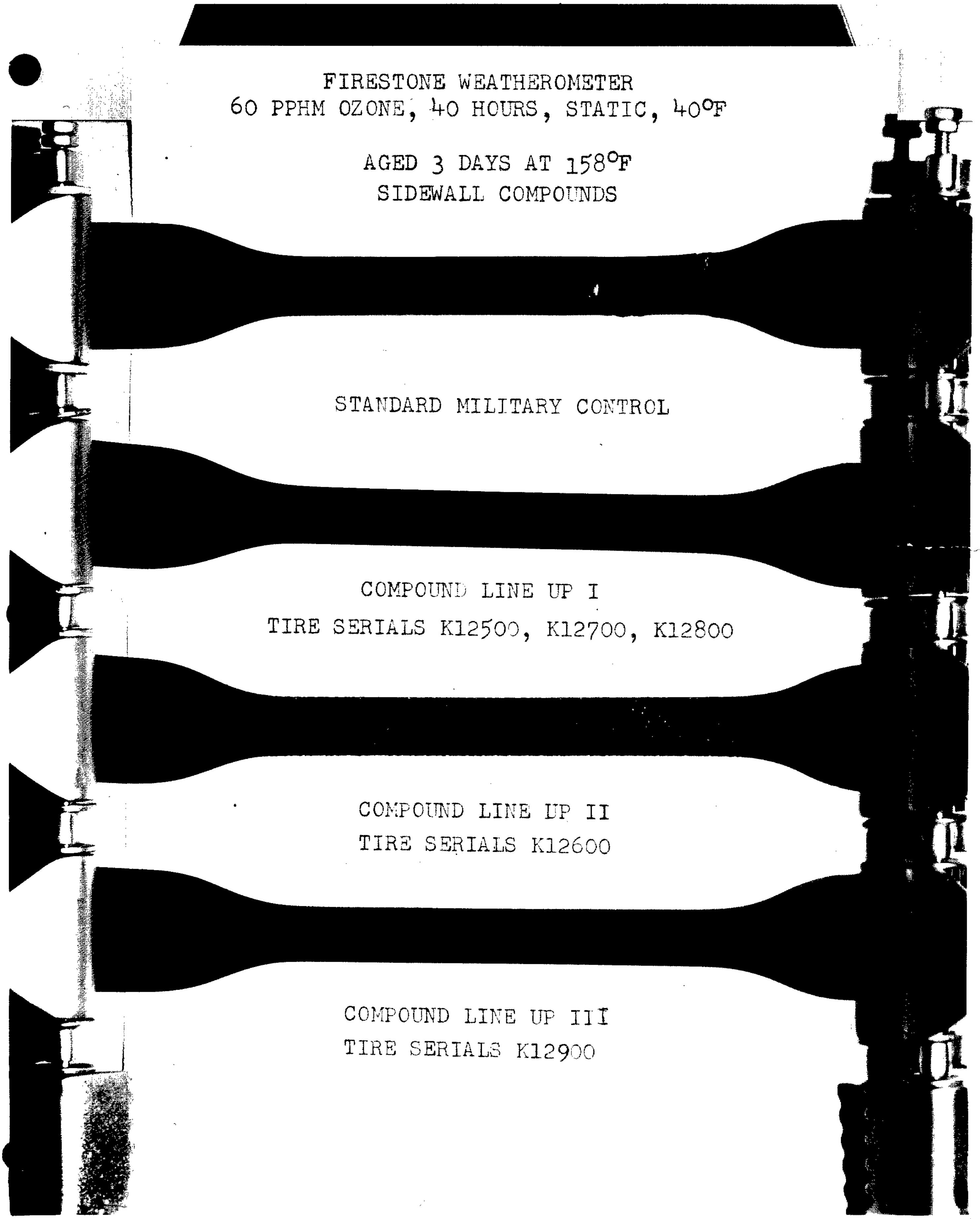

FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, STATIC, 40°F
AGED 3 DAYS AT 158°F
TREAD COMPOUNDS
STANDARD MILITARY CONTROL
COMPOUND LINE UP I
TIRE SERIALS K12500, K12700, K12800
COMPOUND LINE UP II
TIRE SERIALS K12600
COMPOUND LINE UP III
TIRE SERIALS K12900


FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, DYNAMIC, 100°F
SIDEWALL COMPOUNDS
STANDARD MILITARY CONTROL
COMPOUND LINE UP I
TIRE SERIALS K12500, K12700, K12800
COMPOUND LINE UP II
TIRE SERIALS K12600
COMPOUND LINE UP III
TIRE SERIALS K12900


FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, STATIC, 100°F
AGED 3 DAYS AT 158°F
SIDEWALL COMPOUNDS
STANDARD MILITARY CONTROL
COMPOUND LINE UP I
TIRE SERIALS K12500, K12700, K12800
COMPOUND LINE UP II
TIRE SERIALS K12600
COMPOUND LINE UP III
TIRE SERIALS K12900

FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, STATIC, 40°F

AGED 3 DAYS AT 158°F
SIDEWALL COMPOUNDS



6. PROTECTION FROM ATMOSPHERIC DETERIORATION

PROTECTIVE COATINGS

From previous experience and studies during the period of this contract, the following two coatings were selected as the most practical.

A. Firestone protective coating based on N, N'-dioctyl-p-phenylene diamine.

B. Firestone protective coating based on Hypalon.

Coating A protects against atmospheric deterioration by depositing a layer of antiozonant which is absorbed into the surface of the tire.

Coating B protects against atmospheric deterioration by depositing a tough, clinging, elastic, protective film on the surface of the tire.

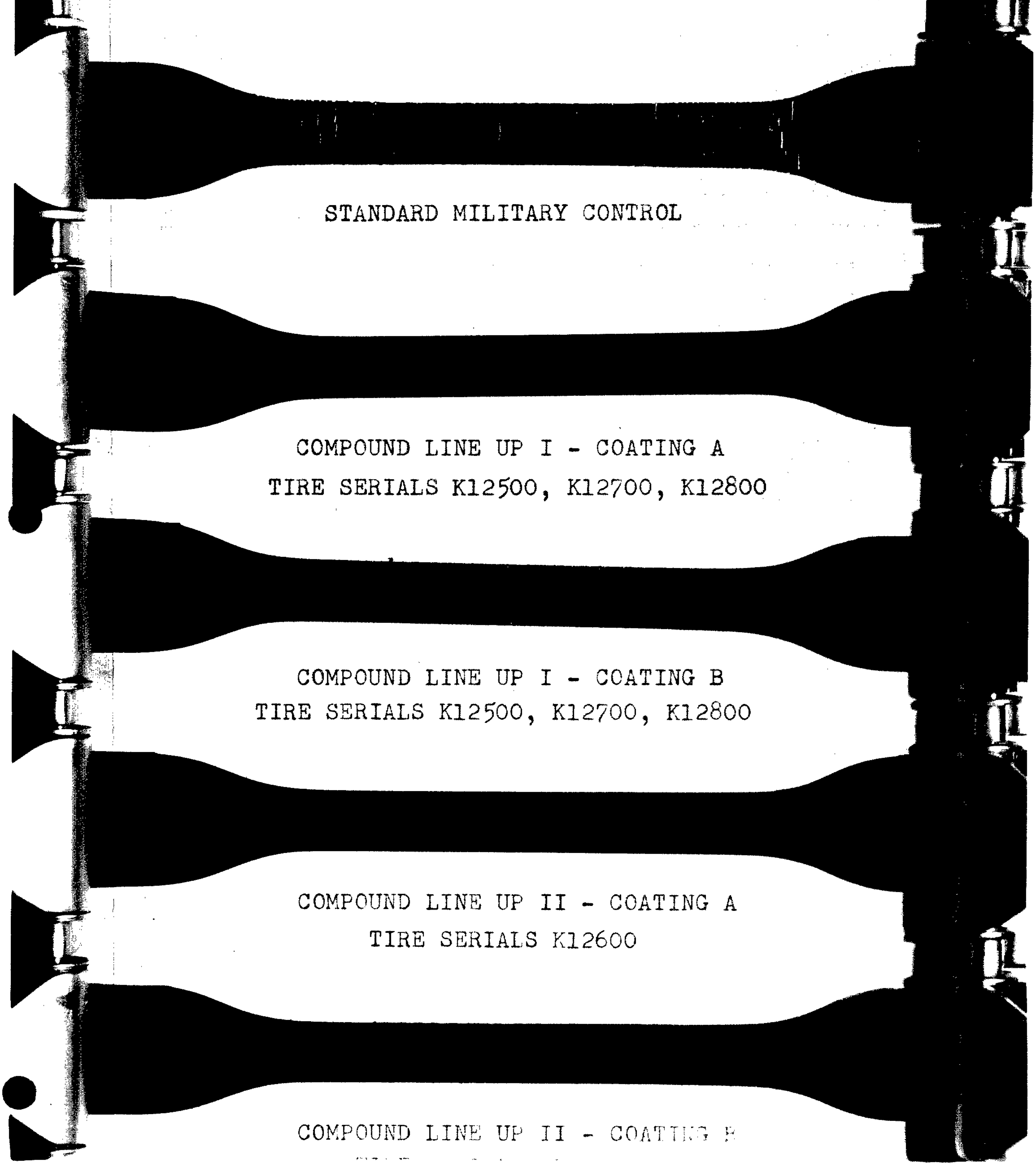
These coatings are very effective, but have the deficiency typical of coatings in that severe weathering occurs where the film is broken or not continuous, as shown in the photographs.

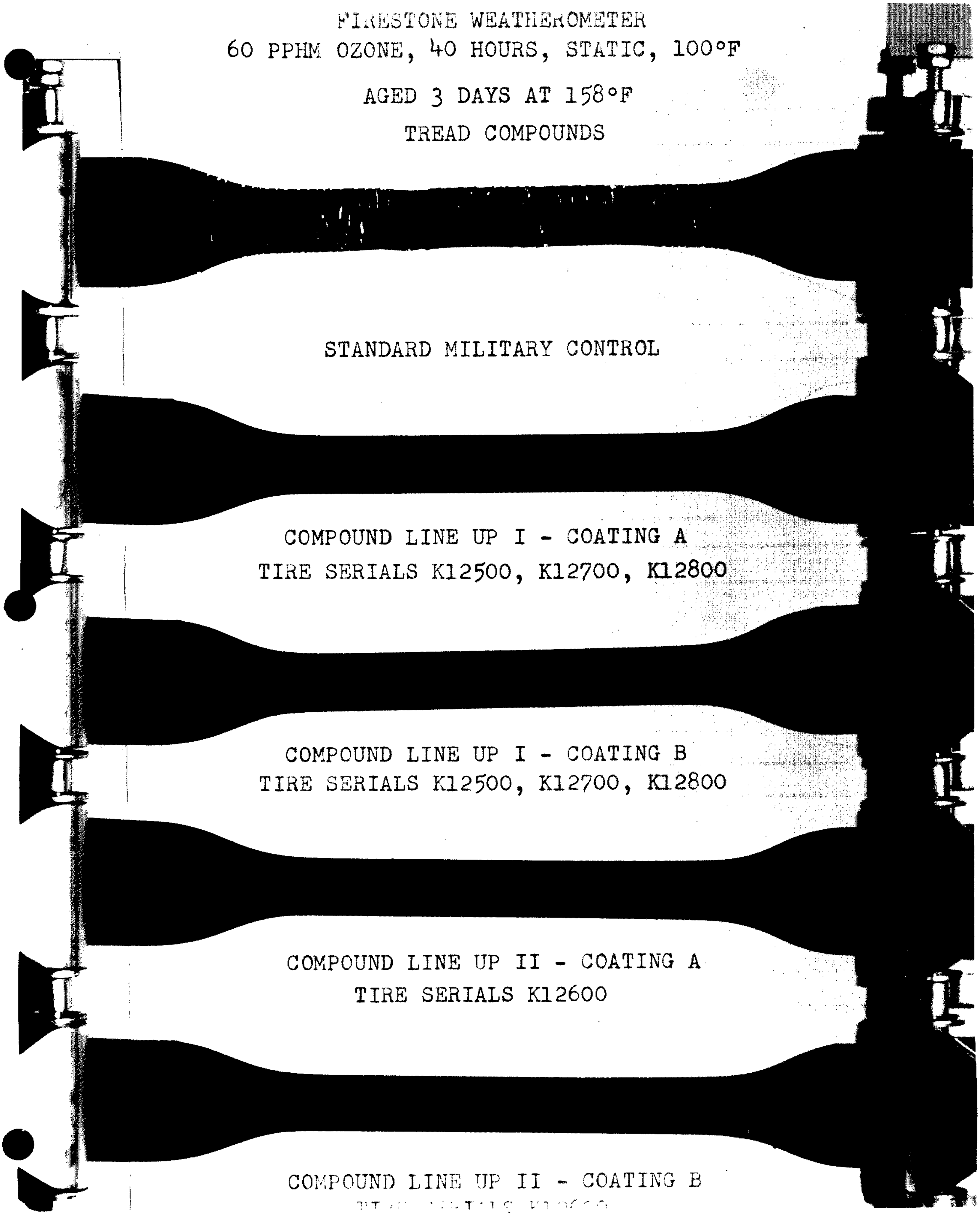
Comparisons of accelerated weathering, in the Firestone Weatherometer, of these coatings on the natural rubber tread (Line Up I), the Isoprene tread (Line Up II), and the natural rubber/Isoprene sidewall (Line Up II) are shown in the attached photographs.

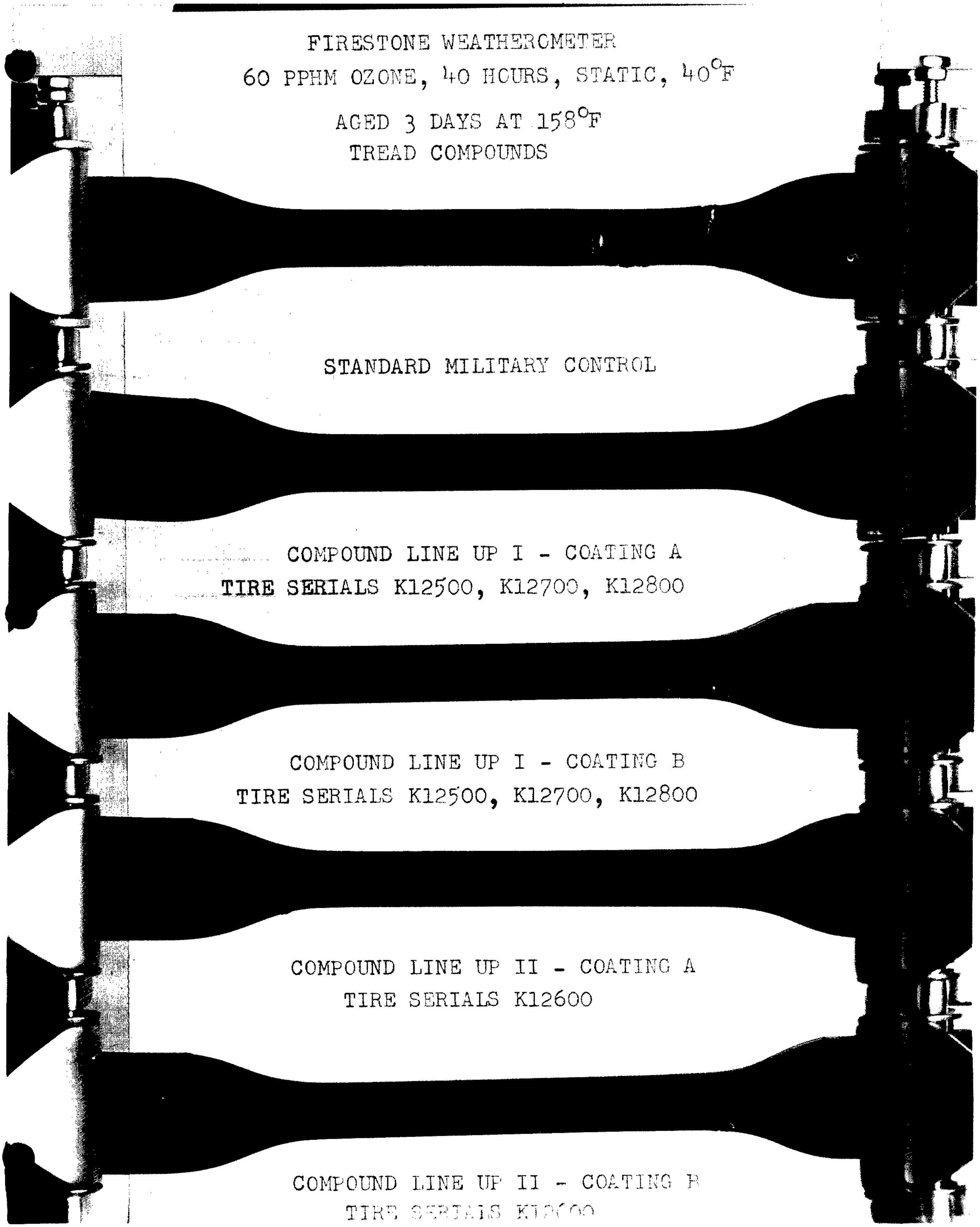
Test conditions are the same as those described under <u>Compound Protection</u>.

FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, DYNAMIC 100°F

TREAD COMPOUNDS

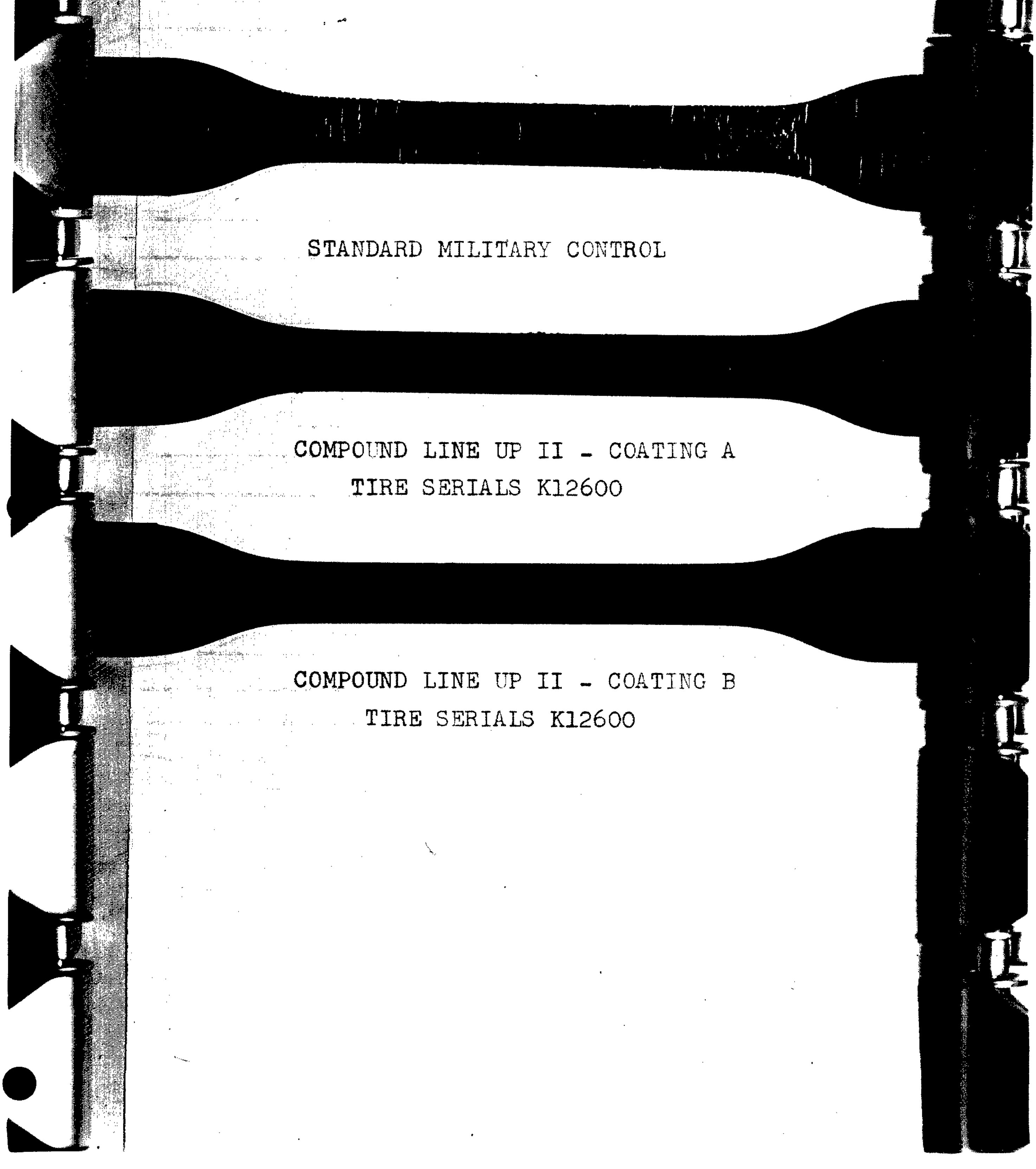



FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, STATIC, 100°F
AGED 3 DAYS AT 158°F
TREAD COMPOUNDS
STANDARD MILITARY CONTROL
COMPOUND LINE UP I - COATING A
TIRE SERIALS K12500, K12700, K12800
COMPOUND LINE UP I - COATING B
TIRE SERIALS K12500, K12700, K12800
COMPOUND LINE UP II - COATING A
TIRE SERIALS K12600
COMPOUND LINE UP II - COATING B


FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, STATIC, 40°F
AGED 3 DAYS AT 158°F
TREAD COMPOUNDS
STANDARD MILITARY CONTROL
COMPOUND LINE UP I - COATING A
TIRE SERIALS K12500, K12700, K12800
COMPOUND LINE UP I - COATING B
TIRE SERIALS K12500, K12700, K12800
COMPOUND LINE UP II - COATING A
TIRE SERIALS K12600
COMPOUND LINE UP II - COATING B

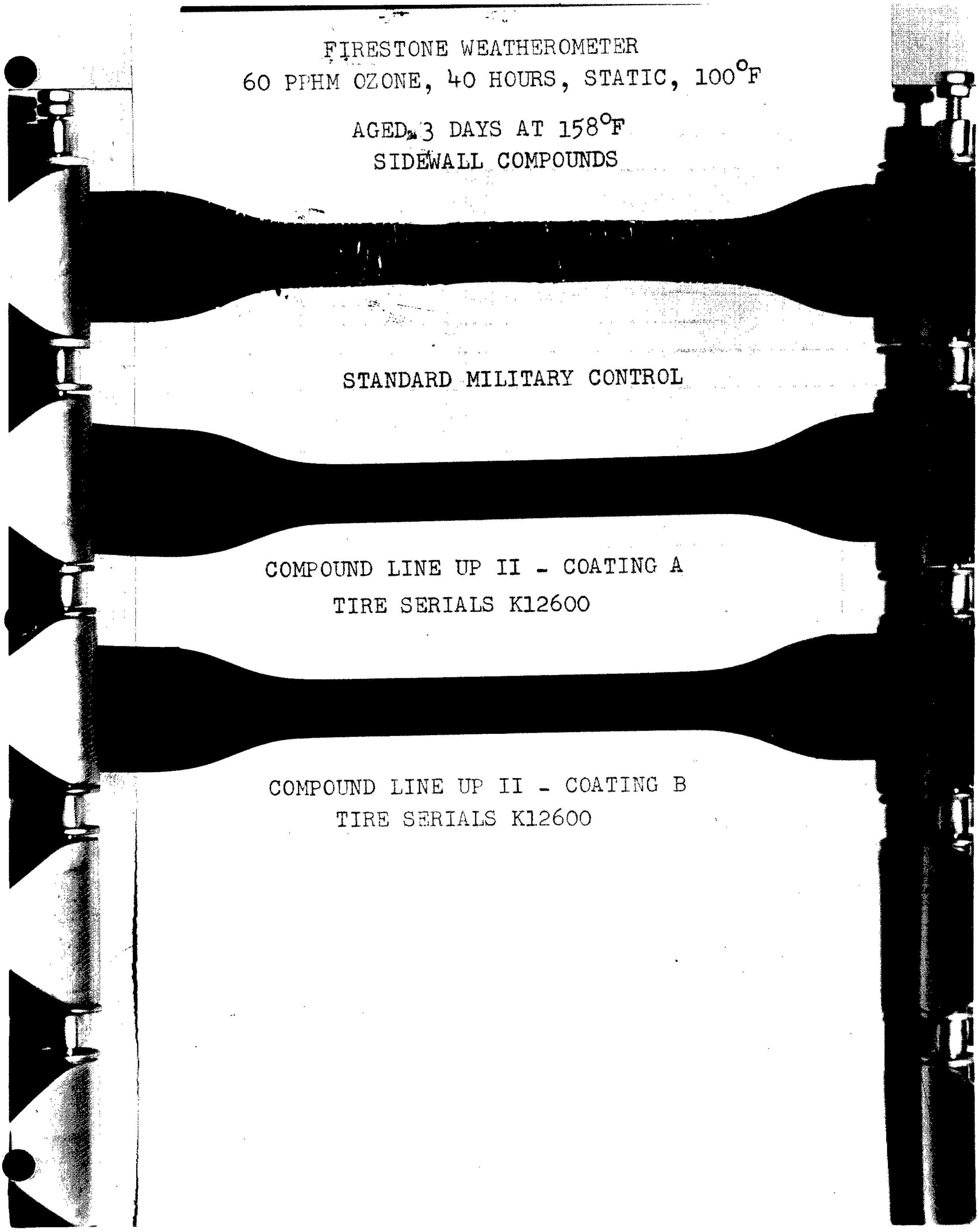
FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, DYNAMIC, 100°F

SIDEWALL COMPOUNDS



FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, STATIC, 100°F

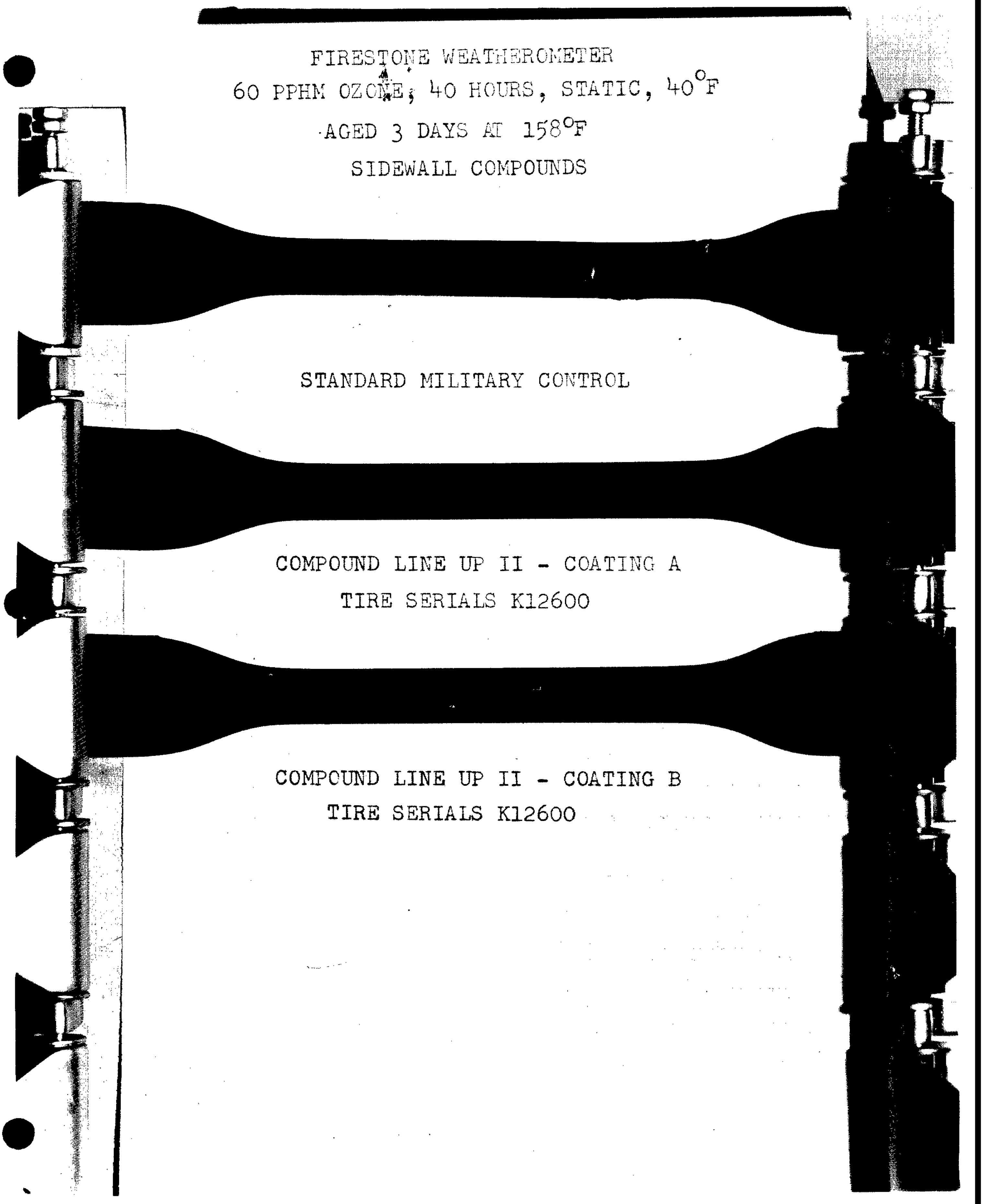
AGED 3 DAYS AT 158°F
SIDEWALL COMPOUNDS



STANDARD MILITARY CONTROL

COMPOUND LINE UP II - COATING A
TIRE SERIALS K12600

COMPOUND LINE UP II - COATING B
TIRE SERIALS K12600


FIRESTONE WEATHEROMETER
60 PPHM OZONE, 40 HOURS, STATIC, 40°F
AGED 3 DAYS AT 158°F
SIDEWALL COMPOUNDS
STANDARD MILITARY CONTROL
COMPOUND LINE UP II - COATING A
TIRE SERIALS K12600
COMPOUND LINE UP II - COATING B
TIRE SERIALS K12600

B. DURABILITY TESTS

1. COMPOUND MODIFICATIONS

Prior to fabricating the 29.5-25, 16 ply SGG GOER tires for the Durability Tests, a review of the original three compound line ups' performance pointed out the need for some reconsiderations of the compound design. In order to improve the tires' durability characteristics from an overall compromise between cool running and cut, chip and wear resistance, a number of modifications were made in the compounding design. An overall compromise, utilizing the maximum synthetic content felt to be permissible, was chosen for one set of tires (K25500 Serial Identification), to be tested against control tires (K25300 Serial Identification) using standard Firestone Off-The-Road compounds (approximately all natural rubber).

The final selection of compounds featured a three-piece tread construction (details below) to obtain the best compromise between cool running for separation resistance and cut, chip, tear and wear resistance, while incorporating synthetic into a portion of tread.

The final compound combination resulted in a synthetic content of 50% of the polymer used.

Tread Cap or Veneer: An all-synthetic compound with a polymer blend of 50% Diene and 50% oil-extended FRS. The synthetic portion of the tread is confined to essentially only the lugs of the design to keep its higher heat build-up characteristics (relative to natural rubber) away from the critical separation area of the tire on top of the tire carcass. The use of Diene imparts added wear and cracking resistance over the previous all oil-extended FRS tread compound (original contract work, Compound Line Up III), plus giving an improvement in low temperature flexibility.

Tread Base: An intermediate layer of a compound with a 75% natural rubber-25% Isoprene polymer blend, compounded to provide the best compromise between cool running and wear, cut, chip and tear resistance. The use of a predominantly natural rubber compound between the tread cap and carcass permits the use of the all-synthetic tread cap with no loss in separation resistance.

Tread Cushion: A separation-resistant layer compound lying between the tread base and tire carcass. This compound contains a polymer blend of 75% natural rubber and 25% Isoprene and is compounded for the best cool running features with the minimum sacrifice in wear, cut, chip and tear resistance. This compound in combination with the tread cap and tread base constitute the three-piece tread construction for the best overall compromise of tire compound properties.

Outer Body: Same as Tread Cushion.

Inner Body: Compounded for cool running and heat resistance, the Inner Body features a polymer blend of 75% natural rubber and 25% Isoprene.

Innerliner: Compounded with a polymer blend of 58% chlorobutyl, 24% natural rubber, and 18% Diene, this Innerliner features improved low temperature flexibility (due addition of Diene), over previous compound used in original contract tires, in addition to properties mentioned previously.

Remainder of Compounds:

Sidewall - Firestone standard Military Truck tire compound.

Others - Firestone standard Off-The-Road compounds.

Coatings - Firestone Coating A referred to under original contract compounding.

2. COMPOUND PROPERTIES

	TREAD CAP	TREAD BASE	TREAD CUSHION	INNER BODY	INNERLINER
Normal (70°F) Stress-Strain					
Tensile, psi	2850	3600	3675	3675	1275
300% Modulus, psi	650	1000	725	675	600
Elongation, %	710	590	645	610	560
Tensile @ 275°F					
Tensile, psi	650	825	725	525	-
Elongation, %	290	425	450	495	-
Normal (70°F) Tensile After *Days @ 212°F					
Tensile, psi	2475	1725	1275	1525	1175
Elongation, %	420	370	335	410	480
Firestone Flexometer					
Running Temp., °F	288	192	184	138	236
Deflection, %	18.7	12.7	26.0	24.7	24.7
Shore "A" Hardness	64	58	52	51	53
Ring Tear					
Normal-70°F, lb/in	525	300	350	575	-
-212°F. lb/in	300	150	150	225	-
Brittle Point					
ASTM D746-57T, °F.	-78	-54	-56	-59	-60

*Aging 6 days at 212°F. for Innerliner
2 days at 212°F. for All Others

3. TEST RESULTS

GENERAL CONSIDERATIONS

In view of the satisfactory performance of the previously mentioned three-piece tread construction for durability and the synthetic tread cap for wear in the Durability Tests, it was decided to use this compounding construction on the 29.5-25 16 Ply Rating SGG GOER tire manufactured for European Troop Tests. However, due to the synthetic's inherent weakness for crack growth, which evidenced itself quite prominently during the Durability Tests, modification of the synthetic tread cap stock was necessary.

TREAD COMPOUND MODIFICATIONS

The synthetic tread cap compound was modified in line with other Firestone compounding practices and experience to improve the compound's crack initiation and growth resistance. These modifications reduced the compound's ability to meet the Standard Military Ozone requirements; however, it is felt that the compound's resistance to atmospheric deterioration, especially with the protective coating used, is adequate. In general the compound's properties are similar to those of the tread cap compound listed under Durability Tests. The improvement in crack initiation and crack growth can be seen from the following data:

Firestone Groove Flexing Machine

	Previous Compound	Modified Compound	Per Cent Improvement
Crack Initiation (Minutes to Crk)	250	510	104
Crack Growth (Inches/ Hour)	.258	.110	.174

29.5-25 GOER TIRE DRUM TEMPERATURE COMPARISON

Equipment: 70.5" diameter steel drum powered by Allis Chalmers 100 H.P. AC Electric motor - 440 volts 495 RPM.

Brown Temperature Recorder and Copper-Constantan Thermocouples.

Test Features:

Serial	Features: Design	Features: Compounding
K12500	Super Ground Grip Goer	11% Synthetic
K12600	Super Ground Grip Goer	52% Synthetic
K12700	Super Ground Grip Goer (With Grooves)	13% Synthetic
K12800	ND-CC Goer	14% Synthetic
K12900	ND-CC Goer	56% Synthetic

Test Conditions:

Load - 18,500 flat plate load
Speed - 17.1 MPH
Inflation - 40 psi
Ambient Temperature - 68°F

Test Results:

	Tread Temperature			Contained	Miles	Final Hot
Serial	Center	Mid Point	Shoulder(Hot Spot)	Air Temp.	Run	Inflation
K12500-2	179	197	208	144	150	48
K12600-1	201	221	229	149	150	50
K12700-4	177	191	196	145	150	49
K12800-2	196	206	222	147	150	50
K12900-2	227	230	240	142	113	47

Conclusions:

1. Using the Super Ground Grip Goer as a control (K12500) for a running temperature comparison of these three designs, we see that the Super Ground Grip Goer (with grooves) is 12° cooler running and the ND-CC Goer is 14° hotter running than this control.

2. There are two comparisons of the effect of synthetic content on running temperature:

   A. K12500 (11%) vs. K12600 (52%)
   (208°) (229°) +21°

B. K12800 (14%) vs. K12900 (56%)
(222°) (240°) +18°

This shows that the higher synthetic content is 18-21° hotter than the same tire with the lower synthetic content.

NOTE: These drum temperatures can not be construed as indicative of actual operating temperatures under these same conditions Only a comparison of one vs. another can be made.

29.5-25 GOER TIRE
ON-VEHICLE TEMPERATURE COMPARISON
CONTINUOUS HIGHWAY SERVICE

Discussion

These on-vehicle temperature tests provide a comparison of the three designs (Super Ground Grip Goer, Super Ground Grip Goer with grooves, and ND-CC Goer) and also a comparison of high synthetic content (52 - 56%) vs. low synthetic content (11 - 14%).

All tires were tested on the same XM438 Goer Tanker with a gross vehicle weight of 69,800 lbs.

All tests were conducted on a 3-1/8 mile loop of highway which was part of the A.A.S.H.O. road test at Ottawa, Illinois. The duration of each test run was determined by the equillibrium point. When the temperatures leveled off, the tests were terminated. The tests were conducted 11-15, September 1961.

Test Features:

	Features	
Serial	Design	Compounding
K12500	Super Ground Grip Goer	11% Synthetic
K12600	Super Ground Grip Goer	52% Synthetic
K12700	Super Ground Grip Goer (With Grooves)	13% Synthetic
K12800	ND-CC Goer	14% Synthetic
K12900	ND-CC Goer	56% Synthetic

Test Conditions:

Load	69,800 lbs. G.V.W.
Inflation	40 psi drive, 30 psi trail
Speed	29 MPH Average.

Test Results (All Temperatures Corrected to 68° Ambient)

Type	Serial	Position	Inflation Cold	Inflation Hot	Actual Ambient	Maximum Temp. (Corr.)	Hours Run
Super Ground Grip Goer	K12500-1	RF	40	52	65°	241°	4.7
Super Ground Grip Goer	K12600-1	LF	40	51	65°	272°	4.7
Super Ground Grip Goer	K12500-2	LR	30	40	65°	234°	4.7
Super Ground Grip Goer	K12600-2	RR	30	40	65°	239°	4.7
Super Ground Grip Goer (With Grooves)	K12700-2	RF	40	51	62°	217°	5.7
Super Ground Grip Goer (With Grooves)	K12700-1	LF	40	50	62°	219°	5.7
Super Ground Grip Goer (With Grooves)	K12700-3	LR	30	41	62°	213°	5.7
Super Ground Grip Goer (With Grooves)	K12700-4	RR	30	41	62°	206°	5.7
ND-CC Goer	K12800-1	RF	40	54	63°	233°	4.5
ND-CC Goer	K12900-1	LF	40	54	63°	255°	4.5
ND-CC Goer	K12800-2	LR	30	43	63°	208°	4.5
ND-CC Goer	K12900-2	RR	30	43	63°	236°	4.5

Conclusions

1. The effect of design on running temperature can be readily determined since one tire of each design was run under the same conditions using the Super Ground Grip Goer (K12500) as a control:

Type	Serial	Position	Maximum Temperature	
SGG Goer	K12500-1	RF	241°	Par
SGG Goer (With Grooves)	K12700-2	RF	217°	-24°
ND-CC Goer	K12800-1	RF	233°	- 8°
SGG Goer	K12500-2	LR	234°	Par
SGG Goer (With Grooves)	K12700-3	LR	213°	-21°
ND-CC Goer	K12800-2	LR	208°	-26°

These differences might be attributed to variations in the individual tires such as base gauge, etc.

2. The effect of synthetic content on tire operating temperature can also be determined. Four direct comparisons are available.

Serial	% Synthetic	Position	Maximum Temperature	
K12500-1	11%	RF	241°	+31°
K12600-1	52%	LF	272°	
K12500-2	11%	LR	234°	+ 5°
K12600-2	52%	RR	239°	
K12800-1	14%	RF	233°	+22°
K12900-1	56%	LF	255°	
K12800-2	14%	LR	208°	+28°
K12900-2	56%	RR	236°	

Ave. Difference +22°

3. These tests determined that at inflation of 40 psi, drive and 30 psi, trail, the Super Ground Grip Goer tires (with grooves - K12700) should operate safely in continuous service at speeds under 30 MPH and at an ambient temperature of 68°.

We use 250°F as a critical temperature, and as an ambient temperature correction factor, we use 1/2°F tire temperature change for each 1°F. ambient change. It can be seen from these temperatures that at higher ambient temperatures all of the other designs would be marginal. Since it is desirable to use as high a synthetic content as possible, the Super Ground Grip Goer tire (with grooves) is the only one capable of continuous highway operation at high ambient temperatures when produced with the high synthetic construction.

TRACTION TEST SUMMARY

SAND, COMPRESSIBLE SOIL, AND NON-COMPRESSIBLE SURFACE

Discussion: The data and resulting conclusions shown in this summary have been abstracted from:

Final Report
Phase I
Project 20-1-102

Traction Ability of Various 29.5-25 Goer Tires in Sand, in a Compressible Soil, and on a Non-Compressible Surface.

This report was prepared by Nevada Automotive Test Center, Carson City, Nevada for Le-Tourneau Westinghouse Company in September, 1962.

OBJECT

The object of this test program was to evaluate the tractive ability of the following test tire groups (each featuring a difference in tread design) in sand, in compressible soil and on non-compressible surface.

Group A: Firestone Ground Grip (Control Tires), 16 PR Directional Design, 29.5-25. Serial numbers K-4300-9 and K-4300-14.

Group B: Firestone ND-CC Goer, 16 PR 29.5-25. Serial numbers K-12900-2 and K-12900-1.

Group C: Firestone Super Ground Grip Goer, 16 PR, Grooved Lug, 29.5-25. Serial numbers K-21700-4 and K-12700-3.

Group D: Firestone Super Ground Grip Goer, 16 PR, Solid Lug, 29.5-25. Serial numbers K12500-1 and K-12600-1.

CONCLUSIONS

SAND

In prepared sand simulating the loose "blow" sand common to the lee side of beach and desert dunes the initial desirable inflation pressure increments of 40, 30 and 20 PSI were predictably high for vehicle operation in the type of sand available at the test site. 20 PSI was found to be the maximum test pressure to which the tires could be inflated to permit movement of the test vehicle from highway to the sand course over a sand road traversable by jeep and pickup.

With maximum sand tire inflation pressure established at 20 PSI, 16 and 12 PSI were arbitrarily selected as the lower increments at which data would be generated.

Little significant difference in performance existed between these tires at 20, 16 and 12 PSI.

The 12 PSI inflation pressure would not be practical for any of these tires due to the severe traction buckle which appeared at this low pressure. Two of the eight tires tested experienced slippage between tire and rim.

The sand gradeability of the 64,000 lb. Goer vehicle equipped with Conventionally designed tires on all four drive wheels is calculated to be as follows:

Tire Group	A			B			C			D		
Inflation, Press.	20	16	12	20	16	12	20	16	12	20	16	12
Gradeability, %	25	30	34	24	29	34	(1)	29	32	27	29	32
Gradeability Rating as compared with Control Group A	100	100	100	96	97	100	(1)	97	94	108	97	94
Travel Efficiency Rating as compared with Control	100	100	100	95	103	96	(1)	103	101	100	104	103

(1) Could not negotiate sand course with drawbar load.

COMPRESSIBLE SOIL WITH GROUND COVER

As opposed to sand, tires in compressible soil continue to develop progressively more drawbar as travel efficiency diminishes (increased wheel spin). This being the case, comparative performance in terms of drawbar must be judged at comparable travel efficiency points. For specific comparisons see SUMMARY OF TEST RESULTS, Tractive Ability, Compressible Soil with Ground Cover. Of the experimental tires, the ND-CC Goer design, Group B, provided maximum drawbar pull under these conditions.

CONCLUSIONS (CONTINUED)

NON-COMPRESSIBLE SURFACE

Under these conditions, the Super Ground Grip Goer, Group D, provided the maximum drawbar pull of any of the experimental designs.

SUMMARY OF TEST RESULTS

Tractive Ability, Sand

Tire Group	A			B			C			D		
Inflation Press. PSI	20	16	12	20	16	12	20	16	12	20	16	12
Maximum Drawbar, Lbs	8.5	10.3	11.5	8.3	9.8	11.5	(1)	9.9	10.9	9.2	9.8	11.0
Rating	100	100	100	98	95	100		96	95	108	95	96
% Travel Efficiency	78	77	77	74	79	74	(1)	79	78	78	80	79
Rating	100	100	100	95	103	96		103	101	100	104	103
Est. Max. Goer Gradeability,% (4 Wheel Drive)	25	30	34	24	29	34	(1)	29	32	27	29	32
Rating	100	100	100	96	97	100		97	94	108	97	94
Max. Calc. Goer Gradeability,% @ 64000 lb. GVW (2 Wh.Dr.)	13	15	18	13	15	18	(1)	15	17	14	15	17
Rating	100	100	100	100	94	100		94	94	108	94	94
Tire to Rim Slippage	No	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No
Traction Buckle	None	Sli.	Sev.	None	Sli.	Sev.	None	Med.	Sev.	None	Sli.	Sev.
Air Loss from Buckle	No	No	Yes	No	No	No	No	No	No	No	No	No
Steering Response and Cornering Roll (Tire)	Good	Good	Fair	Good	Good	Poor	Good	Good	Poor	Good	Good	Fair
Rim Contact with Sidewall	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Hard Surface Measurement Flange to Road, Inches												
Unloaded		19.5			21.3			21.5			19.6	
Loaded	12.9	11.5	10.0	14.3	13.0	9.9	15.5	14.4	12.8	14.1	12.9	10.5
% Deflection	34	41	49	33	39	54	28	33	40	28	34	46
Tire Mounting Ease without Hydraulic Tool Assist and with Hand Tools only (2 men)		Good			Fair			Poor			Poor	

(1) Immobilized.

SUMMARY OF TEST RESULTS (Continued)

Tractive Ability, Compressible Soil with Ground Cover

		40 PSI			30 PSI			20 PSI		
	% T.E.	90	75	60	90	75	60	90	75	60
A Firestone Ground Grip WB (Control Tires) 16 PR	Drawbar Rating	9000 100	16200 100	19300 100	10800 100	16600 100	18700 100	11300 100	16300 100	18400 100
	Est. Grade. (4 Wh. Dr.)	26	48	57	32	49	55	33	48	54
	Calc. Grade. (2 Wh. Dr.)	14	25	30	17	26	29	18	25	29
B Firestone NDCC Goer Mil. 16 PR	Drawbar Rating	11100 123	18000 111	19900 103	11600 107	17600 106	19700 105	9200 81	15700 96	18800 102
	Est. Grade. (4 Wh. Dr.)	33	53	59	34	52	58	27	46	55
	Calc. Grade. (2 Wh. Dr.)	17	28	31	18	27	31	14	25	29
F Firestone Super Ground Grip Goer, 16 PR Grooved Lug	Drawbar Rating	9200 102	14800 91	18200 94	8300 77	14000 84	17900 96	8700 77	14500 89	18100 98
	Est. Grade. (4 Wh. Dr.)	27	44	54	24	41	53	26	43	53
	Calc. Grade. (2 Wh. Dr.)	14	23	28	13	22	28	14	23	28
G Firestone Super Ground Grip Goer, 16 PR Solid Lug	Drawbar Rating	10600 117	15800 98	18200 94	9700 90	15700 95	18100 97	8000 71	15500 95	18000 98
	Est. Grade. (4 Wh. Dr.)	31	46	54	29	46	53	24	46	53
	Calc. Grade. (2 Wh. Dr.)	17	25	28	15	24	28	12	24	28

SUMMARY OF TEST RESULTS (Continued)

Tractive Ability, Compressible Soil with Ground Cover

Group		Averaged Drawbar Values (at 90, 75 and 60% Travel Efficiency) Rated Against Group A.			
		A	B	C	D
Infl. Press.,	40 PSI	14800	16300	14100	14900
	Rating	100	110	95	101
	30 PSI	15400	16300	13400	14500
	Rating	100	106	87	94
	20 PSI	15300	14600	13800	13800
	Rating	100	95	90	90

SUMMARY OF TEST RESULTS (Continued)

Tractive Ability, Non-Compressible Surface (Continued)

		40 PSI			30 PSI			20 PSI		
	% T.E.	90	75	60	90	75	60	90	75	60
A Firestone Ground Grip WB (Control Tires) 16 PR	Drawbar	18000	21300	21900	16500	21200	21700	7800	19000	20400
	Rating	100	100	100	100	100	100	100	100	100
	Est. Grade. (4 Wh. Dr.)	53	63	64	49	62	64	23	56	60
	Calc. Grade (2 Wh. Dr.)	28	33	34	26	33	34	12	30	32
B Firestone NDCC Goer 16 PR	Drawbar	12700	22100	24300	7700	17400	23200	8400	18700	22400
	Rating	71	104	110	47	82	107	107	98	110
	Est. Grade. (4 Wh. Dr.)	37	65	71	23	51	68	25	55	66
	Calc. Grade. (2 Wh. Dr.)	20	35	38	12	27	36	13	29	35
C Firestone Super Ground Grip Goer 16 PR, Grooved Lug	Drawbar	9300	19100	24300	7500	15900	22900	7500	16300	21900
	Rating	52	90	110	45	75	106	96	86	107
	Est. Grade. (4 Wh. Dr.)	27	56	71	22	47	67	22	48	62
	Calc. Grade. (2 Wh. Dr.)	15	30	38	12	25	36	12	25	34
D Firestone Super Ground Grip Goer, 16 PR, Solid Lug	Drawbar	14400	20600	21500	14300	20900	22100	14300	20600	21800
	Rating	80	97	98	87	99	102	183	108	107
	Est. Grade. (4 Wh. Dr.)	42	61	63	42	61	65	42	61	64
	Calc. Grade. (2 Wh. Dr.)	23	32	34	23	33	35	23	32	34

SUMMARY OF TEST RESULTS (Continued)

Tractive Ability, Non-Compressible Surface

Averaged Drawbar Values (at 90, 75 and 60% Travel Efficiency) Rated Against Group A.

Group		A	B	C	D
Infl. Press.,	40 PSI	20400	19700	17600	18800
	Rating	100	97	86	92
	30 PSI	19800	16100	15400	19100
	Rating	100	81	78	96
	20 PSI	15700	16500	15200	18900
	Rating	100	105	97	120

FINAL REPORT

DURABILITY TEST OF GOER TIRES
Phase III

Project 20-1-110

July 1963

Prepared For
LeTourneau-Westinghouse Company
Under Test Directive 224 Revised

Prepared By: Walter H. Statton
Walter H. Statton
Vice President

Approved By: Henry C. Hodges
Henry C. Hodges
President

Nevada Automotive Test Center
Carson City, Nevada

A Division of Hodges Transportation Inc.

FINAL REPORT

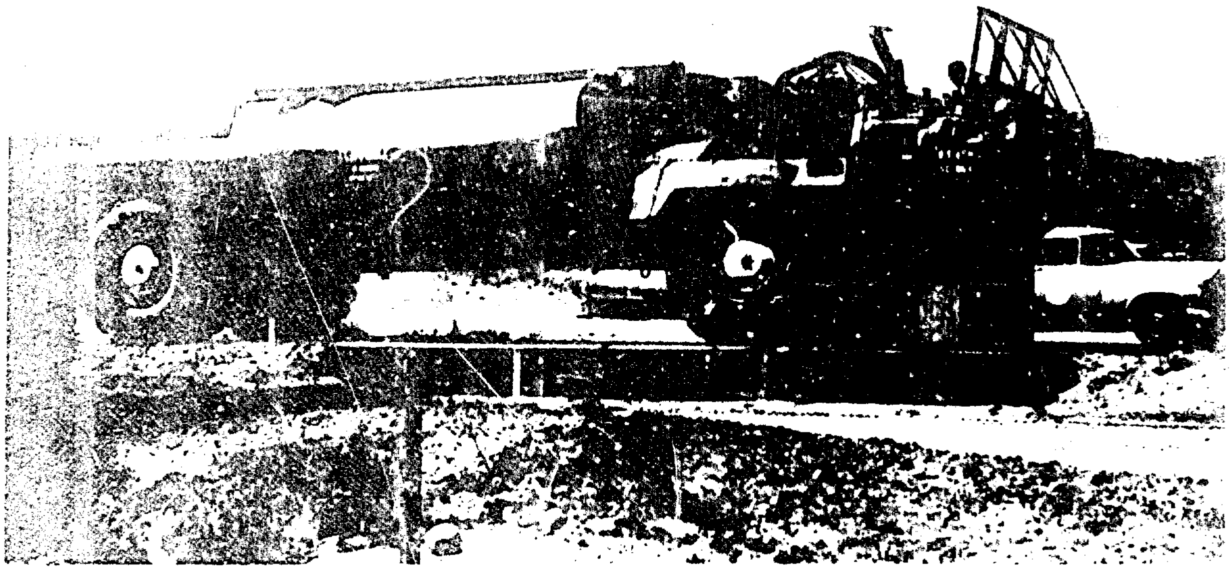
Project 20-1-110

Upper Photograph

XM 438E2 Fuel Tank Truck Being Weighed Prior to "Ride" Evaluation

Lower Photograph

Three (3) Commercial Model "C" Tournapull Vehicles Used In Tread Wear and Durability Test



FINAL REPORT

Project 20-1-110

INDEX

FINAL REPORT

Project 20-1-110

INDEX (Contd.)

HISTORY

In August 1962 the Nevada Automotive Test Center, A Division of Hodges Transportation Inc., conducted an Engineering Study (Project 20-1-102) of the influence of tire tread design and carcass construction on the tractive efficiency of 29.5 - 25 tires applicable to unsprung four wheel vehicles such as the Model "C" Tournapull and the ATAC "Goer".

In February 1963 two experimental tire groups and one control (Standard "Goer" 29.5 - 25) tire group were applied to three commercial Model "C" Tournapull "test bed" vehicles for the purpose of establishing the comparative durability and tread wear performance of these tires when subjected to semi-continuous operation over paved highways, "washboard" secondary roads and cross-country trails.

OBJECT

The three tire test groups selected for this durability and tread wear study featured significant differences and the test program was set up to segregate the effect of these differences in terms of tire durability and tread wear:

Tire Group A, the standard 29.5 - 25 directional tread "Goer" tires, featured 16 ply conventional construction and natural rubber tread.

Tire Group B, the experimental 29.5 - 25 non-directional tread tires, featured radial ply construction.

Tire Group C, the experimental 29.5 - 25 directional tread tires, featured 16 ply conventional construction and synthetic rubber tread.

Two additional tire groups were available for durability and tread wear testing (Groups D and E) should premature failures develop in the original test tire groups.

Tire Group D, the experimental 29.5 - 25 non-directional tread tires, featured 16 ply conventional construction.

Tire Group E, the experimental 29.5 - 25 directional tread tires, featured radial ply construction.

One additional group of non-directional radial ply construction tires (Group F) with the same features as Group B was available for engineering investigation.

TEST PLAN

The tread wear and durability test plan established a requirement for the following:

A maximum of 20,000 vehicle miles per tire test group divided into 8,000 miles of pavement operation, 8,000 miles of secondary road operation and 4,000 miles of cross-country trail operation.

Front tire loads of approximately 19,400 lbs. per tire and rear tire loads of 16,000 lbs. per tire simulating the tire loads of the ATAC "Goer" fuel tank truck, XM 438E2.

Measurements of tread wear and tire deterioration each 2,500 miles of operation.

Rotation of test tires from vehicle to vehicle each measurement period to equate vehicle "test bed" differences.

Test speeds averaging 25 MPH on pavement, 25 MPH on secondary roads and 8 MPH over cross-country trails to be maintained commensurate with driver and vehicle safety.

Tire inflation at the maximum level permitted by cross-country terrain conditions in terms of driver and vehicle fatigue limits at the minimum average speed requirement of 8 MPH.

Tire temperatures on the pavement course.

Driver observations of vehicle "ride" and performance as influenced by tire reaction.

The specific test plan and procedures are set forth in detail in TEST PROGRAM of this report.

CONCLUSIONS

The following conclusions may be drawn from the data generated under the specific conditions of this test program as summarized in TEST RESULTS.

Tire Tread Wear

Regardless of tread design, tires of radial ply construction (Groups B and E) provide a significantly lower tread wear rate than tires of conventional construction (Groups A, C and D). Group B was 14% worn compared with A-79%, C-35% and D-32% worn at equal mileage.

With like tire construction, non-directional tread tires (Groups B and D) provide a lower tread wear rate than directional tread tires (Groups A, C and E).

The synthetic directional tread conventional construction tires (Group C) provide a significantly lower tread wear rate than the natural rubber directional tread conventional construction tires (Group A).

On the Model "C" Tournapull "test beds" rear tire wear rate exceeded front tire wear rate; however, in terms of irregular wear the non-directional design is not sensitive to axle position, whereas the directional design is sensitive.

Directional tread conventional construction tires (Group A) exhibit almost 100% higher lug pressure on the ground than do the non-directional tread radial ply tires (Group B) which increases unit rate of wear.

Tire Durability

The synthetic directional tread conventional construction tires (Group C) developed substantially greater tread cracking than the natural rubber tread tires (Group A) of the same construction.

Conventional construction tires (Groups A and C) are significantly more durable than the radial ply construction tires (Group B) experiencing no carcass failures of the original eight test samples, whereas the radial ply construction experienced three carcass failures and one tread separation of the original four test samples and one carcass failure of the three replacement tires subjected to test.

The relative durability of the two additional tire groups cannot be assessed as the accumulated test miles authorized for a tread wear comparison of these groups (Groups D and E) were respectively 7,500 and 2,500 miles which were not adequate for durability comparison.

CONCLUSIONS (Contd.)

Tire Temperatures

The non-directional radial ply tires (Group B) under normal conditions of pavement test operation ran at a slightly lower mean temperature (198°F) than the Groups A and C directional conventional tires (202°F).

The non-directional conventional tires (Group D) under normal conditions of pavement test operation ran significantly cooler (210°F) than the Group E directional radial ply tires (237°F); however, while the operating conditions were equivalent during the time these temperatures were recorded the accumulated group tire mileages were not (Group D-7,500 miles, Group E-2,500 miles).

In the pavement operation established for this test (8 hours continuous) tire Groups A, B, C and D will not generate temperatures in excess of 235°F providing all tires are normal, i.e., no separations or traumatic frictional generators.

Rolling Resistance

The directional conventional tires (Groups A and C) and the non-directional radial ply tires (Group B) were analyzed in terms of their relative influence on vehicle fuel consumption. A comparison of the fuel consumed by the three test vehicles applied to each tire group for an equal number of miles represents a rate of fuel consumption chargeable to each tire group without regard for vehicle differences. The foregoing disregards many possible variables but a trend was established from these data which snowed a 6% improvement in the rate of fuel consumption attributable to the non-directional radial ply tires (Group B) when compared with the directional conventional tires (Group A) and an 8% improvement when compared with the directional conventional tires (Group C).

CONCLUSIONS (Contd.)

Instrumented "Ride" Study

Compared with the Model "C" Tournapull, the "Goer" Tanker at rated load provides significantly better "ride" characteristics on rough pavement and secondary road surfaces regardless of the influence of the tires.

In cross-country over natural obstacles the vehicle reaction is sharply sensitive to tire reaction which permits the equating of vehicle differences by tire selection, i.e., the "Goer equipped with radial ply tires (Group F) is equally as acceptable as the Model "C" Tournapull equipped with conventional directional tires (Group A), whereas when these tires are reversed in vehicle assignment the two vehicles are equally "ride" deficient.

On pavement and secondary road surfaces the "ride" of the "Goer" Tanker equipped with non-directional radial ply tires (Group F) is essentially insensitive to limited tire pressure change, whereas the Model "C" Tournapull "ride" is extremely sensitive. Equipped with conventional directional tires (Group A) both vehicles exhibit a slight pressure change sensitivity.

By comparison the "ride" characteristics of the non-directional conventional tires (Group D) are considered deficient in any "rough" area on any surface when mounted on the Model "C" Tournapull. The non-directional radial ply tires (Group E) provide the best over-all Model "C" Tournapull "ride" on pavement and secondary road surfaces and better cross-country "ride" than the non-directional radial ply (Group F). Assuming the influence of the "Goer" on the cross-country "ride" of the Group F tires would hold true for the directional radial ply Group E tires, the Group E tires would provide a significantly better over-all "Goer" "ride" than any other tire group tested.

Using the Model "C" Tournapull as a "test bed" and under the eleven different test conditions in the "Ride" Study to which all tire groups were subjected the directional conventional (Group A) tires exceeded the human fatigue limit[1] under five conditions and the vehicle fatigue limit[2] under two conditions; the non-directional radial ply tires (Group F) exceeded the human fatigue limit under six conditions and the vehicle fatigue limit under three conditions; on the same comparative basis, the non-directional conventional ply tires (Group D) exceeded the human fatigue limit seven times and vehicle fatigue limit four times; and the directional radial ply tires (Group E) exceeded the human fatigue limit four times and the vehicle fatigue limit three times.

(1) Acceptable "Human" Continuous Fatigue Limit of .89 (Ride Index), as Interpreted from Goldman's "Unpleasant" Limit.

(2) Acceptable Vehicle Continuous Fatigue Limit of 1.91 (Ride Index), as Interpreted from Goldman's "Intolerable" Limit.

Instrumented "Ride" Study (Contd.)

Using the "Goer" Tanker as a "test bed" and under the same conditions applied to the Model "C" Tournapull "test bed" the directional conventional (Group A) tires exceeded the human fatigue limit three times and the vehicle fatigue limit once, whereas the non-directional radial ply (Group F) tires exceeded the human and vehicle fatigue limit only once under the single cross-country condition.

Instrumented Shallow Mud Traction Study

Only the directional conventional (Group A) tires and the non-directional radial ply (Group F) tires were subjected to this Mud Traction Study and the following conclusions may be drawn from their performance.

The directional conventional (Group A) tires depend upon increased ground pressure for increased traction, whereas the non-directional radial ply (Group F) tires depend upon decreased ground pressure for increased traction.

At their optimum inflation pressure within the range investigated (15-55 psig) the maximum traction of the two groups being compared were equal at 55 psig for the Group A tires and 15 psig for the Group F tires.

The pressure print profile of the two groups at their maximum traction indicated a single high pressure contact in the crown of the Group A tires and two high pressure contacts at the shoulders of the Group F tires.

At their maximum traction the static lug ground pressure of the Group A tires is 228 PSI and the Group F tires is 48 PSI which influences tire flotation characteristics.

The vehicle ground clearance is reduced by the inflation pressure reduction required by the Group F tires.

In shallow mud the tread void areas of the Group A tires are cleared of mud buildup at 15 psig inflation, whereas the Group A are substantially loaded. At 55 psig inflation the Group A tread void areas are cleared of mud buildup and the Group F tires are substantially loaded.

Instrumented Shallow Mud Traction Study (Contd.)

CONSIDERATIONS FOR IMPROVING "GOER" MUD TRACTION

To achieve acceptable mobility, the "Goer" vehicle equipped with non-directional radial ply tires should not be operated in shallow mud with more than 25 psig front tire inflation pressure and 20 psig rear tire inflation pressure, whereas the directional conventional (Group A) tires should not be operated with less than 45 psig front tire inflation pressure and 40 psig rear tire inflation pressure.

To achieve acceptable soil trafficability (mud track pass factor) neither Group A nor Group F should be inflated to more than 25 psig.

These data indicate that in deep mud the directional tread (Group A) tires at 35, 45 or 55 psig inflation can negotiate a more severe condition in forward travel than in reverse; consequently, consideration should be given to what inflation pressure might be used to extricate the vehicle when forward travel is no longer possible.

Serious consideration should be given to evaluating the deep mud potential of:

1. Non-directional conventional and radial ply tires.

2. Directional conventional and radial ply tires.

TEST RESULTS

Table I summarizes the results of the Tire Durability Test in terms of test miles to removal and tread wear rate.

TABLE I

	Tire Groups				
	A	B	C	D	E
Average Test Miles Per Tire Sample(1)	10,022	8,604	15,040	7,509	2,541
Reason for Removal	Worn Smooth	Radial Cracks	Worn Smooth	Test Terminated	Test Terminated
Durability Rating, %	100	86	150	--	--
Tread Wear, Average Miles/Mil(2)	6.1	29.9	12.2	16.3	20.3
Tread Wear Rating, %	100	490	200	267	333

(1) The sum of the failed tire mileages divided by the number of failed tires equals average test miles per tire sample.

(2) These averages are based on two measurement locations (shoulder) and do not include crown wear. (See Summary of Tire Tread Wear; Final, By Period.)

TEST RESULTS (Contd.)

Table II summarizes the result of the "Ride" Study comparing tire group performance in terms of vehicle "ride" index values (See Appendix A, "Ride" Study). A "ride" index value of 0.89 is defined as being the acceptable limit of human fatigue for continuous operation.

TABLE II

Condition	Tire Groups A		F		D		E	
Front Tire psig	40	50	40	50	40	50	40	50
Rear Tire psig	30	40	30	40	30	40	30	40
	"Ride" Index							
Pavement								
#1, Smooth	0.35	0.68	0.51	0.50	0.60	0.30	0.50	0.31
#2, Rough	1.10	1.10	2.30*	0.80	4.60*	2.00*	2.15*	0.72
Secondary								
#1, Smooth	0.54	0.65	0.50	1.20	0.44	0.98	0.22	0.54
#2, Smooth	0.52	1.21	0.37	1.40	0.24	1.90	0.28	1.40
#3, Rough	0.85	2.38*	0.92	2.90*	0.91	4.30*	0.75	2.00*
Cross-Country								
Rough	2.7*	--	6.2*	--	10.2*	--	5.8*	--

Underlined values are in excess of acceptable human fatigue limits for continuous operation.

(*) Asterisked values are in excess of acceptable human and vehicle fatigue limits for continuous operation.

TEST RESULTS (Contd.)

Table III summarizes the result of the "Ride" Study comparing the performance of the Model "C" Tournapull with the "Goer" Tanker, in terms of vehicle "Ride" index value (see Appendix A, Ride Study). A "ride" index of 1.31 is defined as being the acceptable limit of vehicle fatigue for continuous operation (approximately 0.8 to 0.9 G). (See GRAPH LEGEND, Figures 1 and 2.)

TABLE III

Vehicle / Tire Group / Condition	Vehicle "Ride" Indices: Model "C" Tournapull — A		Model "C" Tournapull — F		"Goer" Tanker — A		"Goer" Tanker — F	
Inflation, Front, psig	40	50	40	50	40	50	40	50
Inflation, Rear, psig	30	40	30	40	30	40	30	40
Pavement	"Ride" Index							
#1, Smooth	0.35	0.68	0.51	0.50	0.22	0.27	0.31	0.29
#2, Rough	1.10	1.10	2.30*	0.80	0.57	0.65	0.80	0.75
Secondary								
#1, Smooth	0.54	0.65	0.50	1.20	0.22	0.56	0.20	0.18
#2, Smooth	0.52	1.21	0.37	1.40	0.20	1.40	0.35	0.38
#3, Rough	0.85	2.38*	0.32	2.90*	0.51	0.90	0.58	0.62
Cross-Country								
Rough	2.70*	--	6.20*	--	5.70*	--	2.90*	--

	Comparison of Mean Vehicle "Ride" Indices: Pavement — Smooth	Pavement — Rough	Secondary — Smooth	Secondary — Smooth	Secondary — Rough	Cross-Country — Rough
Goer @ 40-30 psig	0.27	0.63	0.21	0.26	0.53	4.30*
"C" Pull @ 40-30 psig	0.43	1.70	0.52	0.45	0.89	4.45*
Goer @ 50-40 psig	0.28	0.78	0.37	0.89	0.76	--
"C" Pull @ 50-40 psig	0.59	0.95	0.93	1.31	2.64*	--

Underlined values are in excess of acceptable human fatigue limits for continuous operation.

(*) Asterisked values are in excess of acceptable human and vehicle fatigue limits for continuous operation.

TEST RESULTS (Contd.)

Table IV summarizes the results of the Shallow Mud Traction Study (See Appendix B, Mud Traction Study) of the directional tread conventional construction 29.5 - 25 tires and the non-directional tread radial ply 29.5 - 25 tires in terms of the influence of inflation pressure on tractive efficiency.

TABLE IV

Inflation Pressure	Maximum Drawbar, Lbs.		% Travel Efficiency @ Maximum Drawbar		Static Ground-Lug Pressure PSI(2)	
	Group A	Group F	Group A	Group F	Group A	Group F
55	9800	6100	17	26	228	113
45	8200	6800	30	31	146	85
35	7800	7150	30	27	109	62
25	7600	8750	40	32	87	56
15	(7550)(1)	9800	--	36	72	48

(1) Extrapolated from inflation pressure-maximum drawbar curve of Groups A and F.

(2) At 55 PSI the A Group penetrated to a depth of 2.25" in the crown area of the track and the F Group penetrated to a depth of 1.75" in the same area. At 25 PSI the A Group penetrated 0.25" evenly across track and the F Group penetrated to depth of 2.00" in the shoulder area of the track.

TEST RESULTS (Contd.)

Table V summarizes the calculated influence of the directional conventional tire (Group A) and the influence of the non-directional radial ply tire (Group F) on the shallow mud traction of the "Goer" Tanker.

TABLE V

Maximum Drawbar and Gradeability

Inflation Pressure	4 Wheels Driving				2 Wheels Driving			
	Group A		Group F		Group A		Group F	
	D.B.	Grade	D.B.	Grade	D.B.	Grade	D.B.	Grade
55	17950#	25%	11500#	16%	9600#	13%	6100#	8%
45	15100	21	12200	17	8100	11	6500	9
35	14350	20	13000	18	7700	11	6900	10
25	13650	19	15800	22	7300	10	8400	12
15	13650	19	17950	25	7250	10	9600	13

Maximum Drawbar and Gradeability at 75% Travel Efficiency

Inflation Pressure	4 Wheels Driving				2 Wheels Driving			
	Group A		Group F		Group A		Group F	
	D.B.	Grade	D.B.	Grade	D.B.	Grade	D.B.	Grade
55	8200#	12%	2800#	4%	4300#	6%	1500#	2%
45	8600	12	6500	9	4600	6	3450	5
35	9200	13	7900	11	5000	7	4200	6
25	10800	15	8600	12	5750	8	4600	6
15	--	--	11500	16	--	--	6100	8

D.B. = Drawbar
Grade = Gradeability

TEST RESULTS (Contd.)

Table VI summarizes the calculated performance of the "Goer" Tanker in terms of maximum traction (maximum performance) and at 75% travel efficiency.

TABLE VI

	4 Wheel Drive Comparative Performance Ratings			
	Maximum Performance		@ 75% Travel Efficiency	
Pressure	Group A	Group F	Group A	Group F
55	100%	64%	100%	33%
45	100	80	100	75
35	100	90	100	85
25	100	115	100	80
15	100	131	--	--

TEST RESULTS (Contd.)

Table VII summarizes the tire temperatures on pavement without regard for ambient or pavement temperatures as tire temperatures were recorded under equivalent conditions in each period.

TABLE VII

2,500 Mile Test Period	Tread Temperature of Test Tires on Pavement									
	Group A		Group B		Group C		Group D		Group E	
	Max. °F	Avg. °F	Max. °F	Avg. °F	Max. °F	Avg. °F	Max. °F	Avg. °F	Max. °F	Avg. °F
1st	Low temperatures recorded due to probe position.									
2nd, 3rd	230	199	275*	182	224	195	--	--	--	--
4th	220	198	245*	203	205	199	--	--	--	--
5th	265*	209	240*	209	234	213	--	--	--	--
Mean Temperature		202		198		202				
6th	--	--	--	--	200	189	216	203	256	232
7th	--	--	--	--	--	--	233	216	265	242
Mean Temperature								210		237

* Areas influenced by tread condition.

TEST RESULTS (Contd.)

Table VIII summarizes a comparison of vehicle fuel consumption as an index of tire rolling resistance.

TABLE VIII

	Average Miles per Gallon		
	Pavement	Secondary & Cross-Country	Over-All
Group A	2.77	1.91	2.18
Group B	2.81	2.05	2.30
Group C	2.68	1.89	2.14

Over-All Rating % Based on Average Miles/Gallon

Group A	Group B	Group C
100%	106%	98%

RECOMMENDATIONS

The scope of Project 20-1-110 has generated specific conclusions with respect to the tires and vehicles evaluated during this program. Deserving additional investigation to satisfy the specific questions arising from the results of this program are the following:

Tread Wear and Durability

The directional radial ply construction (Group E) and the non-directional conventional construction (Group D) tires should be subjected to additional durability test mileage before a valid performance comparison can be drawn for all tires considered in Project 20-1-110.

"Ride" Evaluation

The "Goer" Tanker vehicle exhibits a marked improvement in "Ride" over the commercial Model "C" Tournapull "test beds" on pavement and secondary roads, but not over cross-country trails with the inflation pressures recommended for the "Goer". As the "Goer" is equipped with a central self inflation system, all tires considered for "Goer" application should be judged in terms of cross-country "Goer" ride index vs inflation pressure curve in order to determine each tire group's tactical speed limit when negotiating cross-country.

"Goer" Mud Traction

In shallow mud the non-directional radial ply tires (Group F) were found to be as effective as the directional conventional construction (Group A) tires when the non-directional tires were inflated at 15 psig and the directional tires were inflated at 55 psig. The effect of this marked difference in inflation pressure and consequent reduction in ground contact pressure for the Group F tires should be measured in deep mud where underbody clearance not tire traction may be the factor limiting mobility. The directional radial tires (Group E) and the non-directional conventional construction tires should be evaluated in both shallow and deep mud to determine the separate effects of radial ply versus conventional construction and non-directional versus directional tread on mud traction. The influence of vehicle configuration should be assessed under these same conditions by measuring the percent effectiveness of the "Goer" rear wheel drive in mud.

DISPOSITION OF TIRES SUBJECTED TO TEST

Group A, Firestone Super Ground Grip Goer H.D. Directional (Control)

Tire Code	Serial Number	Total Test Miles	Reason for Removal	Replacement Tire
A-1	K 25300-14	10,022	Outside shoulder worn smooth.	None
A-2	K 25300-18	10,022	Both shoulders worn smooth.	None
A-3	K 25300-15	10,022	Inside shoulder worn smooth.	None
A-4	K 25300-16	10,022	Test terminated at this mileage.	None

Group B, U.S. Royal Tactical M.S. Radial Ply Construction Non-Directional

Tire Code	Serial Number	Total Test Miles	Reason for Removal	Replacement Tire
B-1	EX 1808	7,231	Air loss above flipper.	B-6
B-2	XF 1867	10,876	Air loss at radial crack.	B-7
B-3	GR 1122	6,097	Tread separation inside shoulder.	B-5
B-4	GR 1351	13,306	Air loss at radial crack.	None
B-5	GR 1099	7,209	Test terminated.	None
B-6	GR 1177	5,512	Tread separation and air loss at radial crack.	Non-Test Spare
B-7	GR 1037	2,430	Test terminated	None

DISPOSITION OF TIRES SUBJECTED TO TEST (Contd.)

Group C, Firestone Super Ground Grip Goer Directional

Tire Code	Serial Number	Total Test Miles	Reason for Removal	Replacement Tire
C-1	K 25500-5	15,040	Near worn smooth condition outside shoulder.	None
C-2	K 25500-4	15,040	Outside shoulder worn smooth.	None
C-3	K 25500-3	15,040	Test terminated.	None
C-4	K 25500-2	15,040	Test terminated.	None

Group D, Firestone NDMS

Tire Code	Serial Number	Total Test Miles	Reason for Removal	Replacement Tire
D-1	K 26400-5	7,509	Test terminated.	None
D-2	K 26400-4	7,509	Test terminated.	None
D-3	K 26400-1	7,509	Test terminated.	None
D-4	K 26400-3	7,509	Test terminated.	None

Group E, U.S. Royal Radial Ply Construction Directional

Tire Code	Serial Number	Total Test Miles	Reason for Removal	Replacement Tire
E-1	CD 1732	2,541	Test terminated.	None
E-2	CD 1706	2,541	Test terminated.	None
E-3	CD 1714	2,541	Test terminated.	None
E-4	CD 1658	2,541	Test terminated.	None

SUMMARY OF TIRE TREAD WEAR

1. Final

Tire Group	Physical Dimensions A	B	C	D	E
Total Miles	10,022	13,305(1)	15,040	7,509	2,541
Cross Section Growth, %	1.1	0.7(2)	1.6	1.7	0.0
Outside Diameter Growth, %	0.1	(3)	0.6	(3)	0.2
Final Shore "A" Hardness	57	57(2)	64	62	63

Tire Group	Tread Wear at Shoulders A(4)	B(5)	C(6)	D	E
Mils Loss, Group	9912	3296	8181	3686	1001
Miles/Mil, Group	6.1	29.9	12.2	16.3	20.3
Rating, Group (Based on Miles/Mil)	100	490	200	267	333
Mils Loss, Front	4256	1414	3385	1724	491
Miles/Mil, Front	7.1	35.4	14.8	17.4	20.7
Rating, Front (Based on Miles/Mil)	100	499	208	245	292
Mils Loss, Rear	5656	1882	4796	1962	510
Miles/Mil, Rear	5.3	25.7	10.4	15.3	19.9
Rating, Rear (Based on Miles/Mil)	100	485	196	289	375
% Worn, Group	79.2	31.0	65.3	32.3	8.4
% Worn, Front	34.0	13.3	27.0	15.1	4.1
% Worn, Rear	45.2	17.7	38.3	17.1	4.3

(1) Tire B-4 accumulated 13,306 test miles before failure. All other original test tires and one replacement tire failed prior to this mileage.

(2) Based on the seven samples tested.

(3) Due to tire design no crown measurements could be taken to correct Outside Diameter on these groups.

(4) One or both of the shoulder measurement areas had worn away on three of the four test tires at 10,022 test miles. Figures shown represent wear rates through 7,522 test miles (last measurement period before worn smooth condition).

(5) Figures are based on the performance of the seven tire samples at the last valid measurement period of each tire.

(6) Figures based on 12,525 mile measurement period due to one tire worn smooth at 15,040 mile measurement period.

SUMMARY OF TIRE TREAD WEAR (Contd.)

1. Final (Contd.)

As the only measurement positions common to all tire groups tested were the shoulders it was felt that a basis of comparison should be drawn from these data; however, even this must be weighed by the fact that there is a wide variation in mileage between the individual groups tested and the ratings even though based on miles per mil are on a total mileage; therefore, the figures do not reflect a true figure as it would if all tires had run equal miles.

A further comparison can be made on the three groups of tires whose design permitted a crown measurement. The following data indicates the tread wear across the tread face rather than in the fastest wearing area.

	Tread Wear at Shoulders and Crown		
Tire Group	A	C	E
Total Miles	7,522	12,525	2,541
Mils Loss, Group	11351	9861	1594
Miles/Mil, Group	8.0	15.2	19.1
Rating, Group (Based on Miles/Mil)	100	190	239
Mils Loss, Front	5179	4347	787
Miles/Mil, Front	8.7	17.3	19.4
Rating, Front (Based on Miles/Mil)	100	199	223
Mils Loss, Rear	6172	5514	807
Miles/Mil, Rear	7.3	13.4	18.9
Rating, Rear (Based on Miles/Mil)	100	184	259
% Worn, Group	61.3	53.2	8.9
% Worn, Front	28.0	23.5	4.4
% Worn, Rear	33.3	29.7	4.5

SUMMARY OF TIRE TREAD WEAR (Contd.)

2. By Period

Tread wear measurements are based on two shoulder measurement locations on the B Group (U.S.) tires and on two and three locations, two shoulder and one crown, on the A and C Groups (Firestone). The shoulder measurements are located [illegible] inches each side of crown, and are taken in [illegible] positions around the circumference of the tire. The A, B and C Groups are compared on the basis of two measurement locations and the A and C Groups are additionally compared on the basis of three measurement locations.

Tire Group	Firestone A		Firestone C		U.S. B
Miles @ Meas.	2,520		2,520		2,520
No. of Meas. Locations	2	3	2	3	2
Mils Loss (Group)	2239	2862	848	1465	584
Miles/Mil (Group)	9.0	10.6	23.8	20.6	34.5
% Worn (Group)	17.9	15.5	6.8	7.9	5.5
Mils Loss (Front)	1039	1416	356	719	331
Miles/Mil (Front)	9.7	10.7	28.3	21.0	30.5
% Worn (Front)	16.5	15.2	5.7	7.8	6.3
Mils Loss (Rear)	1200	1446	492	746	253
Miles/Mil (Rear)	8.4	10.5	20.5	20.3	39.8
% Worn (Rear)	19.1	15.7	7.9	8.1	4.7
Miles @ Meas.	5,022		5,022		5,022
Mils Loss (Group)	[illegible]	6477	2649	3508	1243
Miles/Mil (Group)	6.7	8.0	15.2	17.2	32.3
% Worn (Group)	48.2	37.7	21.1	18.3	11.7
Mils Loss (Front)	2657	3180	1215	1611	599
Miles/Mil (Front)	7.6	9.5	16.5	17.8	33.5
% Worn (Front)	42.2	34.2	19.4	18.2	11.3
Mils Loss (Rear)	3373	3797	1434	1817	644
Miles/Mil (Rear)	6.0	7.3	14.0	16.6	31.2
% Worn (Rear)	54.1	41.1	22.3	19.6	12.0
Miles @ Meas.	7,522		7,522		7,498(1)
Mils Loss (Group)	9912	11151	4338	5604	1808
Miles/Mil (Group)	6.1	8.0	13.6	16.8	32.9
% Worn (Group)(2)	79.2	61.3	34.6	[illegible]	13.6
Mils Loss (Front)	4256	5173	1879	2433	944
Miles/Mil (Front)	7.1	8.7	16.0	18.1	31.7
% Worn in Front(2)	34.0	28.0	15.0	13.5	7.1
Mils Loss (Rear)	5656	6172	2453	2305	864
Miles/Mil (Rear)	5.3	7.3	12.2	15.5	34.1
% Worn in Rear(2)	45.2	33.3	19.6	15.7	6.5

(1) Due to tire failures in this group 24 miles of cross-country operation was lost during tire replacement; therefore, these figures are based on 5 tires.

(2) $\% \text{ Worn} = \dfrac{\text{Total Mils Loss}}{\text{Total Mils Available}} \times 100$

SUMMARY OF TIRE TREAD WEAR (Contd.)

2. By Period (Contd.)

Tire Group	Firestone A	Firestone C		U.S. B
Miles @ Meas.	10,022	10,022		10,024(1)
No. of Meas. Locations	1*	2	3	2
Mils Loss (Group)	2429	6210	7551	2549
Miles/Mil (Group)	16.5	12.9	15.9	31.5
% Worn (Group)(2)	40.5	49.5	40.8	16.0
Mils Loss (Front)	1578	2589	3394	1140
Miles/Mil (Front)	12.7	15.5	17.7	35.2
% Worn in Front(2)	26.3	20.7	18.3	7.1
Mils Loss (Rear)	851	3621	4157	1409
Miles/Mil (Rear)	23.6	11.1	14.5	28.5
% Worn in Rear(2)	14.3	28.9	22.4	8.8

Tire Group	Firestone C		U.S. B(3)	Firestone D
Miles @ Meas.	12,525		12,527	2,503
No. of Meas. Locations	2	3	2	2
Mils Loss (Group)	8181	9861	3296	1357
Miles/Mil (Group)	12.2	15.2	29.9	14.8
% Worn (Group)(2)	65.3	53.2	31.0	11.9
Mils Loss (Front)	3385	4347	1414	791
Miles/Mil (Front)	14.8	17.3	35.4	12.7
% Worn in Front(2)	27.0	23.5	13.3	6.9
Mils Loss (Rear)	4796	5514	1882	566
Miles/Mil (Rear)	10.5	13.6	25.7	17.7
% Worn in Rear(2)	38.3	29.7	17.7	5.0

* Some shoulder measurement positions worn away, negating group averages for 2 and 3 locations. Figures represent crown measurements only.

(1) Figures for B Group based on 6 tires.

(2) $\% \text{ Worn} = \frac{\text{Total Mils Loss}}{\text{Total Mils Available}} \times 100$

(3) Figures for B Group based on 7 tires.

SUMMARY OF TIRE TREAD WEAR (Contd.)

2. By Period (Contd.)

Tire Group	Firestone C	U. S. B(1)	Firestone D
Miles @ Meas.	15,040	13,306	5,003
No. of Meas. Locations	1*	2	2
Mils Loss (Group)	2161	3296	2286
Miles/Mil (Group)	27.8	29.9	17.5
% Worn (Group)(2)	36.0	31.0	20.0
Mils Loss (Front)	1146	1414	1185
Miles/Mil (Front)	26.2	35.4	16.9
% Worn in Front(2)	19.1	13.3	10.4
Mils Loss (Rear)	1015	1882	1101
Miles/Mil (Rear)	29.6	25.7	18.2
% Worn in Rear(2)	16.9	17.7	9.6

Tire Group	Firestone D	U.S. E	
Miles @ Meas.	7,509	2,541	
No. of Meas. Locations	2	2	3
Mils Loss (Group)	3686	1001	1594
Miles/Mil (Group)	16.3	20.3	19.1
% Worn (Group)(2)	32.3	8.4	8.9
Mils Loss (Front)	1724	491	787
Miles/Mil (Front)	17.4	20.7	19.4
% Worn in Front(2)	15.1	4.1	4.4
Mils Loss (Rear)	1962	510	807
Miles/Mil (Rear)	15.3	19.9	18.9
% Worn in Rear (2)	17.1	4.3	4.5

* One tire in group had shoulder measurement positions worn away, negating group averages for 2 and 3 locations. Figures represent crown measurements only.

(1) Figures are based on the performance of the seven tire samples at the last valid measurement period of each tire.

(2) $\% \text{ Worn} = \frac{\text{Total Mils Loss}}{\text{Total Mils Available}} \times 100$

SUMMARY OF TIRE TEMPERATURES

Heat Build-up 1st Period: After tire inflation pressures had been determined tire tread temperatures were taken for six consecutive operating days immediately after the vehicles had completed the pavement portion of the day shift operation. Pavement tire temperatures and pressures for the 2,520 miles covered by 1st period of operation are as follows:

Averages of Tread Temperatures (°F) and Tire Pressures (psig)

Tire Group				A-Firestone Control				B-U.S. Rubber Exp.				C-Firestone Exp.			
Vehicle				C-1				C-2				C-3			
psig Cold Start				F 35		R 25		F 40		R 25		F 35		R 25	
				psig			°F	psig			°F	psig			°F
Pave °F	Amb (1)	°F (2)		Cold	End	Inc	Temp	Cold	End	Inc	Temp	Cold	End	Inc	Temp
71	55	37	F	36.1	48.6	12.5	164.2	41.0	50.2	9.2	148.0	36.0	47.8	11.8	161.
			R	26.0	36.3	10.3	177.7	26.1	34.1	8.0	155.9	25.9	34.8	8.9	182.

(1) At time of temperature measurement.
(2) At cold starting time.

Heat Build-up 2nd and 3rd Periods: Pavement tire temperatures and pressures for the 5,002 miles covered by these periods of operation.

Tire Group	Group A	Group B*	Group C
Maximum Tire Temperature	230°F	213°F	224°F
Average Tire Temperature	199°F	182°F	195°F
Maximum Tire Pressure	51 psig (35 cold)	53.5 psig (40 cold)	58 psig (40 cold)
Average Tire Pressure Build-up (All Tires)	13 psig	11 psig	13 psig
Maximum Ambient	67°F	67°F	67°F
Average Ambient	60°F	60°F	60°F

* 275°F maximum at separated area.

Note: Average tread temperatures for secondary road operation are Group A, 199°F; Group B, 186°F; Group C, 189°F.

SUMMARY OF TIRE TEMPERATURES (Contd.)

Heat Build-up 4th Period: Pavement tire temperatures and pressures for the 2,500 miles covered by this period of operation.

Tire Group	Group A	Group B	Group C
Maximum Tire Temperature °F	220	245	205
Average Tire Temperature °F	198	203	199
Maximum Tire Pressure, psig	51.5 (35 cold)	56.0 (40 cold)	58.0 (40 cold)
Average Tire Pressure Build-up (All Tires) psig	13	12	14
Maximum Ambient Temperature °F	70	70	70
Average Ambient Temperature °F	62	62	62

Heat Build-up 5th Period: Pavement tire temperatures and pressures for the 2,500 miles covered by this period of operation.

Tire Group	Group B	Group C	Group D
Maximum Tire Temperature °F	265(1)	240	234
Average Tire Temperature °F	209	209	213
Maximum Tire Pressure, psig	52.0 (40 cold)	55.0 (40 cold)	52.0 (40 cold)(2)
Average Tire Pressure Build-up (All Tires) psig	11	14	12
Maximum Ambient Temperature °F	83	84	83
Average Ambient Temperature °F	82	83	74

(1) See TEST DATA, 3. Tread Temperatures & Tire Pressures.

(2) Tire pressures were originally set at 35 psig front and 25 psig rear (cold starting). On 5/18/63 at 716 total test miles tire inflation (cold starting) was increased to 40.0 psig front and 30.0 psig rear.

SUMMARY OF TIRE TEMPERATURES (Contd.)

Heat Build-up 6th Period: Pavement tire temperatures and pressures for the 2,500 miles covered by this period of operation.

Tire Group	Group C(1)	Group D	Group E
Maximum Tire Temperature °F	200	216	256
Average Tire Temperature °F	189	203	232
Maximum Tire Pressure, psig	52.5 (40 cold)	56.0 (40 cold)	54.0 (40 cold)
Average Tire Pressure Build-up (All Tires) psig	11	12	11
Maximum Ambient Temperature °F	55	84	84
Average Ambient Temperature °F	55	69	69

Heat Build-up 7th Period: Pavement tire temperatures and pressures for the 2,500 miles covered by this period of operation.

Tire Group	Group D(1)	Group E(1)
Maximum Tire Temperature °F	233	265
Average Tire Temperature °F	216	242
Maximum Tire Pressure, psig	55.0 (40 cold)	55.0 (40 cold)
Average Tire Pressure Build-up (All Tires) psig	13	12
Maximum Ambient Temperature °F	76	76
Average Ambient Temperature °F	76	76

(1) Tire temperatures were only taken once during this period.

TIRE ROLLING RESISTANCE EXPRESSED IN MILES PER GALLON

At the completion of three measurement and rotation periods wherein each tire group operated one period on each vehicle the following fuel consumption data was compiled.

	Group A	Group B	Group C
Miles per Gallon, Pavement	2.77	2.81	2.68
Rating	100	101	97
Miles per Gallon, Secondary and Cross-Country	1.91	2.05	1.89
Rating	100	107	99
Miles per Gallon, Total	2.18	2.30	2.14
Rating	100	106	98

DRIVER EVALUATION OF "RIDE" BY TIRE GROUPS

The first driver reaction to ride by groups was taken at the end of the 7,500 mile period; wherein each driver polled had driven each tire group on each test vehicle thereby eliminating the possibility of one vehicle influencing tire ride.

The following table indicates drivers observed ride:

Group C - Best on pavement and secondary.

Group B - Poorest on pavement and secondary.

Group A, B, C - Equal on Cross-country.

The next poll taken was at the 10,000 mile point and was a rating by the drivers of the three tire groups on the courses on which they had the most driving time. Those who placed the B Group in first place on pavement and secondary qualified the rating to the speed ranges above or below that in which lope was developed.

Preference	Pavement							Secondary							Cross-Country						
Driver #	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
1st	B	C	-	C	C	-	-	C	C	A	B	B	C	A	C	-	C	B	-	C	C
2nd	C	A	-	B	A	-	-	A	A	C	C	A	A	C	A	-	A	C	-	A	A
3rd	A	B	-	A	B	-	-	B	B	B	A	C	B	B	B	-	B	A	-	B	B

As tire groups were removed from test and substitute groups inserted a final observed rating was necessary covering the new groups.

The following table shows a tire Group F which was of similar construction and design as the Group B tires which were removed from test prematurely due to failures:

Preference	Pavement							Secondary							Cross-Country						
Driver #	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
1st	DE	DE	-	DE	DE	-	-	E	E	DE	E	DE	E	-	FE	-	FE	FE	-	FE	FE
2nd	F	F	-	F	F	-	-	DF	DF	F	DF	F	DF	-	D	-	-	D	D	D	D

TEST PROGRAM

Test Courses

Pavement Operation - The first week of test operation on pavement was conducted on Highway 95A from Silver Springs to the Fort Churchill turnaround. This provided 7.1 miles of pavement operation per turnaround; however, due to high lope exciters which prevented operation of over 1800 RPM, 5th gear at the Fort Churchill end of course it was deemed necessary to eliminate the last 3.1 miles of the original course, and a new turnaround was established at the Weeks road (secondary test course) junction.

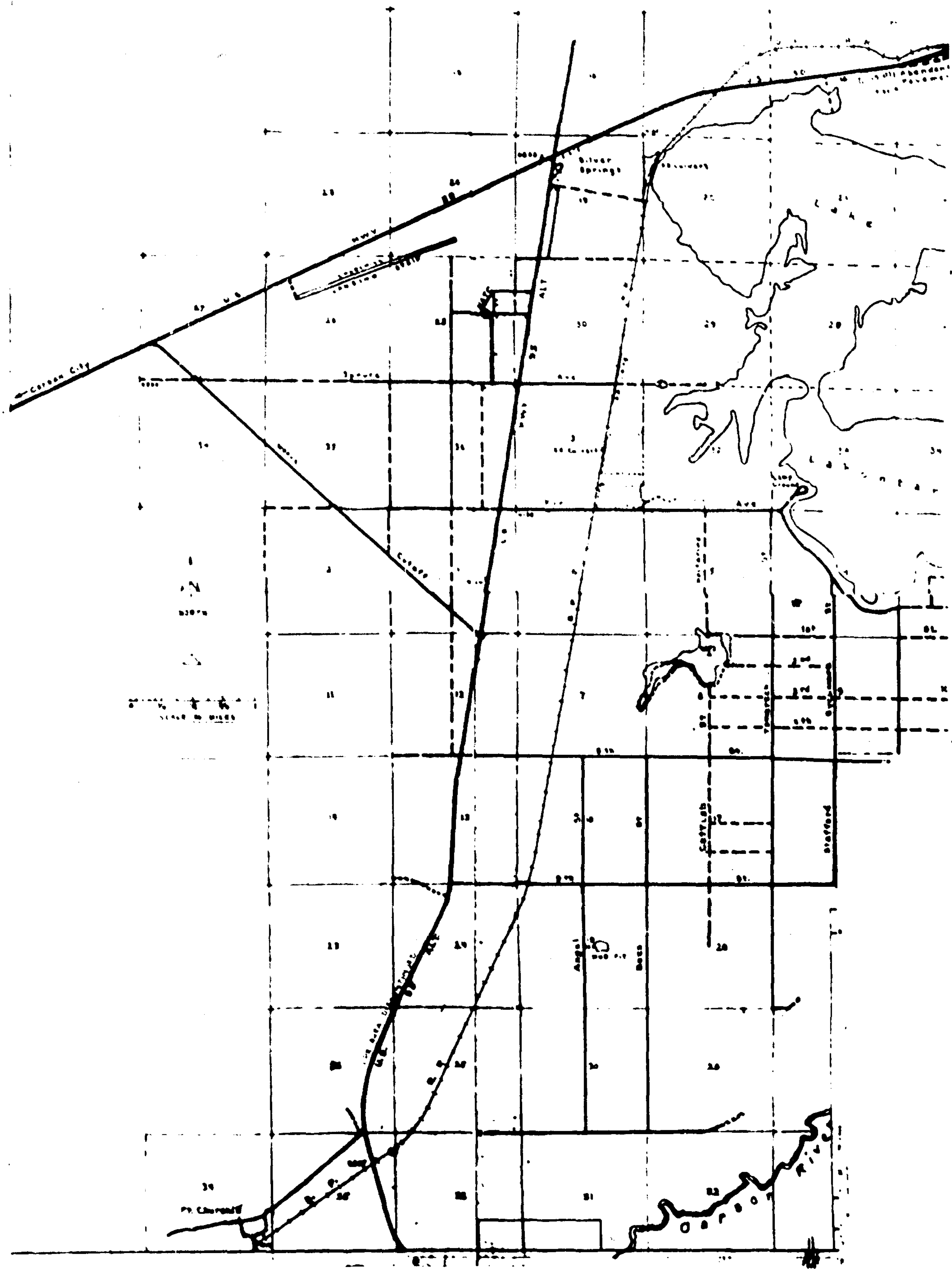
After 6540 total miles of pavement operation and 908 laps the paved course #1 from Silver Springs to Weeks turnaround on Highway 95A deteriorated to the point that a course change was required.

The new route (#2) on abandoned paved highway from Silver Springs to junction of Highways 50 and 95 permitted 194 miles of pavement operation per shift instead of the 104 miles per shift on test course #1, which was limited by Highway Department permit. The length of test course #2 permits an average vehicle speed of 25.8 MPH as opposed to 24.5 MPH on test course #1.

Secondary Operation - A variety of courses was used throughout the test due to the destructive forces applied by the vehicles and aggressive tire designs. As one area became a lope generator wherein maximum speed could not be sustained without undue forces on vehicle and driver, an identical test area was used to permit the destroyed course to be maintained. A noticeable improvement in course condition developed in the third 2500 mile period. The courses appeared to be "packing" a more stable surface and the cause is attributed to the considerable reduction in the aggressive lug penetration of the A and C tire groups due to wear. This same condition was also apparent on the cross-country course.

Cross-Country Operation - The same course was maintained throughout the test with the exception of the alkali flats at the north end of course which became impassable during rain storms.

The following map indicates test courses used during test with the exception of pavement course #2.



Silver Springs
Stafford
Angel
Bass

FINAL REPORT

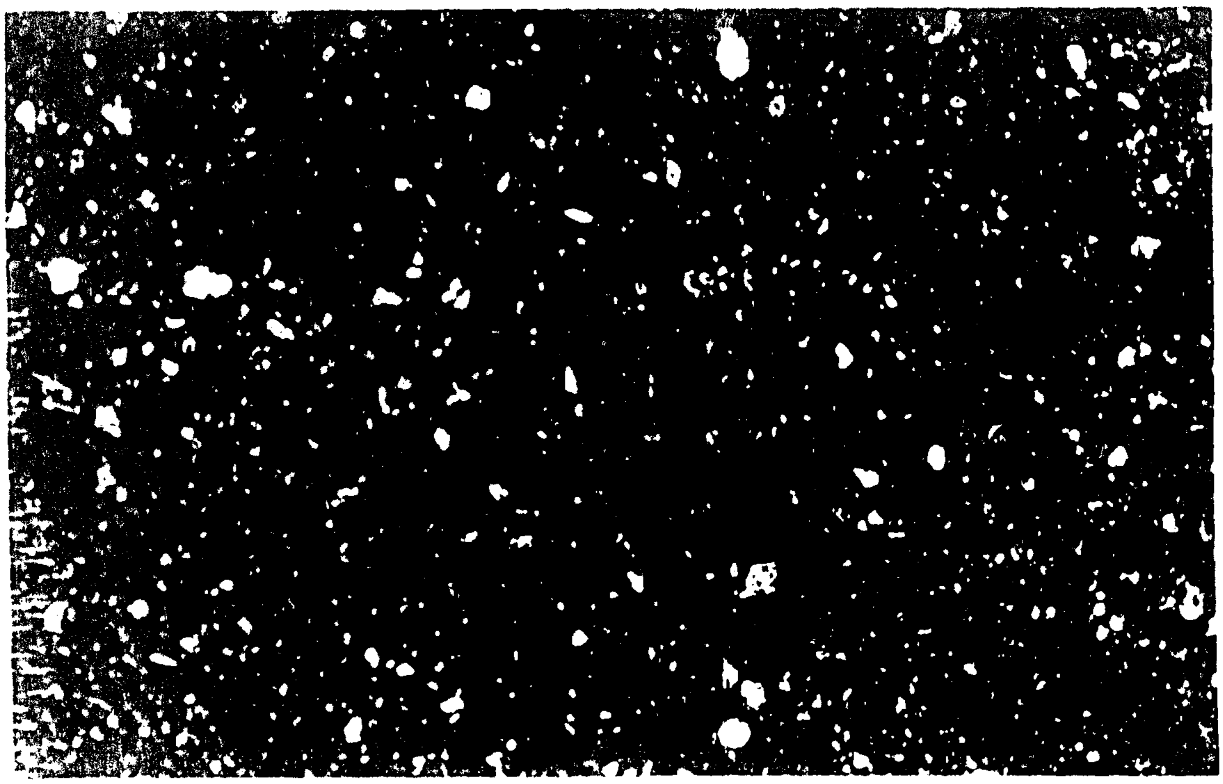
Project 20-1-110

Upper Photograph

Pavement Deterioration of Course #2
Produced by the Random Cyclic Excitations of Test Vehicles

Lower Photograph

Texture of Pavement Surface Course #2



Best Available Copy

FINAL REPORT

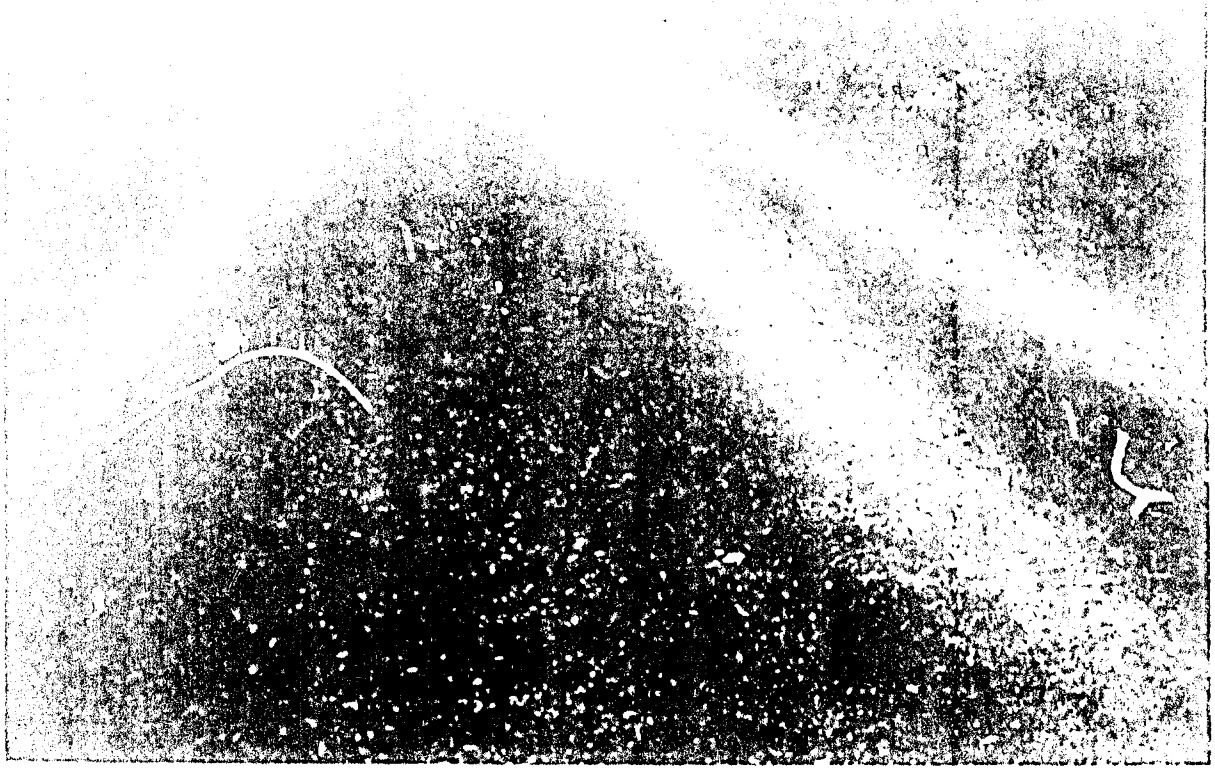
Project 20-1-110

Upper Photograph

Secondary Gravel Test Course (Weeks Road)

Lower Photograph

Cross-Country Test Course Hill Section



TEST PROGRAM (Contd.)

Test Speeds

Cross-Country - Maximum allowed by test course and vehicle conditions.

Gravel-Secondary - Maximum allowed by test course and vehicle conditions.

Highway - Maximum allowed by test course and vehicle conditions.

Tire Break-in. Vehicle operating speeds were reduced to one-half of required test speeds for first 16 hours of operation.

Tire Inflation Pressures

At start of test, tire pressures were established for all three groups at 35 psig, front axle and 30 psig, rear axle. It was found that on pavement and secondary road operation the degree of lope or bounce of the vehicles was so extreme that continued operation was not safe for personnel nor could the equipment withstand continued impact of the G forces involved. Tire pressures were varied in 5 psig increments, front and rear, at cold start as tabulated below, until a combination was established for each tire group that would permit safe convoy operation of the three vehicles at acceptable speeds for each type of terrain.

Miles at psig Settings

Tire Group	A			B			C		
	Miles	F	R	Miles	F	R	Miles	F	R
	446	35	30	359	35	30	446	35	20
	2074	35	25		30	30	2074	35	25
					35	25			
				476	35	35			
					35	45			
					40	45			
					50	45			
					40	20			
				1685	40	25			

On 4 March 1963 at 3267 test miles at the beginning of 1st shift, tire inflation of the C Group tires was raised, at the manufacturer's request, by 5 psig (40 front, 30 rear) to alleviate fast shoulder wear.

When Groups D and E entered the test program the tire inflation pressures were established at 40 psig front and 30 psig rear for purposes of tread wear evaluation.

TEST PROGRAM (Contd.)

Test Vehicles

Three (3) commercial vehicles were loaded to simulate a "Goer" Tanker GVW of 70-72000 lbs. Axle load distribution was approximately 54% front and 46% rear. Test bed vehicles had equivalent torque and braking characteristics. With the exception of failed parts replacement the vehicles were maintained throughout test by the Nevada Automotive Test Center using those methods approved by the vehicle manufacturer.

Vehicle Weights

Vehicle	C-1	C-2	C-3	"Goer"(1)
Front Axle, Lbs.	38,800	39,000	38,400	38,370
Rear Axle, Lbs.	32,000	31,900	31,000	33,450
Gross Vehicle Weight	70,000	70,900	69,400	71,820
Left Rear, Lbs.	16,000	16,000	15,000	--
Right Rear, Lbs.	16,250	16,200	15,600	--
	32,250	32,200	30,600	

(1) Goer vehicle was used in engineering studies and not on tire durability tests.

TEST PROGRAM (Contd.)

Test Mileage

Under the original test directive each group of tires was to be run 20,000 miles divided as follows:

20% - Cross-Country

40% - Secondary Gravel

40% - Highway

The following table indicates the miles accumulated and average miles per hour in each period throughout test.

		Highway Pavement		Secondary Gravel		Cross Country		Total	
Period	Groups Run	Miles	Avg. MPH	Miles	Avg. MPH	Miles	Avg. MPH	Miles	Avg. MPH
1st	A, B & C	1,000	21.9	1,000	19.1	520	9.2	2,520	16.3
2nd	A, B & C	1,000	24.4	1,002	20.7	500	8.9	2,502	17.4
3rd	A, B & C	1,000	22.7*	1,000	19.9*	500(1)	9.6	2,500	17.1
4th	A, B & C	1,000	25.7	1,000(2)	21.7	500(2)	9.8	2,500	18.3
5th	B, C & D(3)	1,003	23.5**	1,000	23.1	500	9.2	2,503	17.8
6th	B(4), C(5) D & E(6)	1,000	25.7	1,000	21.7	500	9.9	2,500	18.5
7th	D & E	1,006	26.1	1,000	23.4	500	9.7	2,506	18.8

(1) B group tires accomplished 476 miles of cross-country due to tire failures.

(2) B group tires accomplished 524 miles of cross-country and 1,002 miles of secondary.

(3) D group replaced A group at start of this period due to worn smooth condition of A group.

(4) B group terminated during this period—replaced with E group. B group accomplished 358 miles pavement, 260 miles secondary and 161 miles of cross-country for a total of 779 miles.

(5) C group due to ride and lone study accomplished 1,015 miles pavement, 1,000 miles secondary and 500 miles cross-country for a total of 2,515 miles this period.

(6) E group, which replaced B group, started test in the middle of 6th period and finished in the middle of 7th period. This group accomplished 1,013 miles pavement, 1,026 miles secondary and 502 miles cross-country for a total of 2,541 miles.

* Average speed reduced; 1/2 speed, 21 hours break-in of replacement B group.

** Average speed reduced; 1/2 speed, 16 hours break-in of new D group tires.

TEST PROGRAM (Contd.)

Test Mileage (Contd.)

The following table indicates the test miles accumulated by each tire under each of the three conditions.

Tire Code	Highway Pave Miles	% of Total Miles	Secondary Gravel Miles	% of Total Miles	Cross-Country Miles	% of Total Miles	Total Miles
A-1	4,000	40	4,002	40	2,020	20	10,022
A-2	4,000	40	4,002	40	2,020	20	10,022
A-3	4,000	40	4,002	40	2,020	20	10,022
A-4	4,000	40	4,002	40	2,020	20	10,022
B-1	3,000	41	2,784	39	1,447	20	7,231
B-2	4,406	40	4,342	40	2,128	20	10,876
B-3	2,374	39	2,539	42	1,184	19	6,097
B-4	5,361	40	5,264	40	2,681	20	13,306
B-5	2,987	41	2,725	38	1,497	21	7,209
B-6	2,141	39	2,220	40	1,151	21	5,512
B-7	955	39	922	38	553	23	2,430
C-1	6,018	40	6,002	40	3,020	20	15,040
C-2	6,018	40	6,002	40	3,020	20	15,040
C-3	6,018	40	6,002	40	3,020	20	15,040
C-4	6,018	40	6,002	40	3,020	20	15,040
D-1	3,009	40	3,000	40	1,500	20	7,509
D-2	3,009	40	3,000	40	1,500	20	7,509
D-3	3,009	40	3,000	40	1,500	20	7,509
D-4	3,009	40	3,000	40	1,500	20	7,509
E-1	1,013	40	1,026	40	502	20	2,541
E-2	1,013	40	1,026	40	502	20	2,541
E-3	1,013	40	1,026	40	502	20	2,541
E-4	1,013	40	1,026	40	502	20	2,541

TEST PROGRAM (Contd.)

Tire Contact Areas

Contact prints were made at start of test of the right front tire of each test group at 30 psig. Additional contact prints were taken on the Group A and B tires at 15, 20 and 40 psig inflation. The gross and net contact areas for each tire and the ratio of net to gross is tabulated below.

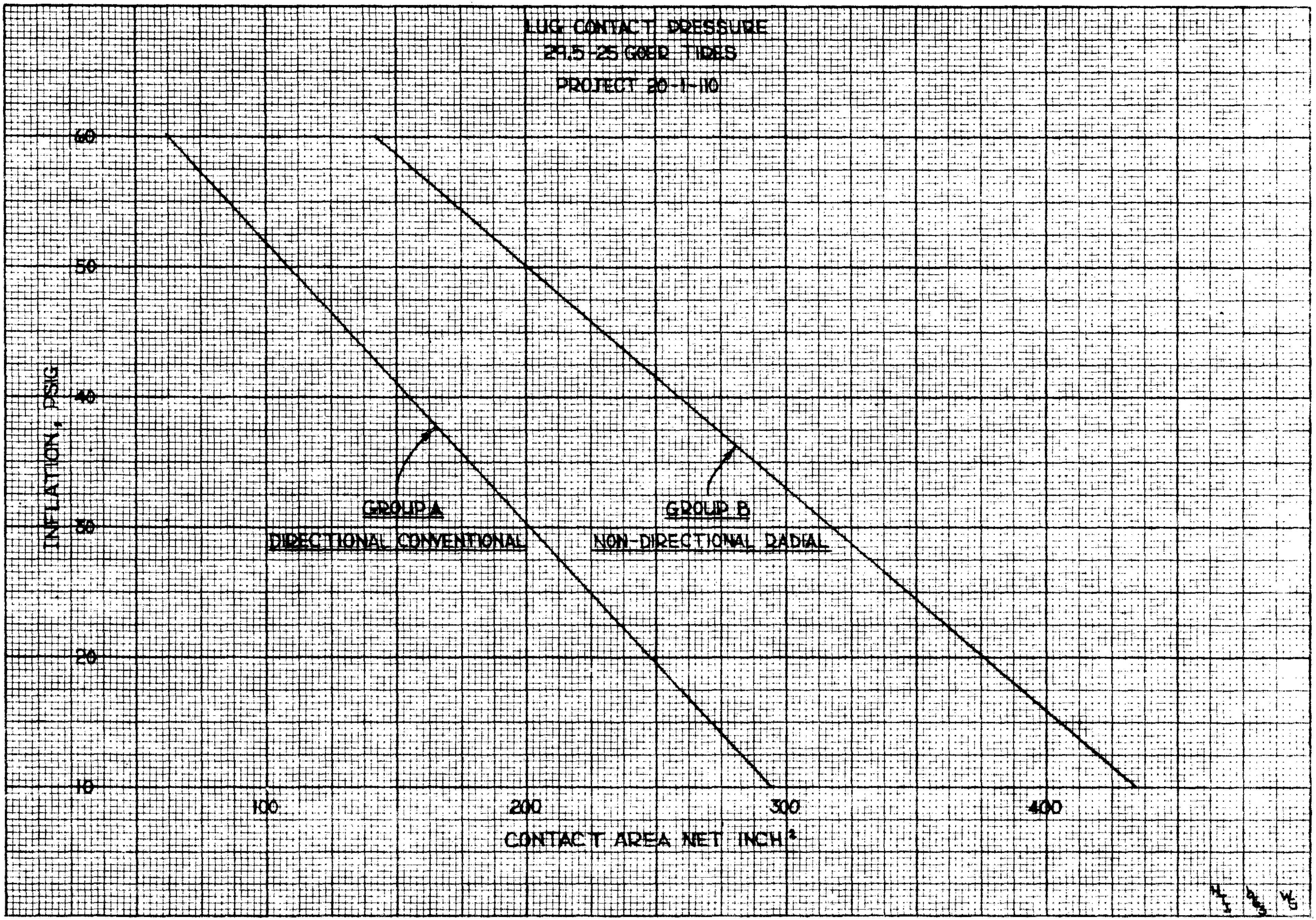
psig	15		20		30			40	
Vehicle Number	C-1	C-2	C-1	C-2	C-1	C-2	C-3	C-1	C-2
Tire Code	A-2	B-2	A-2	B-2	A-2	B-2	C-2	A-2	B-2
Gross Area, in^2	756.3	726.2	633.7	604.4	495.7	484.3	495.7	419.6	435.0
Net Area, in^2	269.2	404.8	253.4	377.9	192.3	284.4	192.3	156.9	255.5
Ratio, Gross to Net	2.81	1.79	2.50	1.60	2.58	1.68	2.58	2.67	1.70
Net % of Gross	35.5	55.7	40.0	62.5	38.8	59.4	38.8	37.4	58.7
PSI/Gross Area*	25.7	26.9	30.6	32.3	39.1	40.3	38.7	46.2	44.8
PSI/Net Area*	72.1	48.2	76.6	51.6	100.9	68.6	99.8	123.6	76.3

* Based on R.F. weight, lbs. A= 19,400 B= 19,500 C= 19,200

Group A: Firestone Super Ground Grip Goer H.D., Control

Group B: U.S. Royal Tactical M.S.

Group C: Firestone Super Ground Grip Goer Directional


LUG CONTACT PRESSURE
29.5-25 GOER TIRES
PROJECT 20-1-110
60
50
40
30
20
10
INFLATION, PSIG
GROUP A
DIRECTIONAL CONVENTIONAL
GROUP B
NON-DIRECTIONAL RADIAL
100
200
300
400
CONTACT AREA NET INCH²

TEST PROGRAM (Contd.)

Test Tire Measurements

The following measurements were taken and recorded prior to start and at every 2300-2500 miles of tire travel:

Outside Diameter
Shore Hardness - 3 places
Tread Depth - 6 places inside and outside
Tread Cutting (number and total length) minimum 2" length, 1/4" sidewall and to fabric in tread
Cross Section - 3 places
Contact Print - 30 psig on right front tire each group at start of test

Tire Rotation

At End of Test Period	Tire Miles Accumulated	Rotation Schedule	Tire Groups Affected
#1	2,520	Vehicle to vehicle-fixed wheel position.	A, B, C
#2	2,502	Diagonally front-to-rear-vehicle to vehicle.	A, B, C
#3	2,500	Vehicle to vehicle-fixed wheel position.	A, B, C
#4	2,500	Vehicle to vehicle-fixed wheel position.	B, C, D
#5	2,503	Vehicle to vehicle-fixed wheel position.	B, C, D
#6	2,500	Vehicle to vehicle-fixed wheel position.	D, E
#7	2,506		Test Terminated

Additional Tests

Due to test termination prior to the 20,000 mile limit it was considered advisable to investigate two phenomenons which occurred during the test. A noticeable difference in the "ride" characteristics between tire groups was found and an observed deficiency of the non-directional radial construction tires in shallow mud. These conditions were further investigated by means of instrumentation and are covered in Appendix A "Ride Study" and Appendix B "Shallow Mud Traction".

SUMMARY OF FUEL CONSUMPTION BY TIRE GROUPS

Group A Tires

	Gallons		
	Pavement Fuel	Off-Road Fuel	Total Fuel
1st Period, 0-2520 Miles, Vehicle C-1	361.2	782.3	1143.5
2nd Period, 2520-5022 Miles, Vehicle C-3	370.2	788.1	1158.3
3rd Period, 5022-7522 Miles, Vehicle C-2	352.0	791.6	1143.6
4th Period, 7522-10022 Miles, Vehicle C-1	360.0	723.9	1083.9
Total	1443.4	3085.9	4529.3
Miles per Gallon	2.77	1.95	2.21
Rating	100	100	100

Group B Tires

	Pavement Fuel	Off-Road Fuel	Total Fuel
1st Period, 0-2520 Miles, Vehicle C-2	371.8	728.9	1100.7
2nd Period, 2520-5022 Miles, Vehicle C-1	362.4	745.2	1107.6
3rd Period, 5022-7498 Miles, Vehicle C-3	332.2	707.3	1039.5
4th Period, 7498-10024 Miles, Vehicle C-2	329.2	726.3	1055.5
5th Period, 10024-12527 Miles, Vehicle C-1	336.0	655.1	991.1
6th Period, 12527-13306 Miles, Vehicle C-3	120.7	216.0	336.7
Total	1852.3	3778.8	5631.1
Miles per Gallon	2.89	2.10	2.36
Rating(1)	104	108	107

Group C Tires

	Pavement Fuel	Off-Road Fuel	Total Fuel
1st Period, 0-2520 Miles, Vehicle C-3	377.9	787.8	1165.7
2nd Period, 2520-5022 Miles Vehicle C-2	390.9	813.9	1204.8
3rd Period, 5022-7522 Miles, Vehicle C-1	349.8	789.7	1139.5
4th Period, 7522-10022 Miles, Vehicle C-3	344.8	773.0	1117.8
5th Period, 10022-12525 Miles, Vehicle C-2	356.6	686.4	1043.0
6th Period, 12525-15040 Miles, Vehicle C-1	355.4	730.4	1085.8
Total	2175.4	4581.2	6756.6
Miles per Gallon	2.77	1.97	2.23
Rating(1)	100	101	101

(1) Ratings are based on the Group A (Control) average miles per gallon consumption during the four periods they ran.

SUMMARY OF FUEL CONSUMPTION BY TIRE GROUPS (Contd.)

Group D Tires

	Gallons: Pavement Fuel	Gallons: Off-Road Fuel	Gallons: Total Fuel
5th Period, 0-2503 Miles, Vehicle C-3	352.0	682.9	1034.9
6th Period, 2503-5003 Miles, Vehicle C-2	318.2	701.1	1019.3
7th Period, 5003-7509 Miles, Vehicle C-1	334.7	703.6	1038.3
Total	1004.9	2087.6	3092.5
Miles Per Gallon	2.99	2.16	2.43
Rating(1)	108	111	110

Group E Tires

	Gallons: Pavement Fuel	Gallons: Off-Road Fuel	Gallons: Total Fuel
6th-7th Period, 0-2541 Miles, Vehicle C-3	333.5	739.9	1073.4
Total	333.5	739.9	1073.4
Miles per Gallon	3.04	2.07	2.37
Rating(1)	110	106	107

(1) Ratings are based on the Group A (Control) average miles per gallon consumption during the four periods they ran.

VEHICLE DURABILITY

The three Model "C" Tournapulls used in this Tire Durability Test to simulate the Army Goer Vehicle experienced a minimal parts mortality record. Other than normal vehicle service and preventative maintenance the following table indicates all failures experienced during test.

Veh. #	Date	Mileage @ Failure	Description of Failure	Cause of Failure	Disposition
C-1	3/11/63	4,799	Cable, Apron, broken.	Believed that apron limit switch was misaligned.	Replaced cable and aligned limit switch.
C-1	4/5/63	8,431	Cab Bolt, right front missing.	Unknown.	Replaced.
C-1	5/17/63	10,725	DC charging rate low.	DC Rectifiers.	Replaced.
C-1	5/27/63	12,292	DC charging rate low.	Flux bridge not property adjusted.	Installed shims in flux bridge.
C-1	6/12/63	18,309	DC charging rate low.	Deficient coil in transformer.	Replaced transformer.
C-2	4/5/63	8,431	Hose, Air Tank Outlet, leaking	Ruptured.	Replaced.
C-2	6/4/63	16,341	Can Arm Ball Cap, right, 2 cap screws broken.	Unknown.	Replaced.
C-2	6/4/63	16,341	Wheel Studs, left missing (Wheel came off bending brake drum).	Wheel Studs not properly tightened.	Replaced brake drum, tapped wheel stud holes and replaced wheel stud
C-2	6/8/63	17,609	Points, Steering Relay, left, burned and not making contact.	High resistance.	Replaced left steering points. Note: Points had been dressed several tim prior to replacemen
C-3	3/30/63	7,522	Cable, Can Hoist, flattened and frayed.	Rubbing against can sheave side plate due to being laced incorrectly.	Replaced cable and laced correctly.
C-3	4/2/63	7,777	Hose, Rear Brake, main line broken at brass fitting.	Unknown.	Replaced.

VEHICLE DURABILITY (Contd.)

Veh. #	Date	Mileage @ Failure	Description of Failure	Cause of Failure	Disposition
C-3	4/5/63	8,517	Pin & Bearing, Apron Sheave, damaged.	Believed that apron cable forced through sheave while looped.	Replaced pin and bearing. Welded torn section of sheave side cover.
C-3	6/8/63	17,600	Points, Steering Relay, left burned and not making contact..	High resistance.	Replaced left steering points. Note: Points had been dressed several times prior to replacement.

TEST DATA

1. TIRE MEASUREMENT SUMMARY

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC.

128MS

Project 20-1-110 Tire Group A-1 Mfg. Descr. Firestone Super Ground Grip Oper H.D. Cont

Date Feb.- 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type psig Rotation Voids 1+3 Veh. Elg. in. ea. 2500 ea. 5000

Pos.	Meas. Per.	Miles Cum.	Lb/Gm Loss	O D* % Inc	X Sec % Inc	Profile	Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils & Loss Per.	Cum.	Miles/Mil Per.	Cum.	% Worn Per	Cum	Est Mi. to [illegible]
LF	orig.	0		73.76	30.52			57	1.575	1.500	1.575				3150						
C-1	2520	2520		74.22	30.84			57	1.463	1.338	1.264				2727						
				0.6	1.0				0.112	0.162	0.311				423	423	11.9	–	13.8		
LF	2502	5022		74.32	30.96			58	1.282	1.264	0.815				2097						
C-3				0.8	1.4				0.181	0.074	0.449				630	1053	7.9	9.5	20.0	33.8	
RR	2500	7522		74.06	30.87			57	0.437	1.244	0.460				897						
C-2				0.4	1.1				0.845	0.020	0.355				1700	2253	4.2	6.7	30.1	71.5	
RR	2500	10022		73.98	30.80			57	WA	1.160	0.102				–	–	–	–	–	–	
C-1				0.3	0.9				–	0.084	0.358										
TEST																					
TERMINATED		10022																			

1/ Tread Loss of Crown Measurement Only % tread on outside shoulder worn away

Voids 1, 2, 3

Mils. % Loss		Miles/Mil		% Worn	
Per.	Cum.	Per.	Cum.	Per	Cum
4650					
4065					
85	585	12.9	—	12.6	—
3361					
704	1289	10.7	11.7	15.1	27.7
2141					
1220	2509	6.1	9.0	26.3	54.0
	1/ 340		1/ 29.5		1/ 22.7

(2)

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC.

Form 128MS

Project 20-1-110 Tire Group A-2 Mfg. Descr. Firestone Super Ground Grip Goer H.D. Control

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type psig Rotation Veh.-Veh. ea. 2500 Fig. X ea. 5000

Voids 1.3

odg ar.	Pos.	Meas. Miles Per.	Meas. Miles Cum.	Lb/Gm Loss	O D* % Inc	X Sec % Inc	Profile	Profile Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils & Loss Per.	Mils & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi. to
-2	RF	Orig			74.15	30.51			57	1 570	1 500	1 569				3139						
	C-1	2520	2520		74.53	30.83			57	1 387	1 285	1 136				2523						
					0.5	1.0				0 183	0 215	0 433				616	616	8.2	--	19.6	-	
	RF	2502	5022		74.57	30.87			58	1 007	1 213	0 528				1535						
	C-3				0.6	1.2				0 380	0 072	0 608				988	1604	5.1	6.3	31.5	51.1	
	LR	2500	7522		74.33	30.83			57	.183	.1141	.269				452						
	C-2				0.2	1.0				.824	.072	.259				1083	2687	4.6	5.6	34.5	85.6	
	LR	2500	10022		74.19	30.86			57	WA	890	WA				—	—	—	—	—	—	
	C-1				0.05	1.1					251											

K 25300-18

(1)

Voids 1,2,3

Mils & Loss Per.	Cum.	Miles/Mil Per.	Cum.	% Worn Per	Cum	Est to
[illegible]						
[illegible]						
[illegible]	[illegible]	9.1	–	17.9	–	
[illegible]						
1060	1821	7.1	8.0	22.8	40.8	
[illegible]						
[illegible]	3046	6.5	7.4	24.9	65.7	
	610		16.4		40.7	

②

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC.

Form 120MS

Project 20-1-110 Tire Group A-3 Mfg. Descr. Firestone Super Ground Grip Goer H.D. Control

Date Feb.- 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type psig Rotation Voids 1.3 Veh.-Veh. eq. 2500 Elg. X eq. 5000

Code No.	Pos. Code	Meas. Miles Per.	Meas. Miles Cum.	Lb/Gm Loss	O D % Inc	X Sec % Inc	Profile	Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils Loss Per.	Mils Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi. to Bald
A-3	LR	Orig.			74.11	30.79			57	1.563	1.500	1.561				3124						
	C-1	2520	2520		73.91	30.74			57	1.475	1.399	1.065				2540			-			
					-0.2	-0.2				0.088	0.101	0.496				584	584	8.6	-	18.7	-	
	LR	2502	5022		73.53	30.83			58	1.128	1.249	0.250				1378						
	C-3				-0.1	0.1				0.347	0.150	0.815				1162	1746	4.3	5.0	37.2	55.9	
	RF	2500	7522		74.25	31.07			55	425	1046	015(1)				—						
	C-2				0.2	0.9				706	703	782(1)				985(1)	2713(1)	5.1	5.5	81.5	87.4	
	RF	2500	10022		74.07	31.16			56	070	513	WA				—	—	—	—	—	—	
	C-1				-(0.08)	1.2				355	533	—										

(1) Tread Loss of Crown Measurement Only o/c tread on inside shoulder worn away.

K25300-15

Outside

1

Mils. & Loss		Miles/Mil		% Worn		Es[illegible]
Per.	Cum.	Per.	Cum.	Per	Cum	to
4624						
3939						
685	685	11.0	—	14.8	—	
2627						
1312	1997	5.7	7.5	28.4	43.2	
—						
1188	3185	6.3	7.1	25.7	68.8	
	987		10.2		65.8	

②

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC.

Fc 128MS

Project 20-1-110 Tire Group A-4 Mfg. Descr. Firestone Super Ground Grip Goer H.D. Control

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type psig Rotation Veh. to Veh. ea. 1500 Fig. X ea. 5000

Voids 1, 3

No. Ca.	Pos.	Meas. Per.	Miles Cum.	Lb/Gm Loss	O D % Inc	X Sec % Inc	Profile	Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils & Loss Per.	Mils & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi. to Bald	Mil Per
4	RR	Orig			74.59	30.48			57	1.554	1500	1556				3110							461
	C-1	2520	2520		74.31	30.53			58	1.242	1355	1252				2494							[illegible]
					-0.1	0.2				.312	0145	0304				616	616	8.2	–	19.8	–		7[illegible]
	RR	2502	5022		74.36	30.63			59	0.863	1327	0620				1483							28
	C-3				0	0.5				0.379	0028	0632				1011	1627	4.9	6.2	32.5	52.3		10[illegible]
	LF	2500	7522		74.74	30.72			55	360	1130	509				869							199
	C-2				0.5	0.8				503	197	111				614	2241	8.1	6.7	19.7	72.0		81
	LF	2500	10022		74.49	30.83			58	047	1008	301				348							13[illegible]
	C-1				0.1	1.1				313	122	208				521	2589	9.6	7.7	16.7	83.2		6[illegible]

V Tread Loss of Crown Measurement Only to correspond with A-1, A-2, A-3

OUTSIDE

Mils. & Loss Per.	Mils. & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est to
4610						
3849						
761	761	9.9	—	16.5	—	
2810						
1039	1800	7.2	8.4	22.5	39.0	
1999						
811	2611	9.2	8.6	17.6	56.6	
1356						
643	3254	11.7	9.2	13.9	70.6	
	1492		20.4		42.[illegible]	

(2)

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC.

Form 128MS

Project 20-1-110 Tire Group B-1 Mfg. Descr. U.S. Royal Tactical M.S.

Date Feb.- 1963 Tire Size 29.5-25 P.R. 16 Ribs Lug Type psig Rotation Voids 1,3 Veh. to Veh. ea. 2500 Fin. X ea. 5000

Code Nr.	Pos.	Meas. Miles Per.	Meas. Miles Cum.	Lb/Gm Loss	O D" % Inc	X Sec % Inc	Profile	Low	Dur. "A"	Orig. Tread Depth V-1	V-2	V-3	V-4	V-5	V-6	Mils Loss Per.	Mils Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi. to Bald
B-1	LF	Orig			73.92	31.85			56	1.314	1.335					2649						
	C-2	2520	2520		73.71	32.24			54	1.226	1.234					2460						
						1.2				0.088	0.101					189	189	26.6	–	7.1	–	
	LF	2502	5022		73.60	32.32			56	1.198	1.134					2332						
Outside EX 1808	C-1					1.5				0.028	0.100					128	317	39.1	31.7	4.8	11.9	
	RR	2209	7231		73.77	31.88			56	1164	1047					2211						
	C-3					0.1				34	87					121	438	36.5	33.0	3.6	14.5	
36	RR	ORIG			74.04	31.02			62	1332	1333					2665						
	C-2																					
	RR	2793			73.39	31.58			56	1170	1116					2286						
	C-2					1.8				162	217					379	379	13.3	13.3	14.2	14.2	
GR 1177	RR	2503	5296		73.87	31.41			56	972	982					1954						
	C-1					1.3				198	134					332	711	15.1	14.9	12.5	26.7	
	RR									916 (1)	891 (1)					–	–	–	–			
	C-3	216	5512		–	–			58	056 (2)	091 (2)					–	–	–	–	–	–	

TIRE MEASUREMENT SUMMARY — HODGES TRANSPORTATION INC. — Fo. 128MS

Project 20-1-110 Tire Group B-2 Mfg. Descr. U.S. Royal Tactical M.S.

Date Feb. 1963 Tire Size 29.5-2.6 P.R. 16 Ribs Lug Type psig Rotation Yards 48 Veh. to Veh. ea. 2500 F/a X ea. 5000

Side Tr.	Pos.	Meas. Miles Per.	Meas. Miles Cum.	Lb/Gm Loss	O D % Inc	X Sec % Inc	Profile	Profile Low	Dur. "A"	Orig. Tread V-1	Depth & Tread V-2	Loss, Mils V-3	V-4	V-5	V-6	Mils & Loss Per.	Mils & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi. to Bald
-2	RF	Orig			73.91	31.87			56	1.319	1.328					2647						
	C-2	2.520	2520		73.62	32.37			54	1.263	1.242					2505						
					0	1.6				0.056	0.086					142	142	35.5	-	5.4	-	
	RF	2502	5022		73.50	32.41			56	1.203	1.162					2365						
	C-1				0	1.7				0.060	0.080					140	282	35.7	35.6	5.3	10.7	
	LR	2476	7498		73.87	32.30			55	1115	1151					2266						
	C-3				0	1.6				088	011					99	381	50.0	39.4	3.7	14.4	
	LR	2526	10024		73.46	32.11			56	1017	1083					2100						
	C-2					0.8				098	068					166	547	30.4	36.7	6.3	20.7	
	LR	852	10876		73.52	31.94			59	848	969					TIRE	FAILED	AND	UNDER-			
	C-1					0.2				169	114					INFLATED	OPERATION					
																PRODUCED	FAST	SHLDR				
																WEAR.						
37	LR	ORIG			74.03	31.56			56	1319	1320					2639						
	C1																					
	LR	1651	1651		73.90	31.90			56	1282	1216					2498						
	C1					1.1				037	104					141	141	23.4	-	5.3	-	
	LR	779	2430		73.71	32.03			57	1185(2)	1106(2)					-	-	-	-			
	C3					1.5				097(2)	110					-	-	-	-	-	-	

Outside XF 1867

GR1037

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC. For 128MS

Project 20-1-110 Tire Group B-3 Mfg. Descr. U.S. Royal Tactical M.S.

Date Feb. 1963 Tire Size 29.5 - 2.5 P.R. 16 Ribs Lug Type psig Rotation Voids 1,3 Veh. to Veh. ea. 2800 Fig. X ea. 8000

Pos. Wheel	Meas. Miles Per.	Meas. Miles Cum.	Lb/Gm Loss	O Dia & Inc	X Sec & Inc	Profile	Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils & Loss Per.	Mils & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi. to Bald
LR	Orig			73.98	32.17			57	1.323	1.326					2649						
C-2	2520	2520		73.80	32.06			54	1.265	1.282					2547						
					-0.3				0.058	0.044					102	102	49.4	–	3.9		
LR	2502	5022		73.70	32.05			56	1.186	1.171					2357						
C-1					-0.4				0.079	0.111					190	292	26.3	34.4	7.2	11.0	
RF	1075	6097**		73.83	31.97				1150	1157					2302						
C-3					0				36	19					55	347	39.1	35.1	2.1	13.1	
RF	ORIG			74.00	31.42			56	1330	1332					2662						
C3																					
RF	1401			73.70	32.42			55	1267	1244					2511						
C-3					3.2				063	088					151	151	18.6	18.6	5.7		
RF	2526	3927		73.58	32.21			56	1213	1188					2401						
C-2					2.5				054	056					110	261	45.9	30.1	4.1	9.8	
[illegible]	2503	6430		73.58	32.26			56	1187	1119					2306						
[illegible]					2.7				026	069					045	356	52.7	36.1	3.6	13.4	
RF	779	7209		73.54	32.02			58	1115 (1)	1031 (1)					–	–	–	–			
[illegible]					1.9				072 (1)	088 (1)					–	–	–	–	–	–	
	TEST TERMINATED 6-5-63																				

(1) MEASUREMENTS WERE TAKEN ON UNMOUNTED TIRES.

** Removed from test, replaced by [illegible]

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC.

Form 120MS

Project 20-1-110 Tire Group B-4 Mfg. Descr. U.S. Royal Tactical M.S.

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lug Type psig Rotation Voids 1,3 Veh. to Veh. ea. 2500 Els X ea. 5000

Pos. Date	Meas. Miles Per.	Meas. Miles Cum.	Lb/Gm Loss	O D* % Inc	X Sec % Inc	Profile	Profile Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils & Loss Per.	Mils & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi. to Bald
RR	Orig.			73.98	31.84			58	1.363	1.339					2702						
C-2	2520	2520		73.80	31.84			54	1.306	1.245					2551						
					0				0.057	0.094					151	151	33.4	-	37	-	
RR	2502	5022		73.70	32.00			56	1.222	1.128					2350						
C-1					0.5				0.084	0.117					201	352	24.9	28.5	7.4	13.0	
LF	2476	7498		73.65	32.35			56	1164	1047					2211						
C-3					1.6				058	081					139	491	35.6	30.5	5.1	18.7	
LF	2526	10024		73.55	32.27			56	1126	999					2125						
C-2					1.4				038	048					086	577	58.7	34.7	3.2	21.4	
LF	2503	12527		73.58	32.02			56	1058	888					1946						
C-1					0.6				068	111					179	756	28.0	33.1	6.6	28.0	
LF	779	13306		—	—			58	950(1)	824(1)					—	—	—	—			
C-1									108(1)	064(1)					—	—	(+)	—	—	—	

TEST TERMINATED 6/5/63

(1) MEASUREMENTS WERE TAKEN ON UNMOUNTED TIRES

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC.

Form 128MS

Project 20-1-110 Tire Group C-1 Mfg. Descr. Firestone Super Ground Grip Goer.

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type psig Rotation Voids 1.3 Veh. to Veh. ed. 2500 Els X ed 5000

Code Ser.	Pos.	Meas. Per.	Miles Cum.	Lb/Gm Loss	O D % Inc	X Sec % Inc	Profile	Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils & Loss Per.	Cum.	Miles/Mil Per.	Cum.	% Worn Per	Cum	Est Mi. to Bald
C-1	LF	Orig.			73.89	30.54			60	1562	1500	1570				3132						
	C-3	2520	2520		74.12	30.58			62	1514	1342	1470				2984						
					0.3	0.1				0048	0158	0100				148	148	34.1	–	4.7	–	
	LF	2502	5022		74.30	31.03			63	1379	1266	1175				2554						
	C-2				0.6	1.6				0135	0076	0295				430	578	11.6	17.4	13.7	18.4	
	RR	2500	7522		74.01	30.88			64	1096	1246	989				2085						
	C-1				0.7	1.1				283	70	186				469	1047	10.1	14.4	15.0	33.9	
	RR	2500	10022		73.99	30.96			67	710	1192	795				1505						
	C-3				0.1	1.4				386	054	194				580	1627	8.6	12.3	18.5	51.9	
	RR	2503	12525		73.80	30.87			64	313	1124	561				874						
	C-2				0.0	1.1				390	068	234				631	2258	7.9	11.1	20.2	72.1	
	RR	2515	15040		74.03	31.00			64	024	997	231				255						
	C-1				0.2	1.5				289	127	330				619	2877	8.1	10.5	19.8	91.9	

TEST TERMINATED 6-11-63

Mils & Loss		Miles/Mil		% Worn	
Per.	Cum.	Per.	Cum.	Per	Cum
4[illegible]2					
4[illegible]6					
3[illegible]6	306	24.7	—	6.6	
3820					
506	812	14.8	18.6	10.9	17.5
3331					
489	1301	15.3	17.3	10.6	28.1
2697					
634	1935	11.8	15.5	13.7	41.8
1998					
699	2634	10.7	14.3	15.1	56.9
1252					
746	3380	10.1	13.3	16.1	73.0

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC.

Form 128MS

Project 20-1-110 Tire Group C-2 Mfg. Desc. Firestone Super Ground Grip Goer

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Rib Lugs Type psig Rotation Veh. to Veh. ea. 2500 Fig. X ea. 5000 Voids 1.3

Code Ser.	Pos.	Meas. Miles Per.	Meas. Miles Cum.	Lb/Gal Loss	O D* % Inc	X Sec % Inc	Profile	Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils & Loss Per.	Mils & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi. to Rtd
C-2	RF	Orig.			73.95	30.65			61	1575	1500	1565				3140						
	C-3	2520	2520		74.32	31.00			62	1454	1295	1478				2932						
					0.5	1.1				0121	0205	0087				208	208	24.2	—	6.6		
	RF	2502	5022		74.46	31.07			63	1278	1258	1225				2503						
	C-2				0.7	1.4				0176	037	0253				429	637	11.7	15.7	13.7	20.1	
	LR	2500	7522		74.26	31.10			64	929	1215	1018				1941						
	C-1				0.4	1.5				349	043	207				556	1193	9.0	12.6	[illegible]	38.	
	LR	2500	10022		74.14	31.13			67	522	1179	843				1365						
	C-3				0.3	1.6				407	036	175				582	1775	8.6	11.3	18.5	56.6	
	LR	[illegible]	12525		74.02	30.99			63	208	1065	613				821						
	C-2				0.1	1.1				314	114	230				544	2319	[illegible]	10.8	[illegible]	[illegible]	
	LR	2515	15040		74.22	31.23			64	W.S.	895	368				W.S.						
	C-1				0.4	1.9				W.S.	170	245				W.S.	W.S.	W.S.	W.S.	WS	WS	

TEST TERMINATED 6-N-63

Outside K25500-4

Voids 12.5

Mils & Loss		Miles/Mil		% Worn	
Per.	Cum.	Per.	Cum.	Per	Cum
[illegible]					
[illegible]					
[illegible]	[illegible]	18.3	–	8.9	-
3161					
464	829	16.1	17.1	10.0	18.9
[illegible]					
[illegible]	[illegible]	17.5	15.3	12.9	31.9
[illegible]					
[illegible]	2096	12.1	14.3	13.3	45.2
[illegible]	[illegible]	11.4	13.6	14.2	59.4
[illegible]					
[illegible]	[illegible]	W.S.	W.S.	W.S	WS

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC.

Form 128MS

Project 20-1-110 Tire Group C-3 Mfg. Descr. Firestone Super Ground Grip Goer

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type psig Rotation Voids 1.3 Veh. to veh. ea. 2500 Fig. X ea. 5000

Code Ser.	Pos.	Meas. Miles Per.	Meas. Miles Cum.	Lb/Ga Loss	O D" % Inc	X Sec % Inc	Profile	Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils & Loss Per.	Mils & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi. to Bald
C-3	LR	Orig.			73.82	30.52			60	1.565	1.500	1570				3135						
	C-3	2520	2520		73.97	30.65			62	1.538	1.373	1310				2848						
					0.2	0.4				0.027	0.127	0260				0287	287	17.6	—	9.2		
	LR	2502	5022		74.20	30.62			64	1.392	1.292	1007				2399						
	C-2				0.5	0.3				0.146	0.081	0303				0449	736	11.1	13.6	14.3	23.5	
	RF	2500	7522		74.56	30.88			63	1206	1221	897				2107						
	C-1				1.0	1.2				187	071	110				797	1033	16.8	14.6	9.5	33.0	
	RF	2500	10022		74.52	30.88			64	897	1093	831				1728						
	C-3				0.9	1.2				308	128	066				374	1407	13.4	14.2	11.9	44.9	
	RF	2503	12525		74.33	30.92			64	587	1023	699				1286						
	C-2				0.7	1.3				310	070	132				442	1849	11.3	13.5	14.1	59.0	
	RF	2515	15040		74.47	30.94			64	422	933	541				963						
	C-1				0.9	1.4				165	090	158				323	2172	15.6	13.8	10.3	69.3	

TEST TERMINATED 6-11-63

K 25 500-3

Outside

Voids 1,2,3

Mils & Loss		Miles/Mil		Worn		E
Per.	Cum.	Per.	Cum.	Per	Cum	
4635						
4221						
414	414	18.3	—	8.9	—	
3691						
530	944	14.2	16.0	11.4	20.4	
3623						
368	1312	20.4	17.3	7.9	[illegible]	
2821						
502	1814	14.9	16.6	10.8	39.1	
2309						
512	2326	14.7	16.2	11.1	50.2	
1896						
413	2739	18.5	16.5	8.9	59.1	

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC. Form 12BMS

Project 20-1-110 Tire Group C-4 Mfg. Descr. U.S. Royal Tactical M.S.

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ________ psig Rotation Voids 1.3 Veh. to veh. ea. 2500 Fig X ea. 5000

Code Ser.	Pos. [redacted]	Meas. Miles Per.	Meas. Miles Cum.	Lb/Gm Loss	O D% Inc	X Sec % Inc	Profile	Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils & Loss Per.	Mils & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi. to Bald
C-4	RR	Orig			73.62	30.40			60	1.570	1.500	1.560				3130						
	C-3	2520	2520		73.75	30.56			63	1.470	1.373	1.455				2925						
					0.2	0.5				0.100	0.127	105				205	205	24.6	-	6.5	-	
	RR	2502	5022		73.90	30.58			65	1.282	1.325	1150				2432						
	C-2				0.4	0.6				0.188	0.048	305				493	698	10.2	14.4	15.6	22.3	
	LF	2500	7522		74.28	30.86			64	1042	1252	1028				2065						
	C-1				09	1.6				240	73	127				367	1065	13.6	14.1	11.7	34.0	
	LF	2500	10022		74.17	30.86			65	818	1195	911				1729						
	C-3				0.7	1.5				224	057	112				336	1401	14.9	14.3	10.7	44.8	
	LF	2503	12525		73.99	30.84			62	569	1108	806				1375						
	C-2				0.5	1.4				249	087	105				354	1755	14.1	14.3	11.3	56.1	
	LF	2515	15040		74.19	30.94			63	346	1.014	709				1055						
	C-1				0.8	1.8				223	094	097				320	2075	15.7	14.5	10.3	66.5	
		TEST TERMINATED 6-11-63																				

K25506-2

Voids 1,2,3

Mils & Loss Per.	Mils & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	E
4630						
4298						
332	332	22.8	-	7.2	-	
3757						
541	873	13.9	17.2	11.7	18.9	
3317						
440	1313	17.0	17.2	9.5	28.4	
2924						
393	1706	19.1	17.6	8.5	36.8	
2483						
441	2147	17.0	17.5	9.5	46.4	
2069						
414	2561	18.2	17.6	8.9	55.3	

TIRE MEASUREMENT SUMMARY — HODGES TRANSPORTATION INC. — Form 1298

Project [illegible] Tire Group D Mfg. Desc. FIRESTONE N.D.G.C.
Date [illegible] Tire Size 29.5x25 P.R. 12 Ribs LUG Type [illegible] Rotation [illegible] 2500 Miles

Tire No.	Pos. Date	Kms. Per.	Kms. Cum.	Lb/Cu Lost	O.D. Ins	X Sec. Ins	Profile		Dur. "A"	Orig. V-1	Tread V-2	V-3	V-4	V-5	V-6	Per.	Cum.	Per.	Cum.	% Worn Per.	Cum.	Est. Hi. to Rel.
D1	RR	ORIG			74.32	29.76			63	1430	1430					2860						
	C-3	2503			74.35	30.07			62	1342	1241					2583	–					
						1.1				088	189					277	277	18.1	18.1	9.6	9.6	
	RR																					
	C-2	2500	5003		74.31	30.07			–	1273	1033					2306						
						1.1				060	208					277	554	18.1	18.1	9.6	19.2	
	RR				74.19	30.18			63	1037	782					1869						
	C-1	2506	7509			1.4				176	251					437	991	11.5	16.2	6.3	25.7	
D2	LR	ORIG			74.05	29.96			66	1424	1436					2859						
	C-3	2503			74.19	30.26			62	1362	1208					2570						
						1.0				062	222					289	289	17.3	17.3	10.1	10.1	
	LR																					
	C-2	2500	5003		74.28	30.21			–	1258	1054					2312						
						0.8				104	154					258	547	19.4	18.3	9.0	19.1	
	LR				74.08	30.79			62	1139	749					1888						
	C-1	2506	7509			1.1				119	305					424	971	11.8	15.5	14.8	34.0	
D3	RF	ORIG			74.30	29.69			64	1430	1430					2860						
	C-3	2503			74.32	30.14			62	1273	1183					2456						
						1.5				157	247					404	404	12.4	12.4	14.1	14.1	
	RF																					
	C-2	2500	5003		74.20	30.07				1170	981					2151						
						1.3			–	103	202					305	709	16.4	14.1	10.7	24.8	
	RF				74.14	30.29			62	1108	710					1818						
	C-1	2506	7509			2.0				062	271					333	1042	15.1	14.4	11.6	36.4	
D4	LF	ORIG			73.91	29.90			67	1430	1430					2860						
	C-3	2503			74.11	30.45			62	1283	1190					2473						
						1.8				147	240					387	387	12.9	12.9	13.5	13.5	
	LF																					
	C-2	2500	5003		74.00	30.50				1242	1142					2384						
						2.0			–	041	048					089	476	56.7	21.0	3.1	16.6	
	LF				74.01	30.54			62	1146	1032					2178						
	C-1	2506	7509			2.1				096	110					206	682	[illegible]	[illegible]	[illegible]	[illegible]	

TIRE MEASUREMENT SUMMARY

HODGES TRANSPORTATION INC.

Form 128MS

Project 20-1-110 Tire Group E Mfg. Descr. U.S. DIRECTIONAL DESIGN- RADIAL PLY CONSTRUCTION
Date FEB-1963 Tire Size 29.5-25 P.R. 16 Ribs lug Type ______ psig 40F-35R Rotation VEH TO VEH EACH 2500 MI.

Code Ser.	Pos. Date	Meas. Miles Per.	Meas. Miles Cum.	Lb/Ga Loss	O D" & Inc	X Sec & Inc	Profile	Profile Low	Dur. "A"	Orig. Tread Depth & Tread Loss, Mils V-1	V-2	V-3	V-4	V-5	V-6	Mils & Loss Per.	Mils & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	Est Mi to Ba
E1	LR	ORIG			73.83	31.71			68	1405	1457	1424				2829						
	C-3	2541	2541	-	73.89	31.63			67	1333	1362	1297				2630						
					0.1	–				072	095	127				199	199	23.5		7.0	-	
CD 1732																						
E2	RR	ORIG			73.82	31.70			68	1543	1515	1495				3038						
	C-3	2541	2541	-	73.98	31.64			64	1426	1313	1301				2727						
					0.2	–				117	202	194				311	311	16.3	-	10.2	-	
CD 1706																						
E3	LF	ORIG			73.85	31.63			60	1450	1527	1548				2998						
	C-3	2541	2541		74.04	31.42			57	1375	1399	1402				2777						
					0.3	–				075	128	146				221	221	23.0	–	7.4	-	
CD 1711																						
E4	RF	ORIG			73.80	31.69			66	1610	1522	1498				3108						
	C-3	2541	2541		74.02	31.73			64	1503	1354	1335				2838						
					0.3	0.1				107	168	163				270	270	18.8	-	8.7	-	
CD 1658	TEST			TERMINATED	6-18-63																	

Vanes 1,2,3

Mils. & Loss Per.	Mils. & Loss Cum.	Miles/Mil Per.	Miles/Mil Cum.	% Worn Per	% Worn Cum	E... to
..86						
3192						
794	794	25.9	-	6.9	-	
4553						
4040						
513	513	14.9	-	11.3	-	
4525						
..16						
..49	349	21.8	-	7.7	-	
..30						
4192						
..38	438	17.4	-	9.5	-	

TIRE CONDITION & SUMMARY — HODGES TRANSPORTATION INC. — Form # 128-C

Proj. # 20-1-110 Tire Group A-1 Mfgr. Descrip. Firestone Super Ground Grip Gear H.D. Control

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ______ psig ______ Rotation [illegible]

Code	Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
A-1	LF	2520							M In		Se Heel		
	C-1	2-26							VS Out		M Toe In		
											S Heel Out		
		2624									VS Out		S wipe out. M wipe in.
		3-28											S wipe out
	LF	5022							M In		S In		
	C-3	3-15							Se Out		M Out		
											Se H+T		
											In		
											S H+T		
											out		
	RR	7527						Se In-Out	Se Crown		Se In-Out		Se. wiping in & out
	C-2	3-20						Lugs [illegible]	S [illegible]		Se Heel		center of ground
											wear in		lug area (area of
											crown		wiping unchanged
													from beginning)
	RR	10022						M across	Se Crown		Se In & Out		Se wiping in & out.
	C-1	4-16						tread			Out. Should.		Tire removed from
											W/A		test due to outside
													shoulder worn smooth

Outside K25800-14

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear SL-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

H = Heel T = Toe Vehicles = C-1, C-2, C-3. In = Inside shoulder Out = Outside Shoulder

TIRE CONDITION & SUMMARY — HODGES TRANSPORTATION INC. — Form # 128-C

Proj.# 20-1-110 Tire Group A-2 Mfgr. Descrip. Firestone Super Ground Grip Gear H.D. / Control

Date Feb. 1963 Tire Size 29.5 - 25 P.R. 16 Ribs Lugs Type ______ psig ______ Rotation Veh. to Veh. ea 2500 / Fix.X ea 5000

Tire	Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
2	RF	2520							M In?		M Toe		
	C-1	2-26							Out		Se Heel		
		2624									In + Out		M wipe In & Out shoulder
		2-28											
	RF	5022							M out		M out		
	C-3	3-15							Se In		Se In		
	LR	7522	1½"x½" TF 2" to					Se in-out	M crown		Se in-out		Se wiping of lugs in
	C-2	3-30	outside of ℄					[illegible]					center grooved area
	LR	10022	1¾ x ¾ TF	Yes				M across	M Heel		Se In & out		TF Outside shoulder
	C-1	4-16	4" to inside of					tire	In crown				5½x2" thru 2 breakers
			crown ℄										2½x1¾ thru 1 breaker
													1½x1 Fabric exposed
													Se wiping In & Out. Tire
													removed from test
													due to both shoulders
													worn smooth.

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear
-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot
H= Heel T= Toe Vehicles = C-1, C-2, C-3. In = Inside Shoulder Out = Outside Shoulder.

TIRE CONDITION & SUMMARY

HODGES TRANSPORTATION INC. Form - 128-C

Proj.# 20-1-110° Tire Group A-3 Mfgr. Descrip. Firestone Super Ground Grip Goer H.D. Control

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ______ psig ______ Rotation Veh. to Veh. ea 2500 Fin X ea. 5000

Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
LR	2520							S Out		Se H		
C-1	2-26							Se In		M T In		
	2624									S H & T		Se wipe in. M wipe out
	2-28									Out		S Ribbon delamination
LR	5022							S Out		Se H&T		Se Wipe In. shoulder
C-3	3-15							Se In		In		M wipe Out "
										M T &		S Ribbon delamination
										S H Out		
RF	7522						Se in-out	Se [illegible]		Se in-out		1/2" cut to fabric. Se
C-2	3-30							on crown				[illegible] at lugs in center
												grooved area. S ribbon
												delamination.
RF	10022						M across	M Heel in		Se In &		Tread cuts opening into
C-1	4-16						tread	Crown.		out		area of tread separation.
								Crown				All located off lug points
								wearing				toward inside shoulder.
								away				First noted as blisters
												w/ rubber oozing out.
												Cut" Area of Sep.
		Tread areas	worn to	fabric.	All on	inside shoulder						2 3/4 6 1/2" diam TF
		Area"	Depth of	Wear								2 5"x4" TF
		1" diam	Fabric	Showing								2 1/4 8 1/2" diam. TF [illegible]
		1" diam.	Fabric	Showing								2 4"x3 1/2 TF
		2" diam.	Thru	1 Breaker								1 1/2 5"x4" TF
		2" diam	Thru	1 Breaker								1 4" diam TF
		2 1/2x2 1/2	Thru 2	Breakers								2 1/4 3 1/2"x4 1/2 TF
		2 1/4 diam	Thru 1	Breaker								1 4" diam TF
		4x5	Thru 4	Breakers								1 4" diam TF
		2 1/2x4 1/2	Thru 3	Breakers								1 4" diam TF
		1 1/2 diam	Thru 1	Breaker								Not open 4" diam
												1 4" diam TF
		NOTE: TIRE REMOVED FROM TEST DUE TO INSIDE SHOULDER WEAR [illegible]										Not open 2 1/2" diam

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear -Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

H-Heel T-Toe Vehicles = C-1, C-2, C-3 In = Inside Shoulder Out = Outside Shoulder.

TIRE CONDITION & SUMMARY — HODGES TRANSPORTATION INC. — Form # 128-C

Proj.# 20-1-110 Tire Group A-4 Mfgr. Descrip. Firestone Super Ground Grip Goer H.D. Control.

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ______ psig ______ Rotation Veh to Veh ea.2500 Fix.X ea 5000

Ve	Pos.	Miles	Void	Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
4	RR	2520								M In &		Se Heel		
	C-1	2-26								out		M Toe		
		2624										In-Out		M wipe In & Out
		2-28												
	RR	5022								Se In		Se Heel		M wipe In-Out
	C-3	3-15								& Out		In-Out		
	LF	7522							M In-Out	Se In-Out		Se In-Out		Se wiping of lugs in
	C-2	3-30							At [illegible]			Se Heel		center grooved area
												In crown		
	LF	10028							M across	M heel		Se In &		Se wiping In & out
	C-1	4-16							tread	crown		out		Tire group removed
														from test due to
														three of the four
														tires worn smooth.

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear SL-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

H= Heel T= Toe. Vehicles = C-1, C-2, C-3 In = Inside Shoulder Out = Outside Shoulder.

TIRE CONDITION & SUMMARY HODGES TRANSPORTATION INC. Form # 128-C

Proj.# 20-1-110 Tire Group B-1 Mfgr. Descrip. U.S. Royal Tactical M.S.

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ______ psig ______ Rotation Veh. to Veh. ea. 2500 / Fig. X ea. 5000

No.	Pos.	Miles	Weld Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
1	LF	2520							VS		VS Heel		Two ½" & One 2"
	C-2	2-26									In & Out		circumferential side-
													wall splice openings,
													outer, above bead, NTF
	LF	8022							S In.		VS Out		90% Fold Splice opening
	C-1	3-15									M. In		outside. Se. bead seat
													chafing outside. One
													chafed area 1¾" long
													broken thru top ply and
													separated toward tread
													1¼".
	RR	7231									[illegible]		TIRE FAILED AND REMOVED
	C-3	3-28									OUTSIDE		FROM TEST DUE EXCESSIVE
											[illegible]		AIR LEAK FROM 4½" AREA
											[illegible]		OF BROKEN CORDS AT TIP
											[illegible]		OF FLIPPER AND UNDER-
											[illegible]		TEARING BACK OF FLIPPER
											HEEL IN		TOWARDS BEAD TOE 1½"
													AND 1" UP SIDEWALL. ALL
													PLYS ON OUTSIDE OF
													FLIPPER AND TWO PLYS
													ON INSIDE OF FLIPPER
													BROKEN. 90% OF TOE
													STRIP WORN THRU. SIX
													AREAS OF SWELLING [illegible]
													SIDEWALL. THESE AREAS
													ARE 5/16" ABOVE NORMAL
													SIDEWALL PROFILE.

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear
Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot
H = Heel T = Toe Vehicles = C-1, C-2, C-3 In = Inside shoulder Out = outside shoulder.

TIRE CONDITION & SUMMARY

HODGES TRANSPORTATION INC.

Form : 128-C

Proj.# 20-1-110 Tire Group B-2 Mfgr. Descrip. U.S. Royal Tactical M.S.
Date Feb. - 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ______ psig ______ Rotation Veh. to Veh. eq 2500 / Fls X ea 5000

Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
RF	2520									VS Heel		1", 3 1/2" & 4 1/2" circum.
C-2	2-26									In		sidewall splice openings
												outer, above bead, NTF
												1/2" circum. sidewall
												splice opening, Inner
												above bead, NTF
RF	5022							S In.	S out	VS H out		Fold openings, outside
C-1	3-15							VS Out		S In.		1-2", 1-6 1/4" 1-8 1/2"
												F.O. inside 1-1/2" NTF
LR	7430							S OUT	S OUT	M IN		FOLD OPENINGS, OUTSIDE
C-3	3-30									VS OUT		1-1", 1-7 1/2", 1-8", 1-10" TF
												F.O. INSIDE 1-1/2" NTF.
												3/4" x 3/8" RADIAL CRACK
												IN OUTSIDE SIDEWALL TF.
												ONE AREA OF SWELLING
												ON INSIDE SIDEWALL.
LR	10024						S across	M heel out				Radial cracks, Inside sidewall
C-2	4-16						tread	S heel In				11" up from flange, 1 1/2" x 1/2"
												thru wire plies, cords exposed.
												11" up from flange, 1" x 1/4 &
												1/2 x 1/4, thru wire plies
												12 1/2" up from flange. 1 1/2 x 1/2,
												thru wire plies, cords exposed.
												Cut 1 1/2 x 1/2 thru wire plies
												cords exposed.
												Fold opening, Inside 1/2 x 1/2
												Break above bead. 1" TF
												Fold openings outside
												9 1/2 x 3/4, 22 x 3/4 TF
		Radial crack	from flange base	2" x 1/4" deep, open			5/8" wide	w/ 2 3/4"	crack extending parallel			1 x 1/2 NTF
		to flange										
		Radial crack	1 1/4 x 3/8	deep	thru wire plies.							

...id R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear
...ipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot
H-Heel T=Toe Vehicles = C-1, C-2, C-3 In = Inside Shoulder, Out = Outside shoulder.

TIRE CONDITION & SUMMARY   HODGES TRANSPORTATION INC.   Form # 128-C

Proj.# 20-1-110   Tire Group B   Mfgr. Descrip. U.S. ROYAL TACTICAL M.S.

Date [illegible] 63   Tire Size [illegible]   P.R. 16   Ribs [illegible]   Type ______ psig ______   Rotation ______

No	Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
2	LR	10876							M-N-OUT	W.A.			FAILED FROM 2.75"
	C-1	5-20							S-M-IN				RADIAL CRACK THROUGH
													INSIDE SIDE WALL AND
													1.25" CRACK IN LINER
													OTHER IN S.W. RAD
													CRACKS:
													1.25 x .025" D
													0.75 x .025" D
													2.25 x .050" D
													2.00 x .050" D
													0.75 x .025" D
													FOLD OPENINGS ABOVE
													INSIDE BEADS
													1.00" x .050" D
													0.50" x .050" D
													FOLD OPENINGS ABOVE
													OUTSIDE BEADS
													32.00" TO FABRIC
													11.00" DOGLEG
													THROUGH SEVERAL PLIES
													THIS FOLD OPENING
													DEVELOPED INTO
													CONNECTED RADIAL
													AND CIRCUM. CRACK

Void [illegible] -Checking W-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. [illegible]

-Sipe [illegible] Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

TIRE CONDITION & SUMMARY — HODGES TRANSPORTATION INC. — For. 128-C

Proj.# 20-1-110 Tire Group B-3 Mfgr. Descrip. U.S. Royal Tactical MS.

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ____ psig____ Rotation Veh. to veh. ea 2500 Fig X ea 5000

	Pos.	Miles	Void Cracks	U T	S L	S.T	T B T	Scuff	I W	T S	F W	F S	Other
3	LR	2520									VS Heel		3 bulged areas appx.
	C-2	2-26									In & Out		18" long, inside sidewall
													appx 3/8" bulge height.
	LR	5022									S Heel		Same as above.
	C-1	3-15									In & Out		
	RF	6097							M H out.	VS in	S In		Tire Removed from test.
	C-3								S H in.	crown	M Out		Tread separation inside
													shoulder, appx. 21" x 11".
													5 side wall bulges on
													inside and outside side-
													walls, directly opposite
													each other. Pronounced
													heel wear on tread
													shoulders at areas
													of bulges, lesser
													heel wear between
													bulge areas
													Radial crack, 1¼" x ½"
													inside side wall 5"
													below end of tread
													design. Several wire
													plys broken in area
													of radial crack. 50"
													of circumferential
													liner splice fold open.
													Slight bead chafer cover
													cracked and separated
													on both beads

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear
-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

H = Heel T = Toe Vehicles = C-1, C-2, C-3 In = Inside shoulder, Out = outside shoulder.

TIRE CONDITION & SUMMARY — HODGES TRANSPORTATION INC. — Form : 128-C

Proj.# 20-1-110 Tire Group B-4 Mfgr. Descrip. U.S. Royal Tactical M.S.
Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ______ psig ______ Rotation Veh. to veh. ea. 2500 Fig. X ea. 5000

Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
RR	2520									VS Heel		Tread Lug Repairs Noted.
C-2	2-26									In.		1-1¼", 1-½" circumfer-
												ential tread splice
												opening, outer, above
												bead NTF
												Several bulged areas
												inside & out. sidewall
												Fold opening, defective
												repair.
RR	5022									M H In.		80% of fold splice
C-1	3-15											open inside. Same as
												above outside.
LF	7498						S in. out			M-Se H in		Fold openings outside
C-3	3-30						at shoulder			S H out		2-½"x ⅜" NTF, 1-2"x ½"
							front					NTF, 1-2"x½" TF & 1-3"x
												½" TF. 6 tread lug
												repairs visible. Scuffing
												flap on inside chafer
												off. Flange scuffing
												inside above bead
												total circumference.
												Two areas of swelling
												on inside sidewall and
												two areas on outside
												sidewall approx. ¾"
												larger than normal
												sidewall profile.
LF	10028						S across	Sl out		M to Se		Lug repair cracked at base
C-2	4-16						tread	M in		Heel In.		2¾ x ½. Chafer strip
		Fold openings, outside, TF -								M Heel		lifting entire circumfer-
		3½x3, 1x¾, 2½x¾, 1½x¾								Out.		ence, inside. M chafing
												in area.

Legend: R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear SL-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot
H=Heel T=Toe Vehicles = C-1, C-2, C-3 In = inside shoulder, out = outside shoulder

TIRE CONDITION & SUMMARY — **HODGES TRANSPORTATION INC.** — Form # 128-C

Proj. # 20-1-110 Tire Group B Mfgr. Descrip. ______
Date FEB. 63 Tire Size ______ P.R. ____ Ribs ____ Type ______ psig ______ Rotation ______

le	Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
34	LF	12527							M-H-Out				LUG BREAK UNCHUNKED
	C-1	5.29							Sev.H-In				CHUNKS "
													Out. S.W. Fold OPENINGS
													6" x .025", 2.00" TE,
													4" TE, 3" TE, 4" TE
													OUT. S.W. RAD. CRACKS
													3.00" x .050" D
													1.50" x .050" D
													1.50" x .050" D
													0.50" x .025" D
34	LF	13306							M-H-Out				FAILED FROM 2.75"
	C-3	6.5							Sev.H-In				OUT S.W. RADIAL
													CRACK THROUGH
													CARCASS AND LINER
													OUT S.W. RAD. CRACKS
													1.00" x .050" D
													2.00" x .050" D
													3.50" x .050" D
													OUT S.W. FOLD OPENINGS
													4.25" TE, 2.50" TE,
													3.00" TE, 3.75" TE,
													20" SEV. OUT FLANGE
													CHAFING WITH 12"
													CIRC. BREAK ABOVE
													.025" deep. SL
													IN FLANGE CHAFING

-Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear
-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

TIRE CONDITION & SUMMARY — HODGES TRANSPORTATION INC. — Form # 128-C

Proj. # 28-1-110 | Tire Group R-5 | Mfgr. Descrip. U.S. Naval Tactical M.S.

Date | Tire Size 18.00-25 | P.R. 16 | Ribs Lugs | Type ______ | psig ______ | Rotation Van to Van on 1500 Hr. X ______

Vehicle	Pos.	Miles	Void	Cracks	UT	SL	ST	TBT	Scuff	IW	TS	FW	FS	Other
5	RF	1401												1/2" Radial crack 3/8"
	C-3	3-30												DEEP INSIDE SIDEWALL
														AT FLANGE ABOVE BEAD
	RF	3927												Radial crack 1/2" x 3/8" deep
	C-2	4-16												same as above
	RF	6430												
	C-1	5-29								M-H-W				1" RADIAL CRACK TF
														INSIDE SIDEWALL
														3 bulges IN S.W.
														2 " OUT S.W.
	RF	7209								M-H-IN				
	C-3	6-5								SEV-H-OUT ON ONE lug				1" RADIAL CRACK TF
														INSIDE SIDEWALL
														bulges unchanged.
														Sl. bead chaf IN-OUT
														STEEL WIRE ENDS
														STICKING OUT OF
														IN. S.W. TWO
														patch repairs
														ORIG. MANUFACTURER
														IN LINER

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear SL-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

H = HEEL T = TOE VEHICLES = C-1, C-2, C-3 IN = INSIDE SHOULDER OUT = OUTSIDE SHOULDER

TIRE CONDITION & SUMMARY | HODGES TRANSPORTATION INC. | Form 12[illegible]-C

Proj.# 70-1-110 Tire Group B-6 Mfgr. Descrip. U.S. Royal Tactical M.S.

Date ______ Tire Size [illegible]-25 P.R. 16 Ribs Lug Type ______ psig ______ Rotation [illegible]

[illegible]de	Pos.	Miles	Void Cracks	UT	SL	ST	TBT	Scuff	IW	TS	FW	FS	Other
-6	RR	267											INSIDE SIDEWALL
	C-3	3-30											INDICATES SLIGHT INTER-
													FERENCE WITH TRAILER
													LOWER SUPPORT MEMBER
	RR	2793							VS heel				3 areas of bulging in
	C-2	4-16							in & out				and out sidewalls.
GR 1177	RR	5512							M-H				FAILED FROM
	C-3	5-30							in & out				4" RADIAL CRACK
													CONNECTED TO AN
													18" CIRC. CRACK
													INSIDE S.W. AND
													1" break in liner
													INSIDE Tread SEP
													From bead to
													CROWN x 25.5" L.
													IN AREA OF CRACK.
37	LR	1651											F.O. out S.W.
	C-1	5-29											2.25" TE.
GR 1037	LR	2430							M-H-out				F.O. out S.W.
	C-3	6-5							SL-H-IN				3.00" TE, 1.75" TE,
													1.50 x .025"

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear
[illegible]-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

H = HEEL T = TOE VEHICLES = C-1, C-2, C-3 IN = INSIDE SHOULDER OUT = OUTSIDE SHOULDER

TIRE CONDITION & SUMMARY — HODGES TRANSPORTATION INC. — Form No. 100-C

Proj.# 20-1-110 Tire Group C-1 Mfgr. Descrip. Firestone Super Ground Grip Gear

Date Feb- 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ____ psig ____ Rotation [illegible]

Code	Pos.	Miles	Void Cracks	UT	SL	ST	TBT	Scuff	IW	TS	FW	FS	Other
C-1	LF	2520									VS Heel		VS wipe out [illegible] Se in
	C-3	2-26									out		VS Ribbon Delamination
		2624									S In		VS wipe out S wipe In.
		2-28											S Ribbon Delamination
	LF	5022							S Out		S Heeled		Same as above.
	C-2	3-15							M In		M H&T		
											In.		
	RR	7572						M worn	M [illegible]		M H [illegible]		M WIPING OF LUGS AT
	C-1	3-30						[illegible]					CENTER GROOVE AREA
													IN & OUT. VS RIBBON
													DELAMINATION IN RIBS &
													WEARING AWAY ON LUGS.
	RR	10022						M across	M heel		Se In &		Se wipe in & out
	C-3	4-16						tread	& crown		out		VS ribbon delamination
	RR	12525											
	C-2	5-29						SAME	SAME		SAME		SAME
	RR	15040						SAME	SEV. HEEL		SAME		SE WIPE IN & OUT
	C-1	6-11							WEAR IN				SL. RIBBON DELAMINATION
									CROWN				CROWN LUGS TEARING
													AT PRESSURE POINT.
													BEAD OK. LINER OK.

outside K 25500-5

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear SL-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

H = Heel T = Toe Vehicles = C-1, C-2, C-3. In = Inside shoulder, Out = Outside shoulder.

TIRE CONDITION & SUMMARY

HODGES TRANSPORTATION INC. Form # 128-C

Proj.# 20-1-110 Tire Group C-2 Mfgr. Descrip. Firestone Super Ground Grip Goer.

Date Feb.- 1963 Tire Size 29.5- 25 P.R. 16 Ribs Lugs Type ______ psig ______ Rotation Veh. to Veh. ea 2500 / Fig X ea 5000

outside K-25500-4

Code	Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
C-2	RF	2520	1 3/4" x 1/2"	Yes @ base							M Heel out		S wipe In. M wipe out.
	C-3	2-26		center lug							S Heel in		VS ribbon delamination
	RF	5022	5" TF	Yes					M In &				S wipe In. M wipe Out.
	C-2	8-15	6" TF	Yes					Out				VS ribbon delamination
	RF	5022	5" TF	Yes					M in & out		S Toe		VS ribbon delamination
	C-2	8-15	6" TF	Yes							M Heel		
											In & out		
	LR	7522	7" TF	Yes 1 1/2"				Se OUT	M IN-OUT		M H IN		SWIPING IN & M WIPING
	C-1	3-30	7 1/4" TF	Yes 1 1/2"				S IN			Se H OUT		OUT AT CENTER GROOVED
								[illegible]			S H [illegible]		AREA. S RIBBON DELAMINA-
													TION.
	LR	10022	8 1/4 x 1/2 TF	Yes 1 3/4				M across	M crown		Se out		Sl Ribbon delamination
	C-3	4-16	7 3/4 x 1/2 Thru	Yes 1 3/4				tire			M in		Se wipe in & out
			top breaker								Sl crown		Cut 3 x 3/8 NTF
			4 1/2 x 1/2 TF	Yes 1/4									
	LR	12525	9 1/2" x 2 1/2"	THROUGH	TWO PLIES			SAME	SAME		SAME		SAME
	C-2	5-29	9 1/2" x 2 1/2"	"	" "	" "							
			7 1/2" x 1" T										
			5 1/4 x 1 1/4										
			2 3/4 x 3/4 TF										
			2 3/4 x 3/4 TF										
	LR	15040	10" x 3 1/4"	YES	THRU FOUR PLIES			SAME	SEV. HEEL		SEV. IN		Se. WIPE IN & OUT
	C-1	6-11	12" x 4"	YES	" SIX PLIES				WEAR IN		& out		SL RIBBON DELAMIN.
			9" x 1 3/4"	YES	" TWO PLIES				CROWN				CROWN LUGS TEARING
			5" x 1"	YES	" ONE PLY								AT PRESSURE POINT
			3 1/2" x 3/4 TF	YES									BEAD O.K. LINER O.K.
			5 1/2" x 1 1/2"	YES	THRU ONE PLY								TIRE REMOVED FROM TEST
			2 1/2" x 1 1/4" NTF	NO									DUE TO OUTSIDE SHOULDER
													WORN SMOOTH.

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear
-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

H = Heel T = Toe Vehicles = C-1, C-2, C-3. In = inside Shoulder Out = outside shoulder.

TIRE CONDITION & SUMMARY — HODGES TRANSPORTATION INC. — Form 128-C

Proj.# 20-1-110 Tire Group C-3 Mfgr. Descrip. Firestone Super Ground Grip Gear
Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ______ psig. ______ Rotation Veh. to veh. ea. 2500; Eld. X ea. 5000

Pos.	Miles	Void Cracks	UT	SL	ST	TBT	Scuff	IW	TS	FW	FS	Other
LR	2520									VS H out		Voit-type ribbon surface
C-3	2-26									S H & T		separations 3/8" to 1/2" wide
										In.		around circumference
	2624											VS wipe out. M wipe in.
												S ribbon delamination
LR	5022							S out		S H & T		
C-2	3-18							M in		out		M ribbon delamination
										M H & T		
										in		
RF	7527						Se in	M [illegible]		M H out		M WIPING IN & VS [illegible]
C-1	3-30						M out			Se H in		OUT OF LUGS AT CENTER
												GROOVED AREA, M RIBBON
												DELAMINATION
RF	10022	2 x 3/16 NTF In					M across	M heel		Se In		Se wipe In., M wipe out
C-3	4-16	4 1/2 x 1/2 TF Out	Yes				tread	in crown		& out		M Ribbon delamination
		6 x 1/2 TF In	Yes 3/4									
RF	12825	8 1/2 x 1 1/4 TF	Yes				Same	Same		Same		Same
C-2	5-29	8 x 1 1/4 TF	Yes									2" x 3/4" Cuts NTF
		4 1/4 x 1/2 NTF	Yes									2 1/2 x 1 1/4 " "
		7" x 1" TF	Yes									
RF	15040	[illegible] TF	Yes									
C-1	6-11	[illegible] TF	Yes									
		[illegible]	Yes	Thru two Plies AND ONE PLY			Same	Sev Heel		Se In		Se Wipe in & out
		8" x [illegible]	Yes	To FABRIC				WEAR IN		& out		M Ribbon delamination
		3 1/2" x 1 1/4" NTF	No					CROWN				BEADS O.K. LINER OK
		[illegible]	Yes	To FABRIC								
		6" x 1 1/4" TF	Yes									
		1 1/2" x 5/8" TF	No									
		2 1/2" x 1/2" Cut	No									

Void R-Rib A-All [illegible] [illegible]-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear
-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot
H-Heel [illegible] Vehicles C-1, C-2, C-3 In - Inside shoulder Out - Outside shoulder

TIRE CONDITION & SUMMARY

HODGES TRANSPORTATION INC.

Proj.# 20-1-110 Tire Group C-4 Mfgr. Descrip. Firestone Super Ground Grip Goer Form # 128-C

Date Feb. 1963 Tire Size 29.5-25 P.R. 16 Ribs Lugs Type ______ psig ______ Rotation Veh. to veh. ea. 2500 / F1s X ea. 5000

Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
-4 RR	2520											
C-3	2-26									S H&T		Voit-type ribbon surface
										In & out		separations 3/8 to 1/2 wide
												around circumference.
	2624											
	2-28											M wipe In & out
												VS ribbon delamination
RR	5022	5 1/2" TF	Yes									Cut 1 1/4 x 3/8
C-2	3-15							S out		S H out		M Ribbon delamination
								M in		M H+T		
										In		
LF	7522	3 1/4" TF	Yes 1/2"									
C-1	3-30	7 1/4 TF	Yes 1 1/2"				SE IN-OUT	M AROUND		SE H IN		M WIPING IN & OUT LUG
										M H OUT		AT CENTER GROOVED AREA
										M H CROWN		M RIBBON DELAMINATION
LF	10022	4 1/2 x 1/2 NTF	Yes 2									
C-3	4-16	3 x 1/2 NTF					M across	M heel		Se out		Sl ribbon delamination
		8 1/2 x 1/2	Yes 2 1/2	Thru 2 breakers			tread	in crown		M In		M wipe, In & out
		4 1/2 x 1/2 TF	Yes 1"									
		3 x 1/2 TF										Cuts 4 1/2 x 1 1/2 diag. NTF
		6 3/4 x 1/2 TF	Yes 1"									2 1/2 x 1/2 NTF
		4 3/4 x 1/2 TF	" 3/4"									
LF	12525	9" x 3"	Yes	thru [illegible]			Same	Same		Same		Same
C-2	3-29	8 x 2	Yes									
		7 1/2 x 1 1/2	Yes									
		7 x 1 1/4	Yes									
		7 1/2 x 1 1/2	Yes									
		7 1/2 x 1 1/2	Yes									
		7 x 1 1/2	Yes									
		5 1/2 x 1 1/2	Yes									
		4 x 1/2" NTF										

...id R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear
...ipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot
H-Heel T-Toe Vehicles C-1, C-2, C-3. In-Inside Shoulder Out-Outside Shoulder.

TIRE CONDITION & SUMMARY

[illegible] TRANSPORTATION INC. — Form # [illegible]

Proj.# 20-1-110 Tire Group C Mfgr. Descrip. FIRESTONE SUPER [illegible] [illegible] GOLD.
Date Feb. 1963 Tire Size 24.5-25 P.R. 16 Ribs [illegible] Type ______ Date ______ Rotation [illegible]

Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
LF	15040	9½" x 3⅓"	Yes	Thru	FOUR PLIES		M. across	Sl. Med		Sl. W		Sl. Wire in 1 out
C-1	6-11	9" x 2½"	Yes	"	TWO PLIES		TREAD	uneven		1/2 out		Sl. Ribbon delaminat.
		8¼" x 1½"	Yes	"	ONE PLY							beads OK - Liner OK
		8¾" x 1½"	Yes	"	TWO PLIES							
		8¾" x 1¾"	Yes	"	TWO PLIES							
		7¾" x 1¾"	Yes	"	TWO PLIES							
		7½" x 2"	Yes	"	TWO PLIES							
		8½" x 1¾"	Yes	"	ONE PLY							
		6½" x 1" TF	Yes									
		5" x 1" TF	Yes									
		7½" x 1½" NTF Cut										
		1¾" x 1¼ NTF Cut										

Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertread
SL-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

TIRE CONDITION & SURVEY — HODGES TRANSPORTATION INC. — Fig. 1 [illegible]-C

[illegible] 20-1-112 Tire Group D Mfr. Descrip. Firestone NRMS
[illegible] Tire Size 24.5x25 P.R. 16 Rib [illegible] Type ______ [illegible] Rotation ______

	Pos.	Miles	Cold Cracks	UT	SL	ST	TBT	Scuff	IW	TS	FW	FS	Other
D1	RF	2503							SL-H-IN				M[illegible] Ribbed Delam
	C-3	5-29											
	RF	5003							SL-H-OUT				SAME
	C-2	6-17							M-H-IN				
	RR	7509							SL-H-OUT				SAME
	C-1	6-24							M-H-IN				
D2	LF	2503							SL-M-IN				
	C-3	5-29											
	LF	5003							V.SL-H-OUT				
	C-2	6-17							M-H-IN				
	LF	7509							SL-H-OUT				
	C-1	6-24							M-H-IN				
D3	RF	2503							SL-H-IN				V.S. Ribbed Delam.
	C-3	5-29											
	RF	5003						SL-IN	V.SL-H-OUT				SAME
	C-2	6-17							M-H-IN				
	RF	7509						SL-IN	V.SL-H-OUT				SAME
	C-1	6-24							M-H-IN				
D4	LF	2503											TIRE NORMAL
	C-3	5-29											
	LF	5003						SL-IN	M-H-IN				
	C-2	6-17											
	LF	7509						SL-IN	SL-H-OUT				
	C-1	6-24							M-H-IN				

Code R-Rib A-All CD-Chordwise WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Sc-Severe. UT-Undertread
SL-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot
H-Heel

TIRE CONDITION & SUMMARY

[illegible] TRANSPORTATION INC. Form # 128-E

Proj.# 70-1-110 Tire Group E Mfgr. Descrip. U.S. DIRECTIONAL DESIGN - RADIAL PLY CONSTRUCTION

Date Feb Tire Size 29.5-25 P.R. 16 Ribs Lug Type ______ [illegible] Rotation [illegible]

Code	Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
E-1	-	ORIG											
		6-4									S-H-ALL		USED TIRE. SL LUG
											LUGS		CHIPPING. 2½" RADIAL
													CRACK 0.100" IN DEPTH
													NTF INSIDE SIDEWALL.
													CIRCUMFERENTIAL FLAW
													CRACKS ABOVE BEAD
													OUTSIDE SIDEWALL. SL
													SHALLOW CUTTING ON
													LUGS.
	LR	2841											
	C-3	6-18									M-H-IN		2¾" x ½" CUT IN VOID
											& OUT		INSIDE. SHALLOW CUTTING
											S-H-CROWN		ON LUGS. 9¼" X 0.150"
													RADIAL CRACK NTF INSIDE
													SIDEWALL. 7¼" X 0.100"
													RADIAL CRACK NTF INSIDE
													SIDEWALL. CIRCUMFERENTIAL
													FLAW CRACKS ABOVE BEAD
													OUTSIDE SIDEWALL.
E-2	-	ORIG											
		6-4									S-H-ALL		USED TIRE. MED LUG
											LUGS		CHIPPING AND TEARING.
													SL OZONE CRACKING
													ACROSS TREAD. SL FLAW
													CRACKING ABOVE BEAD
													INSIDE SIDEWALL.
	RR	2841											
	C-3	6-18									SL H OUT		MED LUG CHIPPING AND
											M H IN		TEARING. 2½" X 0.100"
											M H CROWN		RADIAL CRACK NTF
													INSIDE SHOULDER. SL FLAW
													CRACKING INSIDE & OUTSIDE
													SIDEWALL. SL OZONE
													CRACKING ACROSS TREAD.

V-Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertread
SL-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

TIRE CONDITION & SUMMARY — **HODGES TRANSPORTATION INC.** — Form # 120-C

Proj.# 20-1-110 Tire Group E Mfgr. Descrip. U.S. DIRECTIONAL DESIGN - RADIAL PLY CONSTRUCTION
Date FEB 1963 Tire Size 18.5-25 P.R. 16 Ribs LUG Type ______ psig 40F-30R Rotation VEH TO VEH EACH 2500 MI.

Code	Pos.	Miles	Void Cracks	U T	S L	S T	T B T	Scuff	I W	T S	F W	F S	Other
-3	-	ORIG									SL H ALL		USED TIRE, MED FLOW
		6-4									LUGS		CRACKING OUTSIDE AND
													SL INSIDE SIDEWALL.
													SL OZONE CRACKING
													ACROSS TREAD.
	LF	2541									M-H ALL		CONTINUOUS FLOW CRACK-
	C-3	6-18									OUT		ING 5" ABOVE FLANGE
											SL H CROWN		OUTSIDE SIDEWALL. MED
													FLOW CRACKING INSIDE
													SIDEWALL. 5" X 0.075"
													RADIAL CRACK NTF
													OUTSIDE SIDEWALL. 6" X 0.1
													RADIAL CRACK NTF INSIDE
													SIDEWALL. 9" X 0.150" RADIAL
													CRACK NTF INSIDE SIDEWALL SL OZONE CRACKING ACROSS TREAD
-4	-	ORIG									SL-H-ALL		USED TIRE. 4 MOLD
		6-4									LUGS		BLEMISHES ON INSIDE
													LUG ENDS. MED FLOW
													CRACKING INSIDE AND
													OUTSIDE SIDEWALL. SL
													OZONE CRACKING ACROSS
													TREAD.
	RF	2541									SL H OUT		MED FLOW CRACKING
	C-3	6-18									M H IN		INSIDE AND OUTSIDE
											M H CROWN		SIDEWALL. 4 MOLD
													BLEMISHES ON OUTSIDE
													LUG ENDS. SL OZONE
													CRACKING ACROSS TREAD

V-Void R-Rib A-All CO-Chunkout WA-Worn Away TF-To, NTF-Not To Fabric. VS-Very Slight S-Slight M-Medium Se-Severe. UT-Undertear
SL-Sipe Lift ST-Sipe Tear SET-Sipe End Tear TBT-Tie Bar Tear IW-Irregular Wear TS-Tread Splice FW-Fast Wear FS-Flat Spot

Best Available Copy

TEST DATA (Contd.)

3. Tread Temperature and Tire Pressures

Original Pavement Course Operation (104 Miles per shift)

Tire Group	A	B	C
Vehicle	C-3	C-1	C-2
Date	2/27/63	2/27/63	2/27/63
Miles	2773	2773	2773
Ambient	49°F		
Pavement	--		

		psig Start	psig @ Temp.	psig Inc	°F Temp		psig Start	psig @ Temp.	psig Inc	°F Temp		psig Start	psig @ Temp	psig Inc	°F Temp
LF	A-1	--	--	--	--	B-1	--	--	--	--	C-1	--	--	--	--
RF	A-2	--	--	--	--	B-2	--	--	--	--	C-2	--	--	--	--
Avg. Front		--	--	--	--		--	--	--	--		--	--	--	--
LR	A-3	25.0	33.0	8.0	170	B-3	25.0	35.0	10.0	175	C-3	25.0	36.0	11.0	165
RR	A-4	25.0	33.0	8.0	195	B-4	25.0	36.0	11.0	160	C-4	25.0	36.0	11.0	175
Avg. Rear		25.0	33.0	8.0	183		25.0	35.5	10.5	168		25.0	36.0	11.0	170
Avg. Group		--	--	--	--		--	--	--	--		--	--	--	--
Date			2/28/63					2/28/63					2/28/63		
Miles			2870					2870					2870		
Ambient		50°F													
Pavement		68°F													
LF	A-1	36.0	47.0	11.0	161	B-1	40.5	51.5	11.0	146	C-1	36.0	47.5	11.5	162
RF	A-2	36.0	47.0	11.0	163	B-2	40.5	51.0	10.5	150	C-2	36.0	47.0	11.0	172
Avg. Front		36.0	47.0	11.0	162		40.5	51.5	11.0	148		36.0	47.5	11.5	167
LR	A-3	26.0	35.0	9.0	166	B-3	26.0	34.5	8.5	169	C-3	26.0	34.5	8.5	172
RR	A-4	26.0	35.0	9.0	165	B-4	26.0	35.0	9.0	155	C-4	26.0	35.0	9.0	175
Avg. Rear		26.0	35.0	9.0	166		26.0	35.0	9.0	162		26.0	35.0	9.0	174
Avg. Group		31.0	41.0	10.0	164		33.0	43.0	10.0	155		31.0	41.0	10.0	170

TEST DATA (Contd.)

3. Tread Temperature and Tire Pressures (Contd.)

Original Pavement Course Operation (104 miles per shift) (Contd.)

Tire Group			A					B					C		
Vehicle			C-3					C-1					C-2		
Date			3/1/63(1)					3/1/63(2)					3/1/63(1)		
Miles			3121					3121					3121		
Ambient		55°F													
Pavement		69°F													
		psig			°F		psig			°F		psig			°F
		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp
LF	A-1	36.0	51.0	15.0	177	B-1	41.0	51.5	10.5	185	C-1	36.0	48.5	12.5	185
RF	A-2	36.0	51.5	15.5	175	B-2	41.0	51.0	10.0	185	C-2	36.0	48.5	12.5	200
Avg. Front		36.0	51.5	15.5	176		41.0	51.5	10.5	185		36.0	48.5	12.5	193
LR	A-3	26.0	39.0	13.0	195	B-3	26.0	35.0	9.0	165	C-3	26.0	35.0	9.0	200
RR	A-4	26.0	39.0	13.0	190	B-4	26.0	37.0	11.0	165	C-4	26.0	36.0	10.0	210
Avg. Rear		26.0	39.0	13.0	193		26.0	36.0	10.0	165		26.0	35.5	9.5	205
Avg. Group		31.0	45.0	14.0	184		34.0	44.0	10.0	175		31.0	42.0	11.0	199
Date			3/8/63(1)					3/8/63(2)					3/8/63(1)		
Miles			4399					4399					4399		
Ambient		54°F													
Pavement		68°F													
LF	A-1	35.0	47.5	12.5	190	B-1	40.0	51.0	11.0	210	C-1	40.0	54.0	14.0	185
RF	A-2	35.0	49.0	14.0	183	B-2	40.0	51.5	11.5	205	C-2	40.0	54.5	14.5	192
Avg. Front		35.0	48.0	13.0	187		40.0	51.5	11.5	208		40.0	54.5	14.5	189
LR	A-3	25.0	35.5	10.5	192	B-3	25.0	34.0	9.0	174	C-3	30.0	41.0	11.0	178
RR	A-4	25.0	35.0	10.0	183	B-4	25.0	37.0	12.0	160	C-4	30.0	41.5	11.5	180
Avg. Rear		25.0	35.5	10.5	188		25.0	36.0	11.0	167		30.0	41.5	11.5	179
Avg. Group		30.0	42.0	12.0	187		32.5	43.5	11.0	187		35.0	48.0	13.0	184

(1) Taken 9" from crown center.
(2) Taken 10 1/2" from crown center.

TEST DATA (Contd.)

3. Tread Temperatures and Tire Pressures

Revised Pavement Course Operation (194 miles per shift)

		A	B	C
Tire Group		A	B	C
Vehicle		C-2	C-3	C-1
Date		3/19/63*	3/19/63**	3/19/63*
Miles		5611	5611	5611
Ambient	60°F			
Pavement	78°F			

		psig Start	psig @ Temp	psig Inc	°F Temp		psig Start	psig @ Temp	psig Inc	°F Temp		psig Start	psig @ Temp	psig Inc	°F Temp
LF	A-4	35.0	49.0	14.0	192	B-4	40.0	50.5	10.5	172	C-4	40.0	55.0	15.0	197
RF	A-3	35.0	50.0	15.0	200	B-3	40.0	51.0	11.0	200(1)	C-3	40.0	55.0	15.0	192
Avg.Front		35.0	49.5	14.5	196		40.0	51.0	11.0	186		40.0	55.0	15.0	195
LR	A-2	25.0	37.5	12.5	175	B-2	25.0	35.0	10.0	170	C-2	30.0	40.0	10.0	180
RR	A-1	25.0	38.0	13.0	190	B-1	25.0	34.5	9.5	165	C-1	30.0	43.0	13.0	180
Avg.Rear		25.0	38.0	13.0	183		25.0	35.0	10.0	168		30.0	41.5	11.5	180
Avg.Group		30.0	43.5	13.5	189		32.5	43.0	10.5	177		35.0	48.0	13.0	186

		A	B	C
Date		3/21/63*	3/21/63**	3/21/63*
Miles		6029	6029	6029
Ambient	64°F			
Pavement	72°F			

		psig Start	psig @ Temp	psig Inc	°F Temp		psig Start	psig @ Temp	psig Inc	°F Temp		psig Start	psig @ Temp	psig Inc	°F Temp
LF	A-4	35.0	50.0	15.0	230	B-4	40.0	53.5	13.5	211	C-4	41.0	58.0	17.0	211
RF	A-3	35.0	50.5	15.5	220	B-3	40.0	52.5	12.5	200(2)	C-3	41.0	58.0	17.0	208
Avg.Front		35.0	50.5	15.5	225		40.0	53.0	13.0	206		41.0	58.0	17.0	210
LR	A-2	26.0	38.5	12.5	190	B-2	26.0	36.5	10.5	180	C-2	31.0	44.0	13.0	183
RR	A-1	26.0	37.0	11.0	196	B-1	26.0	36.5	10.5	185	C-1	31.0	46.0	15.0	193
Avg.Rear		26.0	38.0	12.0	193		26.0	36.5	10.5	183		31.0	45.0	14.0	188
Avg.Group		30.5	44.0	13.5	209		33.0	44.5	11.5	194		36.0	51.5	15.5	199

(1) Tire had one area of 265°F.
(2) Tire had one separated tread area at 275°F. Tire was removed at end of shift.
* Taken 9" from crown center.
** Taken 10 1/2" from crown center.

TEST DATA (Contd.)

3. **Tread Temperatures and Tire Pressures (Contd.)**

Revised Pavement Course Operation (194 miles per shift) (Contd.)

Tire Group		A	B	C
Vehicle		C-2	C-3	C-1
Date		3/25/63***	3/25/63**	3/25/63***
Miles		6408	6408	6408
Ambient	57°F			
Pavement	70°F			

Tire Group A

		psig Start	psig @ Temp	psig Inc	°F Temp
LF	A-4	35.0	48.5	13.5	--
RF	A-3	35.0	49.5	14.5	205
Avg. Front		35.0	--	--	--
LR	A-2	25.0	37.0	12.0	--
RR	A-1	25.0	38.0	13.0	--
Avg. Rear		--	--	--	--
Avg. Group		--	--	--	--

Tire Group B

		psig Start	psig @ Temp	psig Inc	°F Temp
LF	B-4	40.0	53.0	13.0	175
RF	B-5	40.0	52.0	12.0	180
Avg. Front		40.0	52.5	12.5	178
LR	B-2	25.0	35.5	10.5	--
RR	B-1	25.0	35.0	10.0	--
Avg. Rear		25.0	35.5	10.5	--
Avg. Group		--	--	--	--

Tire Group C

		psig Start	psig @ Temp	psig Inc	°F Temp
LF	C-4	40.0	56.0	16.0	--
RF	C-3	40.0	56.5	16.5	195
Avg. Front		40.0	56.5	16.5	--
LR	C-2	30.0	42.5	12.5	--
RR	C-1	30.0	44.0	14.0	--
Avg. Rear		30.0	50.0	13.5	--
Avg. Group		35.0	50.0	15.0	--

		A	B	C
Date		3/26/63***	3/26/63**	3/26/63***
Miles		6689	6689	6689
Ambient	64°F			
Pavement	72°F			

Tire Group A

		psig Start	psig @ Temp	psig Inc	°F Temp
LF	A-4	35.0	50.0	15.0	210
RF	A-3	35.0	51.0	16.5	222
Avg. Front		35.0	50.5	15.5	216
LR	A-2	26.0	38.0	12.0	205
RR	A-1	26.0	39.0	13.0	207
Avg. Rear		26.0	38.5	12.5	206
Avg. Group		30.5	44.5	14.0	211

Tire Group B

		psig Start	psig @ Temp	psig Inc	°F Temp
LF	B-4	40.0	53.0	13.0	199
RF	B-5	40.0	52.0	12.0	190
Avg. Front		40.0	52.5	12.5	195
LR	B-2	25.0	36.5	11.5	186
RR	B-1	25.0	35.5	10.5	199
Avg. Rear		25.0	36.0	11.0	193
Avg. Group		32.5	44.0	11.5	194

Tire Group C

		psig Start	psig @ Temp	psig Inc	°F Temp
LF	C-4	40.0	57.5	17.5	211
RF	C-3	40.0	57.5	17.5	205
Avg. Front		40.0	57.5	17.5	208
LR	C-2	30.0	37.5	7.5	199
RR	C-1	30.0	38.5	8.5	199
Avg. Rear		30.0	38.0	8.0	199
Avg. Group		35.0	48.0	13.0	204

** Taken 10 1/2" from crown center.
***Taken 5 1/4" from crown center.

TEST DATA (Contd.)

3. Tread Temperatures and Tire Pressures (Contd.)

Revised Pavement Course Operation (194 miles per shift) (Contd.)

		psig			°F		psig			°F		psig			°F
Tire Group			A					B					C		
Vehicle			C-2					C-3					C-1		
Date			3/26/63***					3/26/63**					3/26/63***		
Miles			6717					6731					6745		
Ambient		66°F													
Pavement		77°F													
		Start	Δ Temp	Inc	Temp		Start	Δ Temp	Inc	Temp		Start	Δ Temp	Inc	Temp
LF	A-4	--	--	--	208	B-4	--	--	--	203	C-4	--	--	--	224
RF	A-3	--	--	--	220	B-5	--	--	--	191	C-3	--	--	--	217
Avg. Front					214					197					221
LR	A-2	--	--	--	210	B-2	--	--	--	187	C-2	--	--	--	218
RR	A-1	--	--	--	209	B-1	--	--	--	195(1)	C-1	--	--	--	220
Avg. Rear					210					191					219
Avg. Group					212					194					220
Date								3/26/63**							
Miles								6745							
Ambient		67°F													
Pavement		79°F													
LF						B-4	--	--	--	--					
RF						B-5	--	--	--	--					
Avg. Front							--	--	--	--					
LR						B-2	--	--	--	185					
RR						B-1	--	--	--	190(1)					
Avg. Rear							--	--	--	188					

** Taken 10 1/2" from crown center.
*** Taken 5 1/4" from crown center.
(1) Tire had one area of 230-237°F (suspected separation). The same area 14 miles later recorded a temperature of 237°F. No separation developed.

TEST DATA (Contd.)

3. **Tread Temperatures and Tire Pressures (Contd.)**

Secondary Road Operation

Tire Group		A	B	C
Vehicle		C-2	C-3	C-1
Date		3/27/63***	3/27/63**	3/27/63***
Miles		6923	6923	6923
Ambient	63°F			
Pavement	(1)			

		Start (psig)	@ Temp (psig)	Inc	°F Temp		Start (psig)	@ Temp (psig)	Inc	°F Temp		Start (psig)	@ Temp (psig)	Inc	°F Temp
LF	A-4	37.5	48.0	10.5	205	B-4	42.0	52.5	10.5	190	C-4	43.0	54.5	11.5	195
RF	A-3	37.5	47.5	10.0	202	B-5	42.0	50.5	8.5	180	C-3	43.0	54.5	11.5	195
Avg. Front		37.5	48.0	10.5	204		42.0	51.5	9.5	185		43.0	54.5	11.5	195
LR	A-2	28.0	38.0	10.0	195	B-2	27.5	35.0	7.5	180	C-2	31.5	41.5	10.0	185
RR	A-1	28.0	37.5	9.5	195	B-1	27.0	34.0	7.0	192(2)	C-1	31.5	42.0	10.5	180
Avg. Rear		28.0	38.0	10.0	195		27.0	34.5	7.5	186		31.5	42.0	10.5	183
Avg. Group		33.0	43.0	10.0	199		34.5	43.0	8.5	186		37.0	48.0	11.0	189

(1) Temperature taken this day were of secondary operation.
(2) Tire had one tread area of 215°F.
** Taken 10 1/2" from crown center.
*** Taken 5 1/4" from crown center.

TEST DATA (Contd.)

3. Tread Temperatures and Tire Pressures (Contd.)

Revised Pavement Course Operation (194 miles per shift) (Contd.)

Tire Group			A					B					C		
Vehicle			C-1					C-2					C-3		
Date			4/4/63***					4/4/63**					4/4/63***		
Miles to Date			8106					8096					8135		
Ambient		60°F					60°F								
Pavement		70°F					75°F								
		psig			°F		psig			°F		psig			°F
		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp
LF	A-4	36.0	48.0	12.0	195	B-4	41.0	53.0	12.0	181	C-4	41.0	53.0	12.0	205
RF	A-3	36.0	50.0	14.0	202	B-5	41.0	51.0	10.0	188	C-3	41.0	55.0	14.0	202
Avg. Front		--	--	--	199		--	--	--	185		--	--	--	204
LR	A-2	26.0	37.0	11.0	185	B-2	26.0	37.0	11.0	218	C-2	31.0	40.0	9.0	197
RR	A-1	26.0	37.0	11.0	185	B-6	26.0	36.0	10.0	205	C-1	31.0	42.0	11.0	195
Avg. Rear		--	--	--	185		--	--	--	212		--	--	--	196
Avg. Group		--	--	--	192		--	--	--	198		--	--	--	200
Date			4/4/63					4/4/63					4/4/63		
Miles to Date			8191					8139					8177		
Ambient		70°F													
Pavement		85°F													
LF	A-4	36.0	49.0	13.0	206	B-4	41.0	53.0	12.0	185	C-4	41.0	56.0	15.0	200
RF	A-3	36.0	50.0	14.0	220	B-5	41.0	51.5	10.5	185	C-3	41.0	57.0	16.0	204
Avg. Front		--	--	--	213		--	--	--	185		--	--	--	202
LR	A-2	26.0	38.5	12.5	210	B-2	26.0	37.5	11.5	212	C-2	31.0	42.5	11.5	197
RR	A-1	26.0	39.0	13.0	200	B-6	26.0	36.0	11.0	203	C-1	31.0	43.5	12.5	195
Avg. Rear		--	--	--	205		--	--	--	208		--	--	--	196
Avg. Group		--	--	--	209		--	--	--	196		--	--	--	199

** Taken 10 1/2" from crown center.
*** Taken 5 1/4" from crown center.

TEST DATA (Contd.)

3. Tread Temperatures and Tire Pressures (Contd.)

Revised Pavement Course Operation (194 miles per shift) (Contd.)

Tire Group		A					B					C			
Vehicle		C-1					C-2					C-3			
Date		4/10/63***					4/10/63**					4/10/63***			
Miles to Date		9195					9185					9223			
Ambient		52°F										70°F			
Pavement		60°F										90°F			
		psig			°F		psig			°F		psig			°F
		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp
LF	A-4	35.0	48.0	13.0	180	B-4	40.0	54.0	14.0	208	C-4	40.0	55.0	15.0	200
RF	A-3	35.0	48.0	13.0	183	B-5	40.0	51.0	11.0	178	C-3	40.0	56.0	16.0	192
Avg. Front		--	--	--	182		--	--	--	193		--	--	--	196
LR	A-2	26.0	37.0	11.0	183	B-2	26.0	37.0	11.0	215	C-2	30.0	42.0	12.0	200
RR	A-1	25.0	37.5	12.5	192	B-6	26.0	36.5	10.5	245	C-1	30.0	42.5	12.5	190
Avg. Rear		--	--	--	188		--	--	--	230		--	--	--	195
Avg. Group		--	--	--	185		--	--	--	212		--	--	--	196
Date		4/12/63					4/12/63					4/12/63			
Miles to Date		9607					9555					9593			
Ambient		68°F													
Pavement		85°F													
LF	A-4	35.0	51.0	16.0	204	B-4	40.0	56.0	16.0	200	C-4	40.0	56.5	16.5	205
RF	A-3	35.0	51.5	16.5	208	B-5	40.0	54.0	14.0	175	C-3	40.0	58.0	18.0	198
Avg. Front		--	--	--	206		--	--	--	188		--	--	--	202
LR	A-2	25.0	40.0	15.0	210	B-2	26.0	39.0	13.0	208	C-2	30.0	45.0	15.0	200
RR	A-1	25.0	41.0	16.0	210	B-6	26.0	39.0	13.0	235	C-1	30.0	43.5	13.5	200
Avg. Rear		--	--	--	210		--	--	--	222		--	--	--	200
Avg. Group		--	--	--	208		--	--	--	205		--	--	--	201

** Taken 10 1/2" from crown center.
***Taken 5 1/4" from crown center.

TEST DATA (Contd.)

3. **Tread Temperatures and Tire Pressures (Contd.)**

Revised Pavement Course Operation (194 miles per shift) (Contd.)

Tire Group		B					C					D			
Vehicle		C-1					C-2					C-3			
Date		5/13/63					5/13/63					5/17/63			
Miles to Date		10204					10214					616			
Ambient		63°F					63°F					~~74°F~~			
Pavement		81°F					81°F					104°F			
		psig			°F		psig			°F		psig			°F
		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp
LF	B-4	40.0	52.0	12.0	190	C-4	40.0	54.0	14.0	195	D-4	35.0	47.0	12.0	229
RF	B-5	40.0	51.0	11.0	185	C-3	40.0	55.0	15.0	200	D-3	35.0	48.0	13.0	234
Avg. Front		--	--	--	188		--	--	--	198		--	--	--	232
LR	B-2	25.0	36.5	11.5	200	C-2	25.0	43.0	18.0	205	D-2	25.5	38.0	12.5	215
RR	B-6	25.0	36.5	11.5	205(1)	C-1	25.0	45.0	20.0	195	D-1	26.0	38.0	12.0	210
Avg. Rear		--	--	--	203		--	--	--	200		--	--	--	213
Avg. Group		--	--	--	195		--	--	--	199		--	--	--	222
Date		5/21/63					5/21/63					5/21/63			
Miles to Date		10997					11072					1062			
Ambient		82°F					84°F					83°F			
Pavement		110°F					115°F					112°F			
LF	B-4	40.0	52.0	12.0	193	C-4	40.0	55.0	15.0	220	D-4	40.0	52.0	12.0	225
RF	B-5	40.0	50.5	10.5	193	C-3	40.0	55.0	15.0	211	D-3	40.0	52.0	12.0	225
Avg. Front		--	--	--	193		--	--	--	216		--	--	--	225
LR	B-7	25.0	35.5	10.5	184	C-2	30.0	41.0	11.0	240	D-2	30.0	41.0	11.0	200
RR	B-6	25.0	36.0	11.0	265	C-1	30.0	43.0	13.0	200	D-1	30.0	42.0	12.0	205
Avg. Rear		--	--	--	225		--	--	--	220		--	--	--	203
Avg. Group		--	--	--	209		--	--	--	218		--	--	--	214

(1) Tire had tread separation on inside shoulder which recorded a temperature of 255°F.

TEST DATA (Contd.)

3. **Tread Temperatures and Tire Pressures (Contd.)**

Revised Pavement Course Operation (194 miles per shift) (Contd.)

Tire Group	B	C	D
Vehicle	C-1	C-2	C-3
Date	5/23/63	5/23/63	5/23/63
Miles to Date	11466	11616	1603
Ambient	71°F	70°F	65°F
Pavement	83°F	83°F	79°F

		psig			°F		psig			°F		psig			°F
		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp
LF	B-4	40.0	52.0	12.0	215	C-4	40.0	54.0	14.0	205	D-4	40.0	50.0	10.0	207
RF	B-5	40.0	51.5	11.5	210	C-3	40.0	54.0	14.0	200	D-3	40.0	51.0	11.0	217
Avg. Front		--	--	--	213		--	--	--	203		--	--	--	212
LR	B-7	25.0	36.0	11.0	200	C-2	30.0	40.0	10.0	225	D-2	30.0	40.0	10.0	195
RR	B-6	25.0	36.5	11.5	265(1)	C-1	30.0	40.0	10.0	210	D-1	30.0	40.5	10.5	193
Avg. Rear		--	--	--	233		--	--	--	218		--	--	--	194
Avg. Group		--	--	--	223		--	--	--	210		--	--	--	203

(1) Tire separated around entire inside shoulder.

TEST DATA (Contd.)

3. Tread Temperatures and Tire Pressures (Contd.)

Revised Pavement Course Operation (194 miles per shift.) (Contd.)

	C	D	E
Tire Group	C	D	E
Vehicle	C-1	C-2	C-3
Date	6/6/63	6/6/63	6/6/63
Miles to Date	14189	3631	153
Ambient	55°F	55°F	55°F
Pavement	65°F	65°F	65°F

		psig			°F		psig			°F		psig			°F
		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp
LF	C-4	40.0	52.5	12.5	189	D-4	40.0	50.0	10.0	212	E-3	40.0	50.0	10.0	215
RF	C-3	40.0	52.0	12.0	186	D-3	40.0	49.5	9.5	206	E-4	40.0	50.0	10.0	225
Avg.Front		--	--	--	186		--	--	--	209		--	--	--	220
LR	C-2	30.0	39.5	9.5	200	D-2	30.0	39.0	9.0	190	E-1	30.0	39.0	9.0	215
RR	C-1	30.0	39.0	9.0	180	D-1	30.0	39.0	9.0	195	E-2	30.0	39.0	9.0	230
Avg.Rear		--	--	--	190		--	--	--	193		--	--	--	223
Avg.Group		--	--	--	189		--	--	--	201		--	--	--	221

TEST DATA (Contd.)

3. Tread Temperatures and Tire Pressures (Contd.)

Revised Pavement Course Operation (194 miles per shift) (Contd.)

Tire Group				D					E		
Vehicle				C-2					C-3		
Date				6/11/63					6/11/63		
Miles to Date				4708					1199		
Ambient	68°F										
Pavement	87°F										
			psig			°F		psig			°F
			Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp
LF		D-4	40.0	54.0	14.0	187	E-3	40.0	52.5	12.5	252
RF		D-3	40.0	53.5	13.5	192	E-4	40.0	52.0	12.0	225
Avg. Front			--	--	--	190		--	--	--	239
LR		D-2	30.0	41.0	11.0	203	E-1	30.0	38.0	8.0	234
RR		D-1	30.0	41.0	11.0	198	E-2	30.0	39.5	9.5	230
Avg. Rear			--	--	--	201		--	--	--	232
Avg. Group			--	--	--	195		--	--	--	235
Date				6/12/63					6/12/63		
Miles to Date				4995					1635		
Ambient	84°F										
Pavement	97°F										
LF		D-4	40.0	56.0	16.0	216	E-3	40.0	54.0	14.0	232
RF		D-3	40.0	55.0	15.0	212	E-4	40.0	53.0	13.0	242
Avg. Front			--	--	--	214		--	--	--	237
LR		D-2	30.0	43.0	13.0	215	E-1	30.0	40.0	10.0	256
RR		D-1	30.0	43.0	13.0	210	E-2	30.0	40.5	10.5	227
Avg. Rear			--	--	--	213		--	--	--	242
Avg. Group			--	--	--	213		--	--	--	239

TEST DATA (Contd.)

3. Tread Temperatures and Tire Pressures (Contd.)

Revised Pavement Course Operation (194 miles per shift) (Contd.)

Tire Group			D					E			
Vehicle			C-1					C-3			
Date			6/17/63					6/17/63			
Miles to Date			5887					2487			
Ambient	76°F										
Pavement	92°F										
			psig			°F		psig			°F
			Start	@ Temp	Inc	Temp		Start	@ Temp	Inc	Temp
LF		D-4	40.0	53.0	13.0	217	E-3	40.0	55.0	15.0	248
RF		D-3	40.0	55.0	15.0	233	E-4	40.0	52.5	12.5	228
Avg. Front			--	--	--	225		--	--	--	238
LR		D-2	30.0	41.5	11.5	209	E-1	30.0	40.0	10.0	265
RR		D-1	30.0	42.5	12.5	205	E-2	30.0	40.5	10.5	225
Avg. Rear			--	--	--	207		--	--	--	245
Avg. Group			--	--	--	216		--	--	--	242

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FINAL REPORT

Project 20-1-110

Appendix A - "Ride" Study
and
Appendix B - Shallow Mud Traction

July 1963

Nevada Automotive Test Center
A Division of Hodges Transportation Inc.
Box 234 Carson City, Nevada

APPENDIX A

FINAL REPORT

Project 20-1-110

Comparison of Vehicle "Ride" as Influenced By Vehicle Configuration and Tire Design

July 1963

Nevada Automotive Test Center
A Division of Hodges Transportation Inc.
Box 234 Carson City, Nevada

APPENDIX A

FINAL REPORT

Project 20-1-110

This Photograph Shows the Recording and Measurement Equipment Necessary to Conduct this "Ride" Study.

1. General Radio Model 761A Vibration, Displacement and Velocity Meter.

2. Sanborne Strip Chart Recorder (not used during test due to the forces acting on the recording system and absence of suitable mount; therefore, visual readings were recorded directly from the vibration meter).

3. "Lock-on" Helmet with Vibration Meter Pickup used in measuring drivers' reaction to ride.

4. Vibration Meter Pickup used in measuring vehicles' reaction to ride.

5. Stadia Rod used in measuring course profile.

6. Transit used in conjunction with Stadia Rod.

7. Notebook of instrument manuals.

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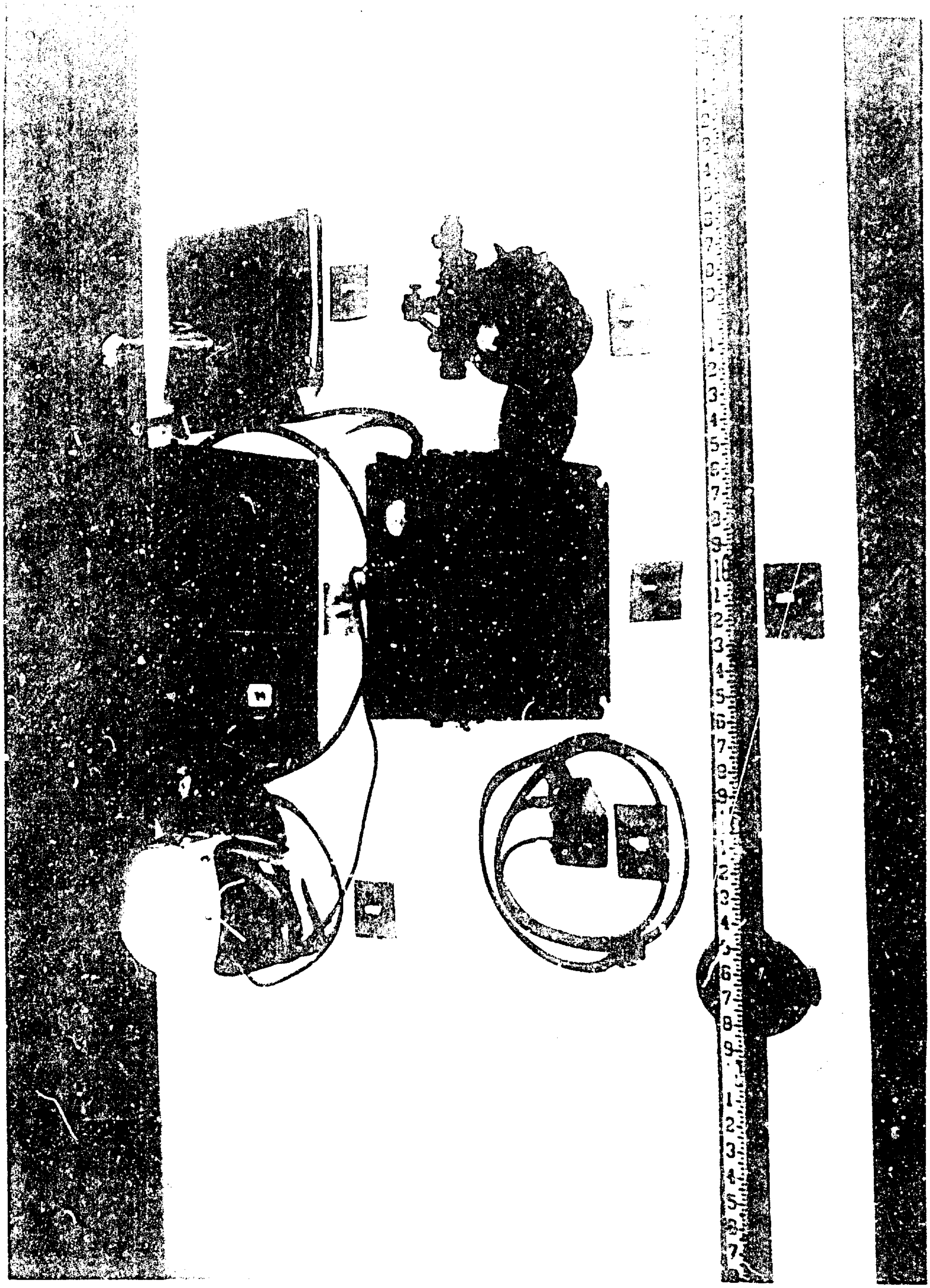

APPENDIX A

HISTORY

Shortly after the inception of the tire tread wear and durability evaluation, Project 20-1-110, it became obvious that the "ride" severity of the "test bed" Model "C" Tournapull on the pavement, secondary and cross-country courses was limiting the desired vehicle speed. Adjustment of test tire inflation pressures was made to improve pavement "ride", but by necessity secondary and cross-country terrain was negotiated at the pressure established as the most reasonable optimum for pavement.

The tire manufacturers' representatives and the vehicle manufacturer's representative had previously observed certain "ride" characteristics of the ATAC "Goer" Tanker unit which were influenced differently by the performance of non-directional radial ply tires (Group B) when compared with the directional conventional construction tires (Group A). These observed differences were not confirmed by the performance of the Model "C" Tournapull "test beds" mounted on similar tires. The seriousness of the Model "C" Tournapull's "ride" problem was climaxed by the failure of the paved test course, Route #1, due in part to the high dynamic loads imposed by the tires during periods of random cyclic excitation which developed progressively larger areas of pavement deterioration.

The secondary road courses also suffered under these dynamic loads but the absence of public traffic on these roads provided the operators a certain latitude in avoiding known exciters.

On pavement the most sensitive tires in terms of "lope" generation were the non-directional radial ply, Group B. On secondary road surfaces the Group B tires were difficult to excite, but once excited, rate of decay was exceptionally slow compared with the directional conventional tires (Groups A and C). In cross-country the non-directional radial ply Group B tires could negotiate "rough" single impacts at a higher rate of speed than Groups A or C, but if a combination of three or more closely spaced impacts was present, the Group B tires would achieve a compound amplitude quickly reaching the intolerable limit for both driver and vehicle. The Group A and C, on the contrary, would transmit a higher initial "jerk" force but would require a considerably greater number of closely spaced impacts before an intolerable compound reaction resulted.

As the Group A and C tires became severely worn and the directional tread elements were significantly reduced, the operator's subjective "ride" experience improved, whereas the Group B tires reacted essentially without change throughout the test.

TEST PLAN

Establishing the cause of the adverse "ride" reaction of the non-directional radial ply (Group B) tires required a subjective "ride" comparison of the non-directional radial ply tires (Group F) originally used on the "Goer" Tanker. At the conclusion of the tire tread wear and durability study a set of Group F tires formerly applied to the "Goer" Tanker were mounted on one of the Model "C" Tournapull "test beds". Although a direct comparison with the Group B tires was impossible, a complete lap of each test course with the Group F tires indicated little, if any, change in the operator's subjective "ride" experience. This comparative evaluation, however crude, identified Groups B and F as developing similar ride characteristics; consequently, this process of elimination suggested a significant difference in the "ride" reaction of the "Goer" Tanker compared with the Model "C" Tournapull "test beds". To permit a dimensional analysis of the "ride" differences between "Goer" and Model "C" Tournapull, all comparative "ride" reactions were determined by measurements expressed in terms of a "ride" index value.

Each test course was carefully surveyed for particularly significant sections which would support high density test use without change. Upon location of the test course the Group F and the Group A tires at two different inflation pressures were used to establish a constant test speed based on subjective reaction while the vibration meter simultaneously identified the significant exciters and the area of maximum effect. The inflation pressures selected for the "Ride" Study were a compromise based on different pressure build-up rates for the various tires tested as well as different build-up rates for cross-country and pavement-secondary operation. The selection of 50 psig front and 40 psig rear represented a mean pressure build-up for pavement and secondary roads from a cold starting pressure of 35-40 psig front and 25-30 psig rear. The selection of 40 psig front and 30 psig rear for all three "ride" test courses represented a mean pressure build-up for pavement and secondary roads from a cold starting pressure of 25-30 psig front and 18-23 psig rear, and for cross-country a cold starting pressure of 30-35 psig front and 20-25 psig rear.

A "Goer" Tanker was available for this comparative "ride" study and was loaded with sufficient liquid ballast to provide a "Goer" GVW equal to its rated GVW with a 5,000 gallon gasoline load (71820#). The Model "C" Tournapull was loaded at a comparable weight and weight distribution.

Two test areas on pavement, one "smooth" and one "rough"; three test areas on secondary, one which was visually "smooth" but generated a significant Model "C" Tournapull "lope", one "smooth" and one "rough"; and one test area in cross-country identified as "rough" represented six significantly different surface conditions, five of which were negotiated at two inflation pressures, while the sixth was the single cross-country area to be negotiated at only one inflation pressure.

CONCLUSIONS

The "Goer" Tanker at rated load provides a significantly better "ride" than the Model "C" Tournapull on rough pavement and secondary road surfaces regardless of tire influence.

In cross-country terrain both vehicles are sharply sensitive to tire differences; specifically, the "Goer" equipped with radial ply non-directional tires is equally as good as the Model "C" Tournapull equipped with directional conventional tires. Inversely when the tire groups are reversed, the "ride" of both vehicles is equally severe.

The natural frequency of both vehicles is sensitive to the type of tires applied. On the Model "C" Tournapull "test bed" the directional conventional tires (Group A develop 2.15 cycles per second; the non-directional radial ply tires (Group F) develop 1.73-1.80 cycles per second; the non-directional conventional construction tires (Group D) develop 2.00-2.16 cycles per second; and directional radial ply tires (Group E) develop 1.80 cycles per second at 50-40 psig front and 40-30 psig rear. At 30 psig front and 20 psig rear the natural frequency is reduced to 1.50 cycles per second for Groups F and E and 1.80 for Group D.

When the Group A is applied to the "Goer" the natural frequency at 50-40 psig front and 40-30 psig rear is reduced from 1.80 cycles per second to 1.67-1.70 cycles per second. Under the same conditions the Group F natural frequency is reduced from 1.80 cycles per second to 1.70 cycles per second.

Under the eleven test conditions established for the "ride" study the "Goer" vehicle equipped with the directional conventional tires (Group A) exceeded the human fatigue limit (Ride Index 0.89) on three conditions and the vehicle fatigue limit (Ride Index 1.91) on one of these three conditions. The "Goer" vehicle equipped with the non-directional radial ply tires (Group F) exceeded the human and vehicle fatigue limit in cross-country only.

A similar comparison of the influence of tire groups on the Model "C" Tournapull found the Group A tires exceeding the human fatigue limit on five conditions of which two exceeded the vehicle fatigue limit and the Group F tires exceeding the human fatigue limit on six conditions of which three exceeded the vehicle fatigue limit.

The non-directional conventional tires (Group D) and the directional radial ply tires (Group E) were only evaluated on the Model "C" Tournapull. The Group D tires exceeded the human fatigue limit on seven of the eleven conditions of which four exceeded the vehicle fatigue limit. The Group E tires exceeded the human fatigue limit on four of the eleven conditions of which three exceeded the vehicle fatigue limit.

CONCLUSIONS (Contd.)

The subjective "ride" impressions of operators during the tread wear and durability study as well as the operator during the "ride" study confirmed the measured results in terms of "good" and "bad" but without any apparent "feel" for degree of severity once "bad" was reached.

At the beginning of the "ride" study it was necessary to evaluate a subjective "ride" impression expressed by the Model "C" Tournapull operators that one particular type of seat cushion was the most comfortable. By measuring the operator's displacement as influenced by the seat cushion, it was determined that the reduced depth cushion was more comfortable and provided less amplification of input displacement than the deep cushion, consequently the shallow cushion was used throughout the "ride" study.

The non-directional conventional construction tires (Group D) required a speed reduction of 0.6 miles per hour on the rough pavement condition and 1.6 miles per hour on the rough secondary road condition due to the violent reaction of the Model "C" Tournapull at the pre-established test speed.

When driver "ride" measurements are compared with Model "C" Tournapull "ride" measurements under identical conditions, we find the driver generally suffers a proportionately greater increase in amplitude with increased input severity.

Where significant exciters exist, a small increase in vehicle speed (i.e., 1.2 MPH) amplifies Model "C" Tournapull "ride" reaction as much as six times for the Group D tires, four times for the Group F tires and three times for the Group E tires. The Group A tires on the "Goer" indicated no significant increase under the same conditions.

TEST RESULTS

Measured "Ride" Reaction

The results of this study are given on the following pages in tabular and graph form.

Table I summarizes the result of the "Ride" Study comparing tire group performance in terms of vehicle "ride" index values. A "ride" index value of 0.89 is defined as being the acceptable limit of human fatigue for continuous operation.

Table II summarizes the result of the "Ride" Study comparing the performance of the Model "C" Tournapull with the "Goer" Tanker, in terms of vehicle "Ride" index value. A "ride" index of 1.91 is defined as being the acceptable limit of vehicle fatigue for continuous operation (approximately 0.8 to 0.9 G). (See GRAPH LEGEND, Figures 1 and 2).

Figure 1 illustrates the "ride" comparison on pavement of each tire group on the Model "C" Tournapull at two inflation pressures.

Figure 2 illustrates the "ride" comparison on pavement of the "Goer" versus the Model "C" Tournapull with Group A and F tires at two inflation pressures.

Figure 3 illustrates the "ride" comparison of each tire group on the Model "C" Tournapull at two inflation pressures under three conditions of secondary road surfaces.

Figure 4 illustrates the "ride" comparison under three conditions of secondary road surfaces of the "Goer" versus the Model "C" Tournapull vehicle with Group A and F tires at two inflation pressures.

Figure 5 illustrates the "ride" comparison of the Model "C" Tournapull versus driver reaction under three conditions of secondary road surfaces on Group F and D tires at two inflation pressures.

Figure 6 illustrates the same conditions as Figure 5 but with Group A and E tires.

Figure 7 illustrates the "ride" comparison of driver on deep versus shallow seat cushion under three conditions of secondary road surfaces using Group D tires on the Model "C" Tournapull at one inflation pressure.

[illegible] (Contd.)

Measured "Ride" Reaction (Contd.)

Figure [illegible] illustrates the "ride" comparison on cross-country as influenced by the vehicles as well as the tires at one inflation pressure.

Figure [illegible] illustrates the "ride" comparison of Groups D, E and F under two conditions of pavement at two test speeds on the Model "C" Tournapull and the Group A tires on the "Goer" vehicle at one inflation pressure.

TABLE I

Condition	Tire Groups A		F		D		E	
Front Tire, psig	40	50	40	50	40	50	40	50
Rear Tire, psig	30	40	30	40	30	40	30	40
	"Ride" Index							
Pavement								
#1, Smooth	0.35	0.68	0.51	0.50	0.60	0.30	0.50	0.31
#2, Rough	1.10	1.10	2.30*	0.60	4.60*	2.00*	2.15*	0.72
Secondary								
#1, Smooth	0.54	0.65	0.50	1.20	0.44	0.98	0.22	0.54
#2, Smooth	0.52	1.21	0.37	1.40	0.24	1.90	0.28	1.40
#3, Rough	0.85	2.38*	0.92	2.90*	0.91	4.30*	0.75	2.00*
Cross-Country								
Rough	2.7*	--	6.2*	--	10.2*	--	5.8*	--

Underlined values are in excess of acceptable human fatigue limits for continuous operation.

(*) Asterisked values are in excess of acceptable human and vehicle fatigue limits for continuous operation.

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TEST RESULTS (Contd.)

TABLE II

Vehicle Tire Group Condition	Vehicle "Ride" Indices: Model "C" Tournapull A		Model "C" Tournapull F		"Goer" Tanker A		"Goer" Tanker F	
Inflation, Front, psig	40	50	40	50	40	50	40	50
Inflation, Rear, psig	30	40	30	40	30	40	30	40
	"Ride" Index							
Pavement								
#1, Smooth	0.35	0.68	0.51	0.50	0.22	0.27	0.31	0.29
#2, Rough	<u>1.10</u>	<u>1.10</u>	<u>2.30</u>*	0.80	0.57	0.65	0.80	0.75
Secondary								
#1, Smooth	0.54	0.66	0.50	<u>1.20</u>	0.22	0.56	0.20	0.18
#2, Smooth	0.52	<u>1.21</u>	0.37	<u>1.40</u>	0.20	<u>1.40</u>	0.35	0.38
#3, Rough	0.85	<u>2.38</u>*	<u>0.92</u>	<u>2.90</u>*	0.51	<u>0.90</u>	0.55	0.62
Cross-Country								
Rough	<u>2.70</u>*	--	<u>6.20</u>*	--	<u>5.70</u>*	--	<u>2.90</u>*	--

Comparison of Mean Vehicle "Ride" Indices

	Pavement Smooth	Pavement Rough	Secondary Smooth	Secondary Smooth	Secondary Rough	Cross-Country Rough
Goer @ 40-30 psig	0.27	0.69	0.21	0.28	0.53	<u>4.30</u>*
"C" Pull @ 40-30 psig	0.43	<u>1.70</u>	0.52	0.45	0.89	<u>4.45</u>*
Goer @ 50-40 psig	0.28	0.78	0.37	0.69	0.76	--
"C" Pull @ 50-40 psig	0.59	<u>0.95</u>	<u>0.93</u>	<u>1.31</u>	<u>2.64</u>*	--

<u>Underlined</u> values are in excess of acceptable human fatigue limits for continuous operation.

(*) Asterisked values are in excess of acceptable human and vehicle fatigue limits for continuous operation.

GRAPH LEGEND

Figures 1 and 2

Speed: 27.6 Miles Per Hour

Key		Description
40 - 50	=	50 PSI Front Tires 40 PSI Rear Tires
40 - 30	=	40 PSI Front Tires 30 PSI Rear Tires
Cond. 1	=	Smooth Road
Cond. 2	=	Rough Road
----- "Human Limit"	=	Acceptable "Human" Continuous Fatigue Limit of .89* (Ride Index)
____ "Vehicle Limit"	=	Acceptable Vehicle Continuous Fatigue Limit of 1.91 (Ride Index) as Interpreted from Goldman's "Intolerable" Limit*
Ride Index	=	Displacement (inches) X frequency (cycles per second)

Note: Speed reduced to 27.0 MPH on D Group, Condition 2, due to D Group's adverse reaction.

* Goldman, D.E., A Review of Subjective Responses to Vibratory Motion of the Human Body in the Frequency Range 1 to 70 Cycles per Second Report No. 1, Project NM 004001, Naval Medical Research Institute, March 16, 1948.

Figure #1

"Ride" Comparison On Pavement At Constant Speed And Variable Inflation Pressure

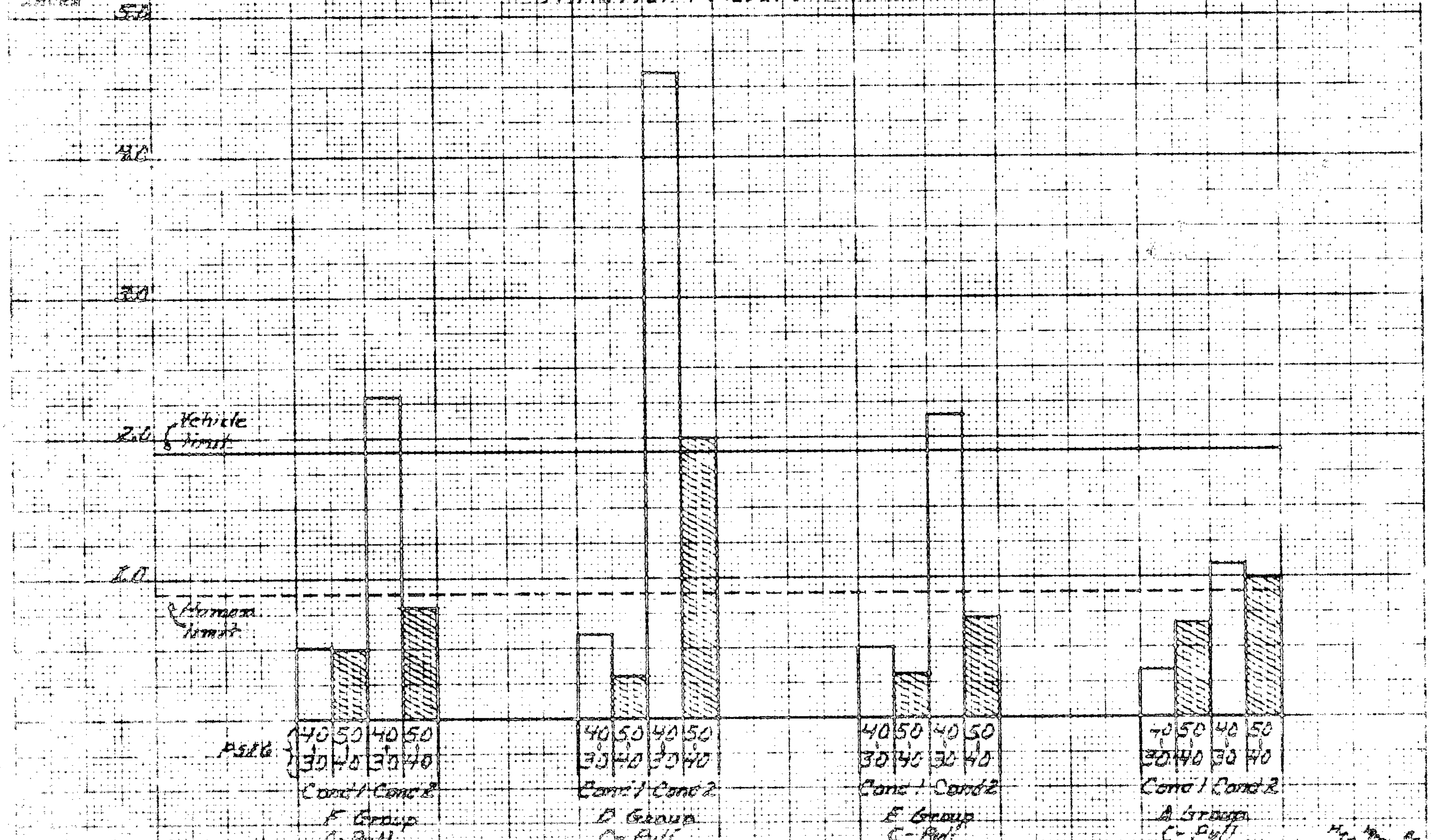
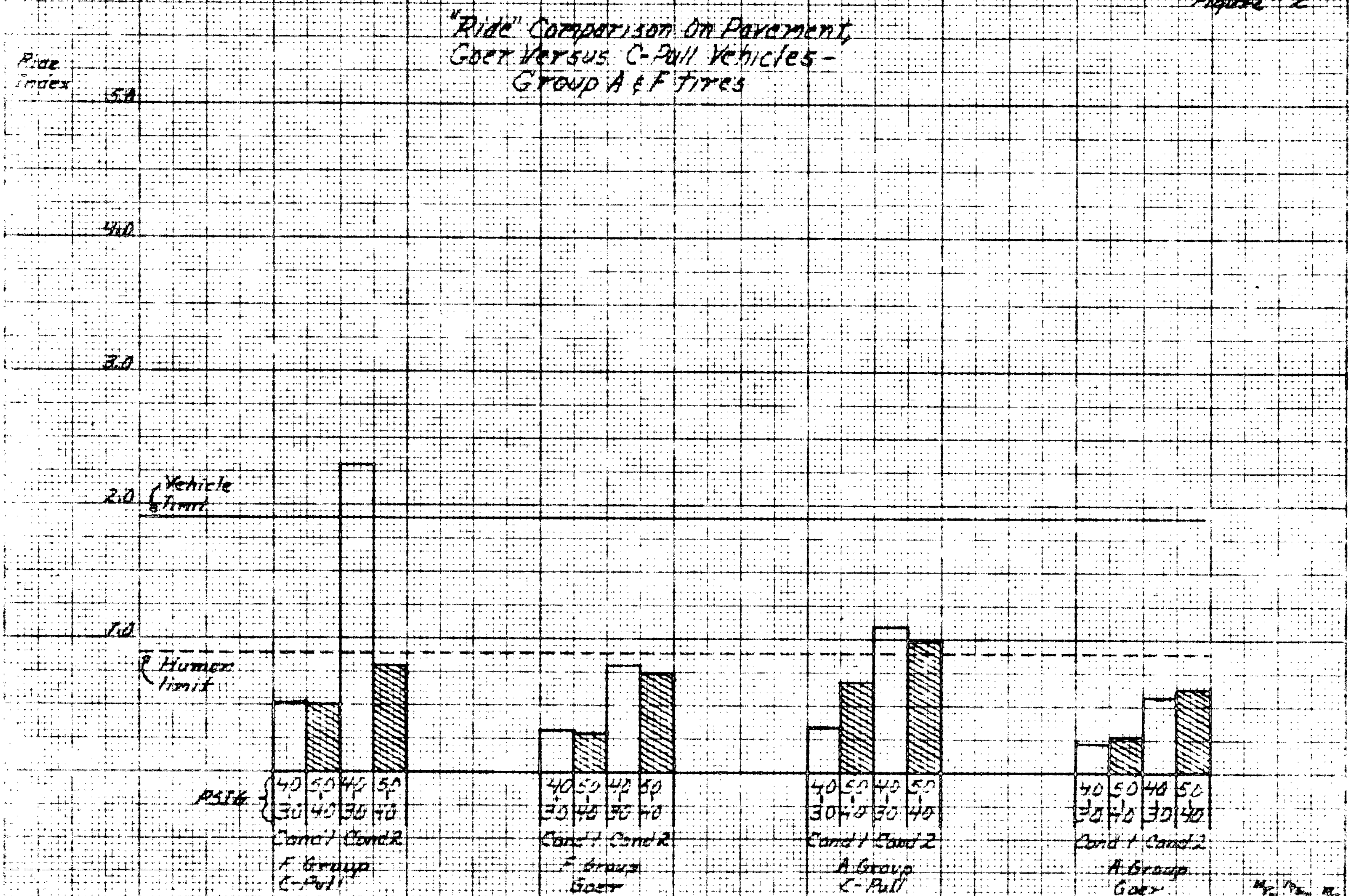


Figure #2


"Ride" Comparison On Pavement,
Goer Versus C-Pull Vehicles -
Group A & F Tires
Ride Index
5.0
4.0
3.0
2.0
1.0
Vehicle limit
Human limit
PSIG
40 30
50 40
40 30
50 40
Cond 1
Cond 2
F Group C-Pull
F Group Goer
A Group C-Pull
A Group Goer

GRAPH LEGEND

Figures 3 and 4

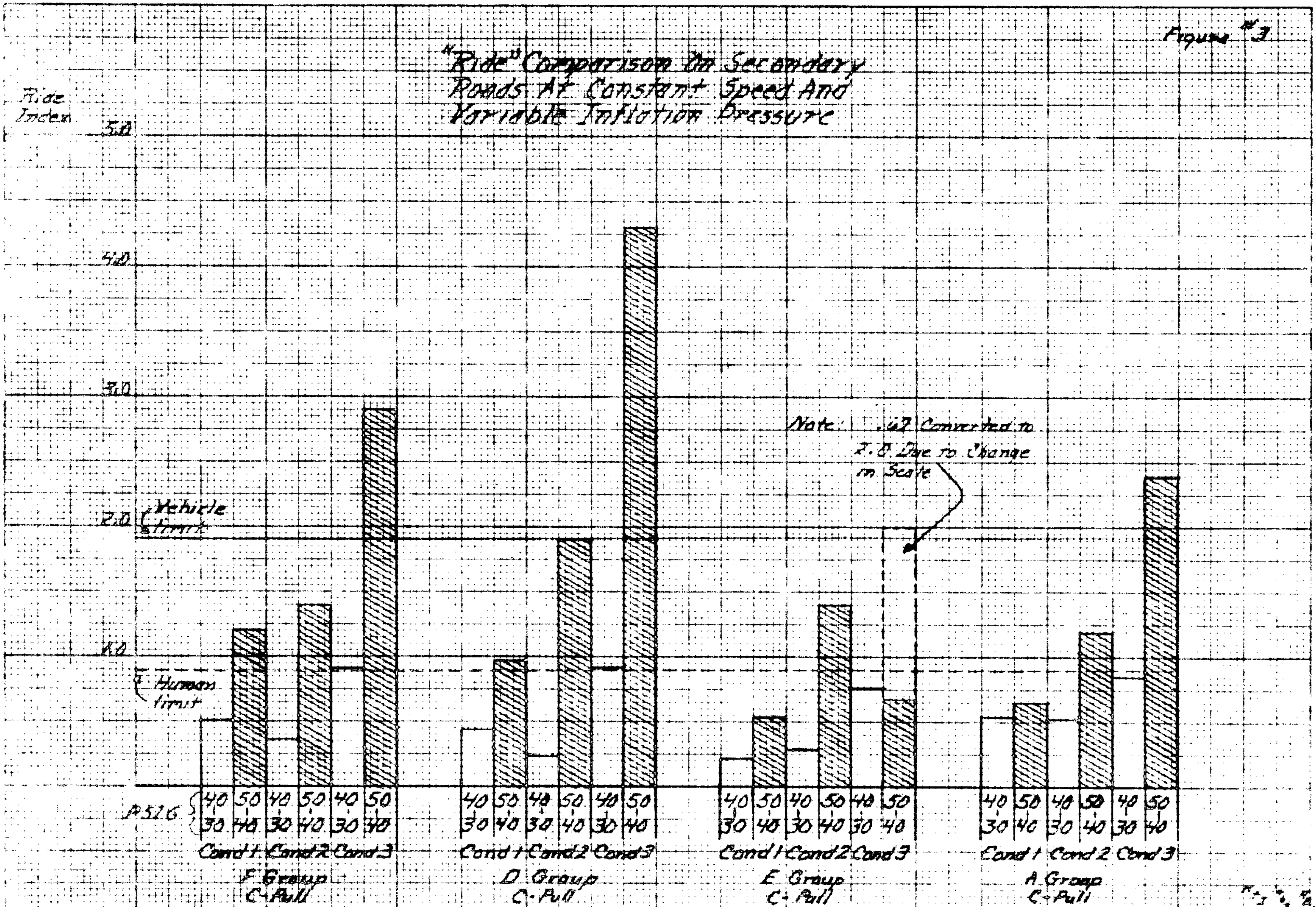
Speed: 22.6 Miles Per Hour

Key		Description
	=	50 PSI Front Tires 40 PSI Rear Tires
	=	40 PSI Front Tires 30 PSI Rear Tires
Cond. 1	=	100 Foot Smooth Road Section Acting as Lope Generator
Cond. 2	=	100 Foot Smooth Road Section
Cond. 3	=	100 Foot Road Section with Three Exciters Followed by a Smooth Road Section
----- "Human Limit"	=	Acceptable "Human" Continuous Fatigue Limit of .89* (Ride Index)
_____ "Vehicle Limit"	=	Acceptable Vehicle Continuous Fatigue Limit of 1.91 (Ride Index) as Interpreted from Goldman's "Intolerable" Limit*

Note: All #3 Conditions are at 21.0 MPH or 1.6 MPH below specified speed due to D Group's adverse reaction.

* Goldman, D.E., A Review of Subjective Responses to Vibratory Motion of the Human Body in the Frequency Range 1 to 70 Cycles per Second Report No. 1, Project NM 004001, Naval Medical Research Institute, March 16, 1948.

Figure #3


"Ride" Comparison On Secondary
Roads At Constant Speed And
Variable Inflation Pressure
Ride
Index
5.0
4.0
3.0
2.0
1.0
Vehicle
limit
Human
limit
Note: .47 Converted to
2.0 Due to Change
in Scale
PSIG
40 50 40 50 40 50
30 40 30 40 30 40
Cond 1 Cond 2 Cond 3
F Group
C-Pull
D Group
C-Pull
E Group
C-Pull
A Group
C-Pull

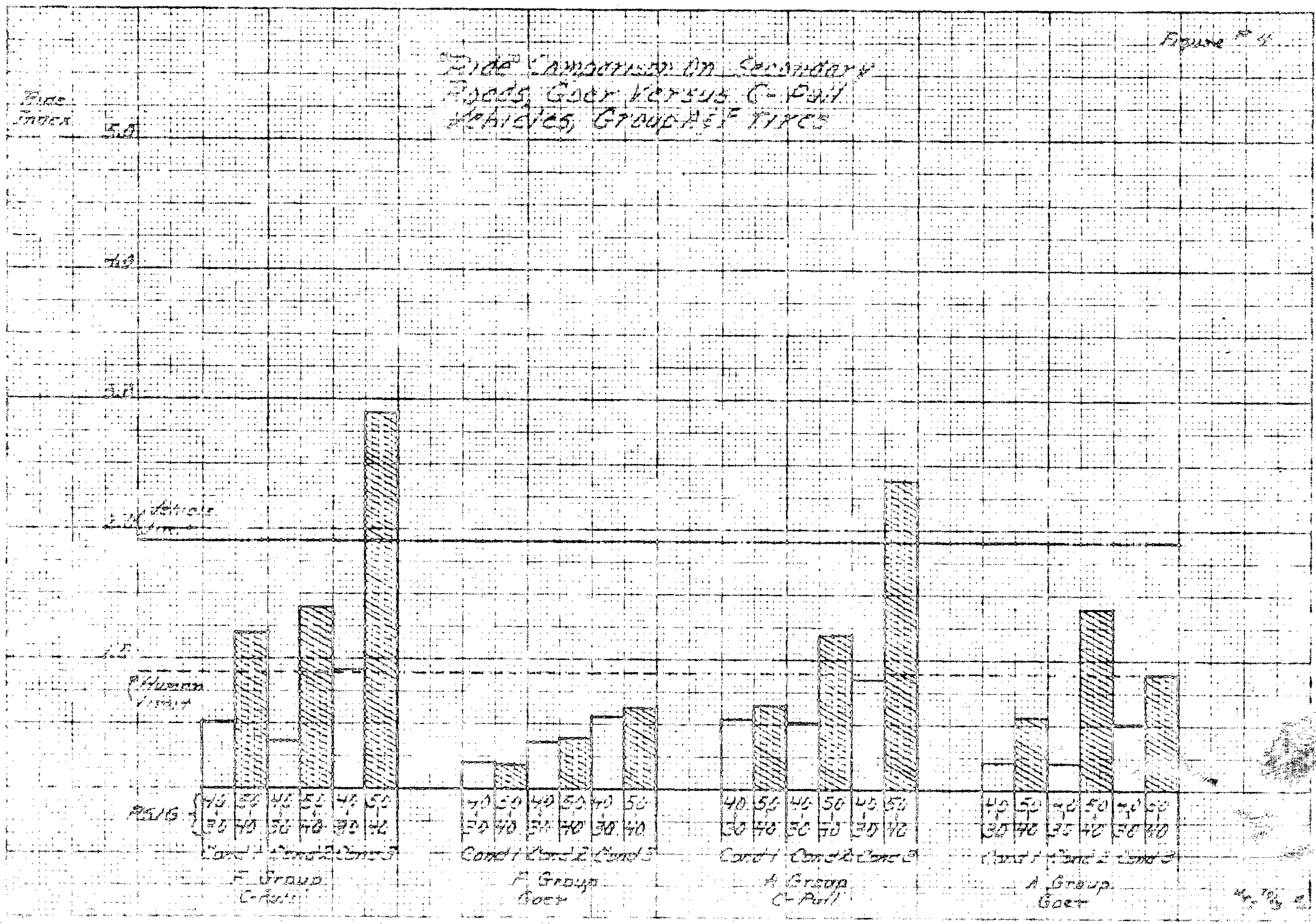


Figure # 5
Ride Comparison on Secondary Roads, Goer Versus C-Pull Vehicles, Group A & F Tires
Ride Index
5.0
4.0
3.0
Vehicle Limit
1.5
Human Limit
PSIG
40 30
50 40
Cond 1 Cond 2 Cond 3
F Group C-Pull
F Group Goer
A Group C-Pull
A Group Goer

G R A P H   L E G E N D

Figures 5 and 6

Speed: 22.6 Miles Per Hour

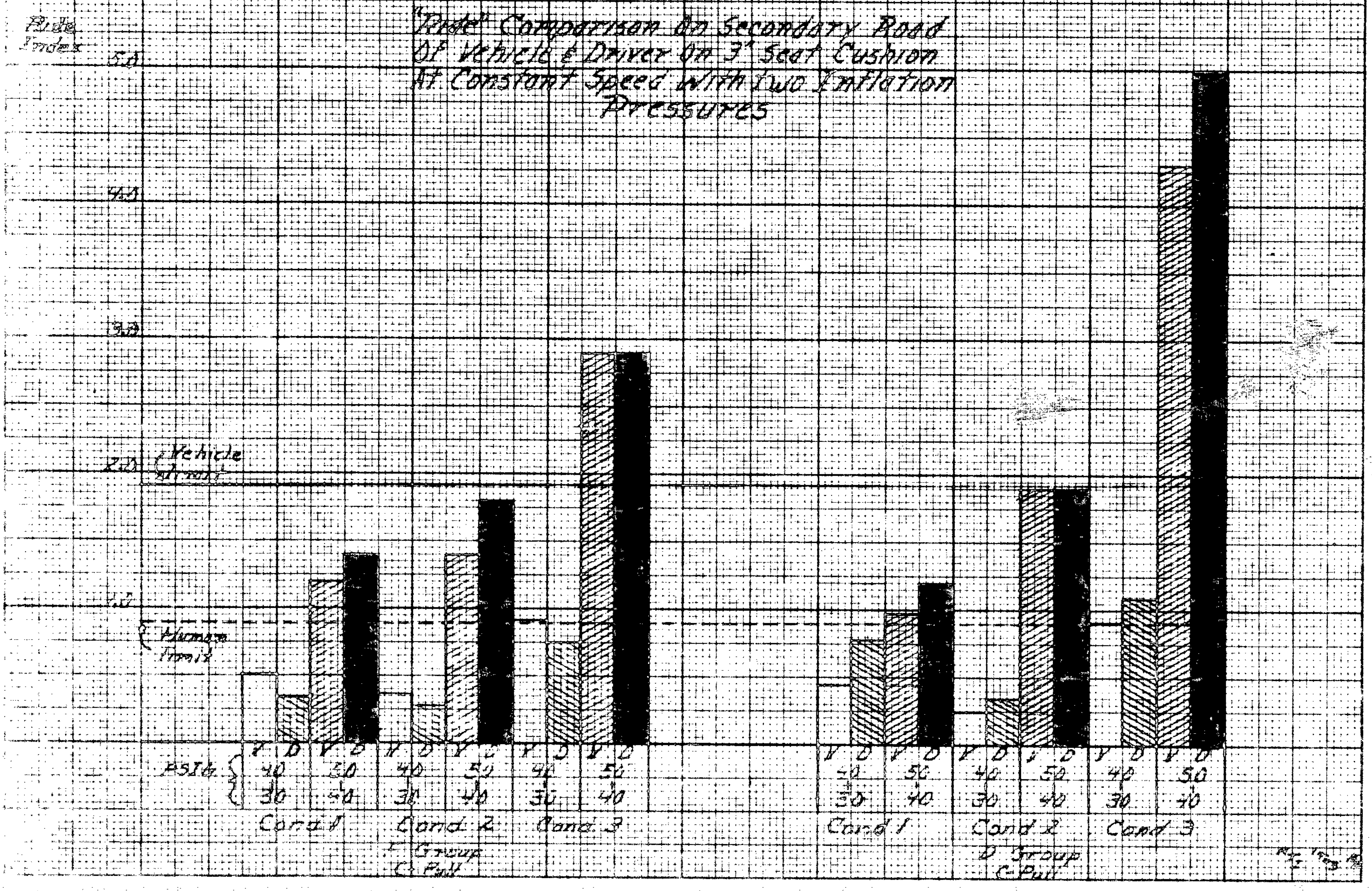
Key		Description
 V	=	Vehicle Reaction-40 PSI Front Tires 30 PSI Rear Tires
 D	=	Driver Reaction-40 PSI Front Tires 30 PSI Rear Tires
 V	=	Vehicle Reaction-50 PSI Front Tires 40 PSI Rear Tires
 D	=	Driver Reaction-50 PSI Front Tires 40 PSI Rear Tires
Cond. 1	=	100 Foot Smooth Road Section Acting as Lope Generator
Cond. 2	=	100 Foot Smooth Road Section
Cond. 3	=	100 Foot Road Section with Three Shallow Exciters Followed by a Smooth Road Section
---- "Human Limit"	=	Acceptable "Human" Continuous Fatigue Limit of .89* (Ride Index)
____ "Vehicle Limit"	=	Acceptable Vehicle Continuous Fatigue Limit of 1.91 (Ride Index) as Interpreted from Goldman's "Intolerable" Limit*

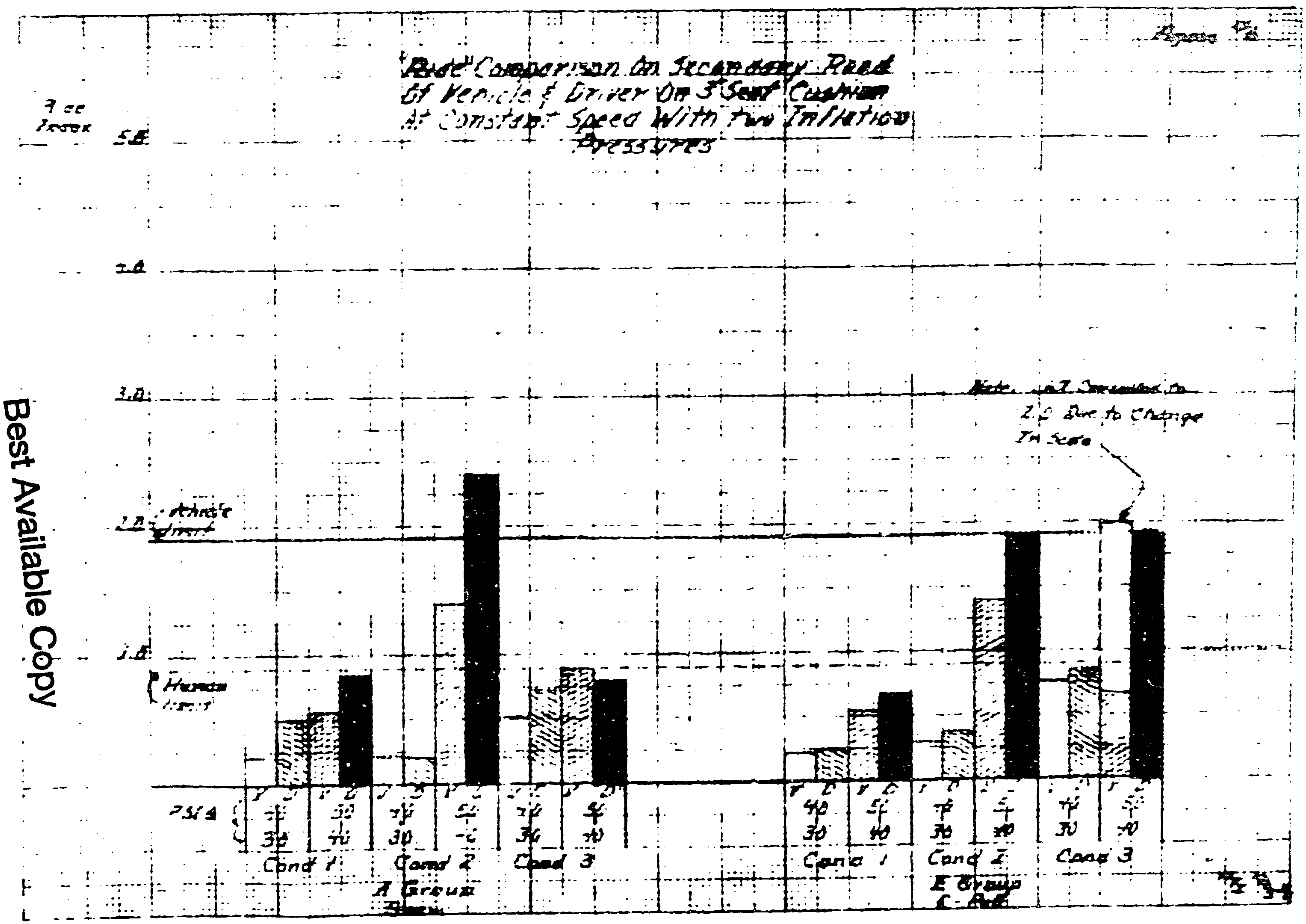
Note: All #3 Conditions are at 21.0 MPH or 1.6 MPH below specified speed due to D Group's adverse reaction.

* Goldman, D.E., A Review of Subjective Responses to Vibratory Motion of the Human Body in the Frequency Range 1 to 70 Cycles per Second Report No. 1, Project NM 004001, Naval Medical Research Institute, March 16, 1948.

Figure #5

"Ride" Comparison On Secondary Road Of Vehicle & Driver On 3" Seat Cushion At Constant Speed With Two Inflation Pressures





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GRAPH LEGEND

Figure 7

Speed: 22.6 Miles Per Hour

40 PSI Front, 30 PSI Rear

Key		Description
Cond. 1	=	100 Foot Smooth Road Section Acting as Lope Generator
Cond. 2	=	100 Foot Smooth Road Section
Cond. 3	=	100 Foot Road Section with Three Shallow Exciters Followed by a Smooth Road Section
----- "Human Limit"	=	Acceptable "Human" Continuous Fatigue Limit of .89* (Ride Index)
____ "Vehicle Limit"	=	Acceptable Vehicle Continuous Fatigue Limit of 1.91 (Ride Index) as Interpreted from Goldman's "Intolerable" Limit*

Note: All #3 Conditions are at 21.0 MPH or 1.6 MPH below specified speed due to D Group's adverse reaction.

* Goldman, D.E., A Review of Subjective Responses to Vibratory Motion of the Human Body in the Frequency Range 1 to 70 Cycles per Second Report No. 1, Project NM 004001, Naval Medical Research Institute, March 16, 1948.

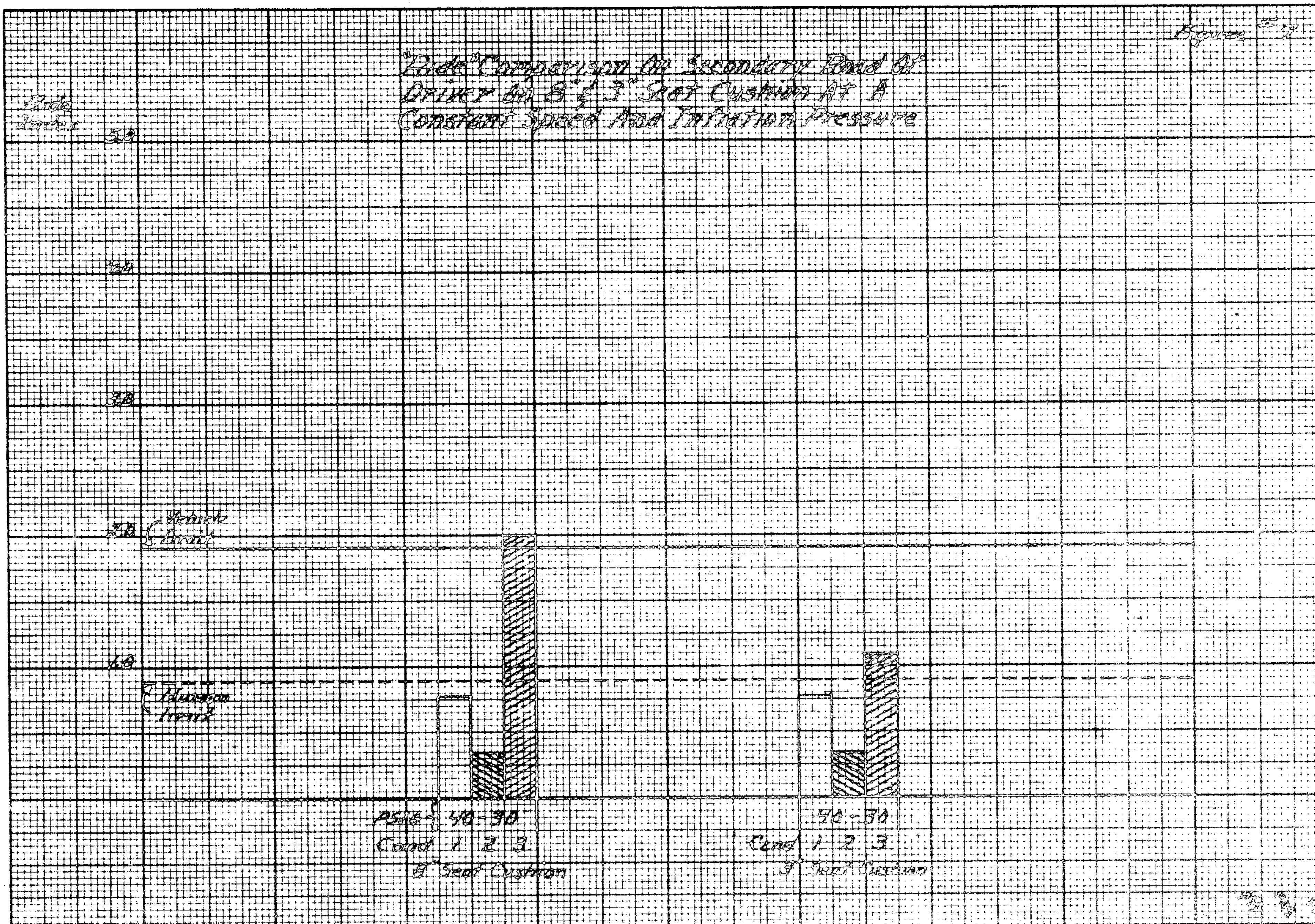


Figure
"Ride" Comparison On Secondary Road Of Driver On 8" & 3" Seat Cushion At A Constant Speed And Inflation Pressure
Ride Index
5.0
4.0
3.0
2.0
1.0
Vehicle Limit
Human Limit
PSIG 40-30
Cond 1 2 3
8" Seat Cushion
40-30
Cond 1 2 3
3" Seat Cushion

G R A P H   L E G E N D

Figure 8

Speed: 7.4 Miles Per Hour

40 PSI Front, 30 PSI Rear

Course Involved 3 Depressions and 3 Lifts

Key		Description
----- "Human Limit"	=	Acceptable "Human" Continuous Fatigue Limit of .89* (Ride Index)
_____ "Vehicle Limit"	=	Acceptable Vehicle Continuous Fatigue Limit of 1.91 (Ride Index) as Interpreted from Goldman's "Intolerable" Limit*

* Goldman, D.E., A Review of Subjective Responses to Vibratory Motion of the Human Body in the Frequency Range 1 to 70 Cycles per Second Report No. 1, Project NM 004001, Naval Medical Research Institute, March 16, 1948.

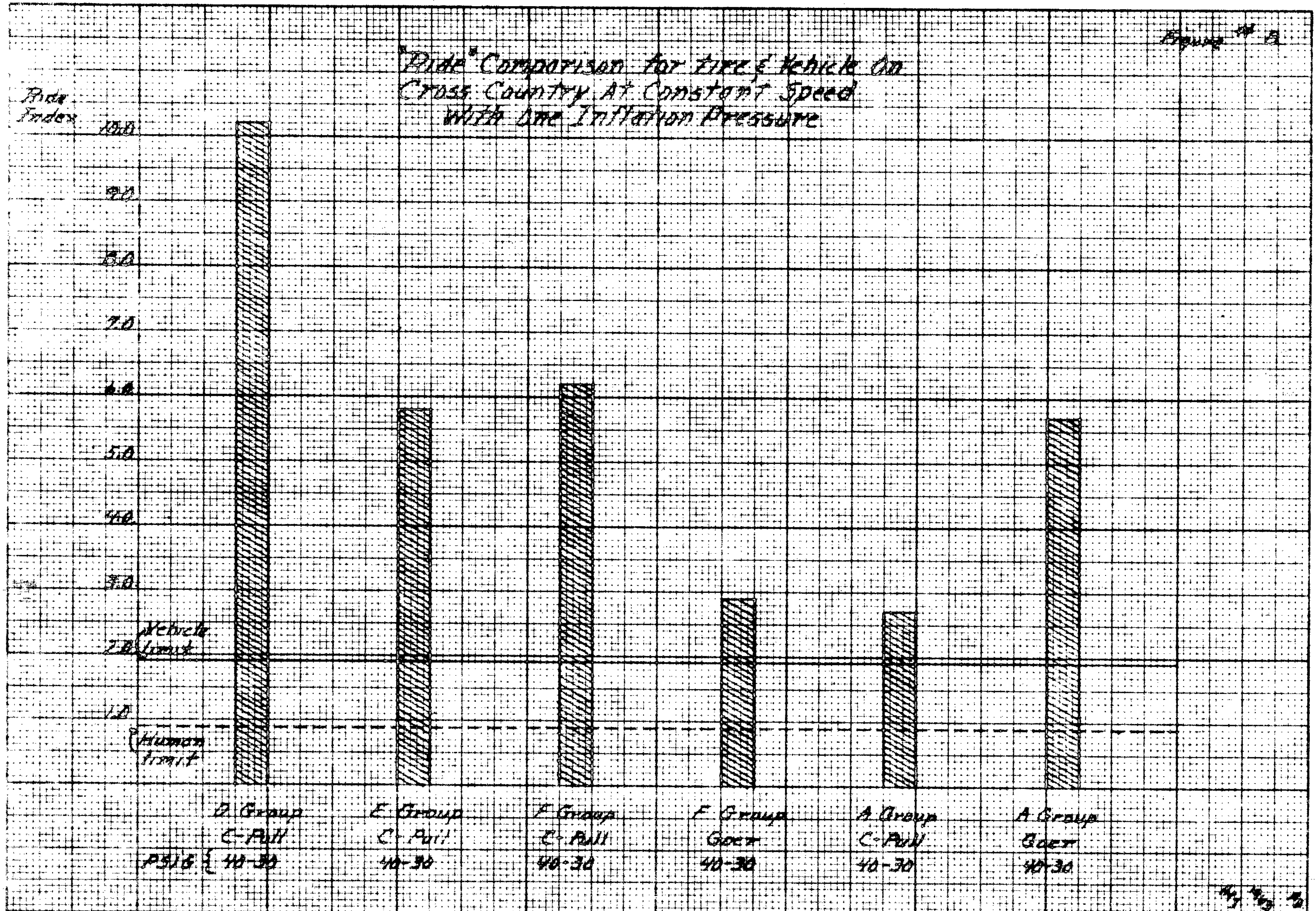


Figure # 8
"Ride" Comparison for Tire & Vehicle On
Cross Country At Constant Speed
With One Inflation Pressure
Ride Index
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
Vehicle Limit
1.0
Human limit
D Group
C-Pull
PSIG 40-30
E Group
C-Pull
40-30
F Group
C-Pull
40-30
F Group
Goer
40-30
A Group
C-Pull
40-30
A Group
Goer
40-30

G R A P H   L E G E N D

Figure 9

40 PSI Front, 30 PSI Rear

Key		Description
L	=	26.4 Miles Per Hour
H	=	27.6 Miles Per Hour
Cond. 1	=	Smooth Road
Cond. 2	=	Rough Road
----- "Human Limit"	=	Acceptable "Human" Continuous Fatigue Limit of .89* (Ride Index)
_____ "Vehicle Limit"	=	Acceptable Vehicle Continuous Fatigue Limit of 1.91 (Ride Index) as Interpreted from Goldman's "Intolerable" Limit*

* Goldman, D.E., A Review of Subjective Responses to Vibratory Motion of the Human Body in the Frequency Range 1 to 70 Cycles per Second Report No. 1, Project NM 004001, Naval Medical Research Institute, March 16, 1948.

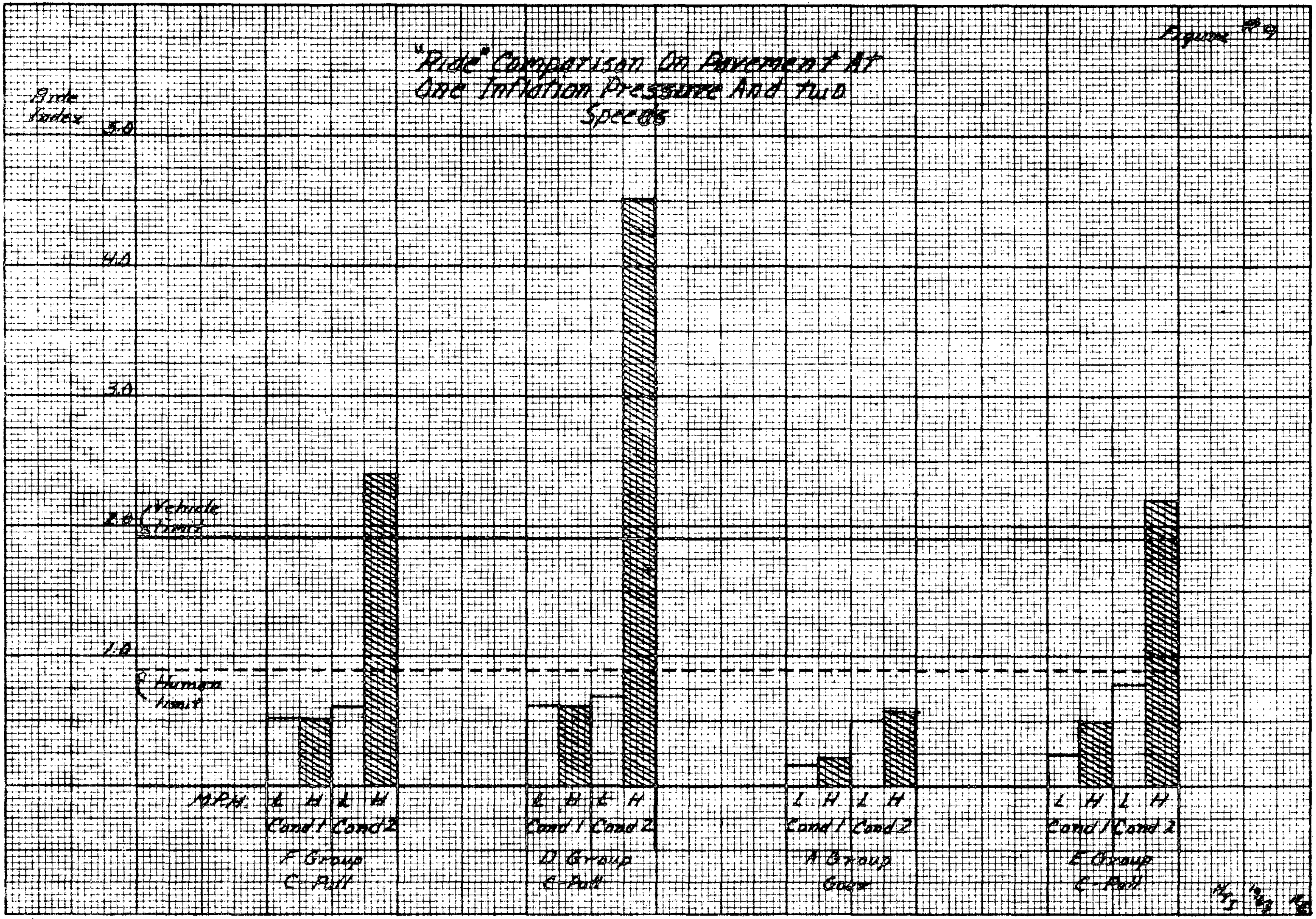


Figure #9
"Ride" Comparison On Pavement At One Inflation Pressure And Two Speeds
Ride Index
5.0
4.0
3.0
2.0 Vehicle Limit
1.0
Human Limit
M.P.H.
L H L H
Cond 1 Cond 2
F Group
C-Pull
D Group
C-Pull
A Group
Gear
E Group
C-Pull

TEST RESULTS (Contd.)

Subjective "Ride" Reaction

The following table reflects the operator's "ride" impressions of the two tire Groups D and E which were added to the tread wear and durability test and the tire Group F which was of similar construction and design as the Group B tires.

Preference	Pavement							Secondary							Cross-Country						
Driver #	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
1st	DE	DE	-	DE	DE	-	-	E	E	DE	E	DE	E	-	FE	-	FE	FE	-	FE	FE
2nd	F	F	-	F	F	-	-	DF	DF	F	DF	F	DF	-	D	-	-	D	D	D	D

TEST PROGRAM

Test Courses

Pavement - A portion of Nevada Automotive Test Center's highway pavement test course #2 (abandoned U.S. Highway 50) was chosen to provide two test sections. Test section #1 was smooth, whereas test section #2 (See Road Profile of Pavement Test Section Figures #1 and #2) was of rolling contour featuring two major exciters.

Secondary - A portion of Nevada Automotive Test Center's secondary test course having a compaction of 300+ PSI was chosen to provide three test sections. Test section #1 was a visually smooth surface which generated "lope" in the Model "C" Tournapull units. Test section #2 was smooth surface creating no lope. Test section #3 (See Road Profile of Secondary Test Section #3 Figures #3 and #4) was of rolling contour featuring three major exciters.

Cross-Country - A section of Nevada Automotive Test Center's cross-country test course was chosen as a severe but not extreme condition. This test section provided three exciters (See Road Profile of Cross-Country Test Section Figure #5).

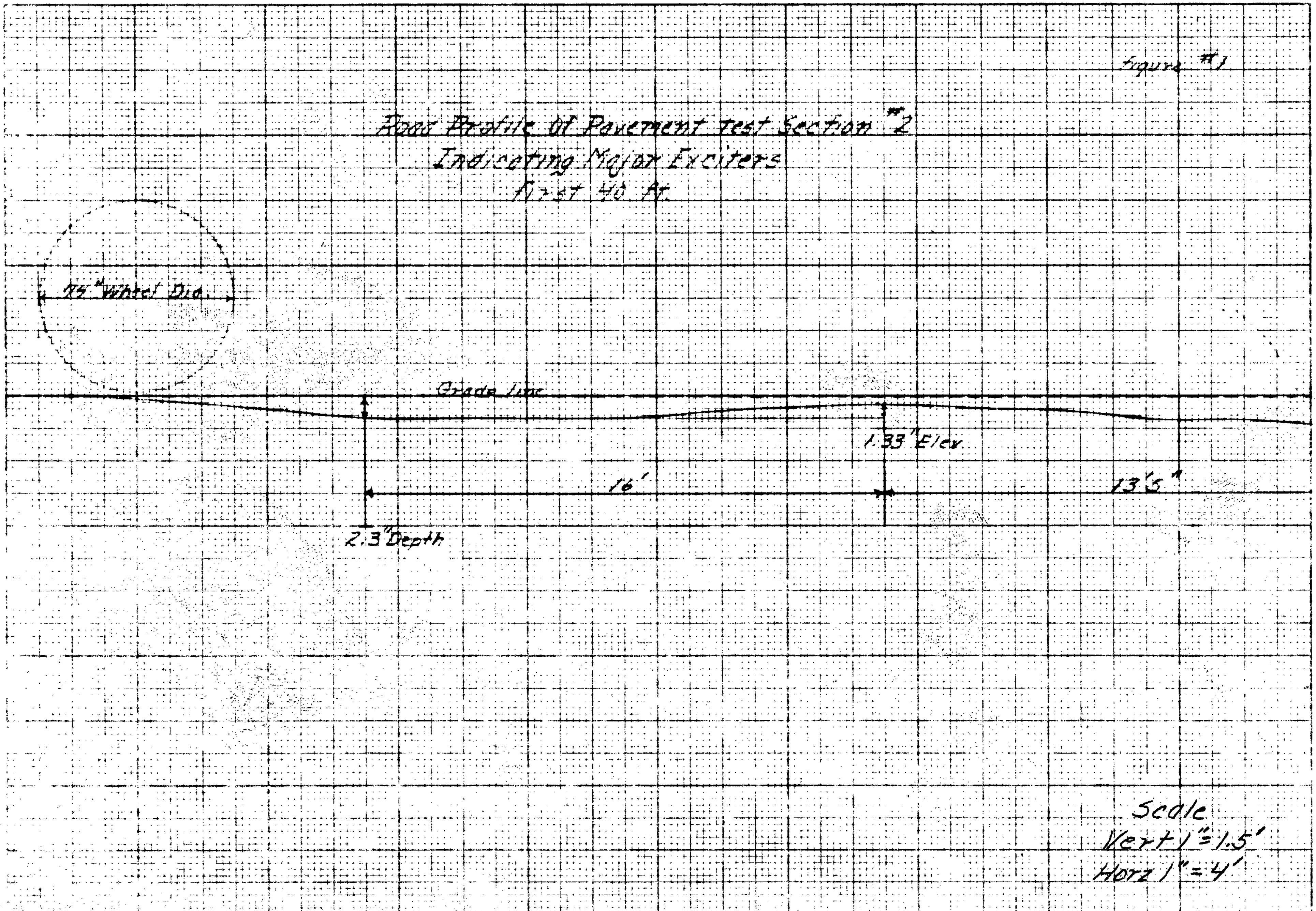


Figure #1
Road Profile Of Pavement Test Section #2
Indicating Major Exciters
First 40 ft.
74" Wheel Dia.
Grade line
1.33" Elev.
16'
13'5"
2.3" Depth
Scale
Vert 1" = 1.5'
Horz 1" = 4'

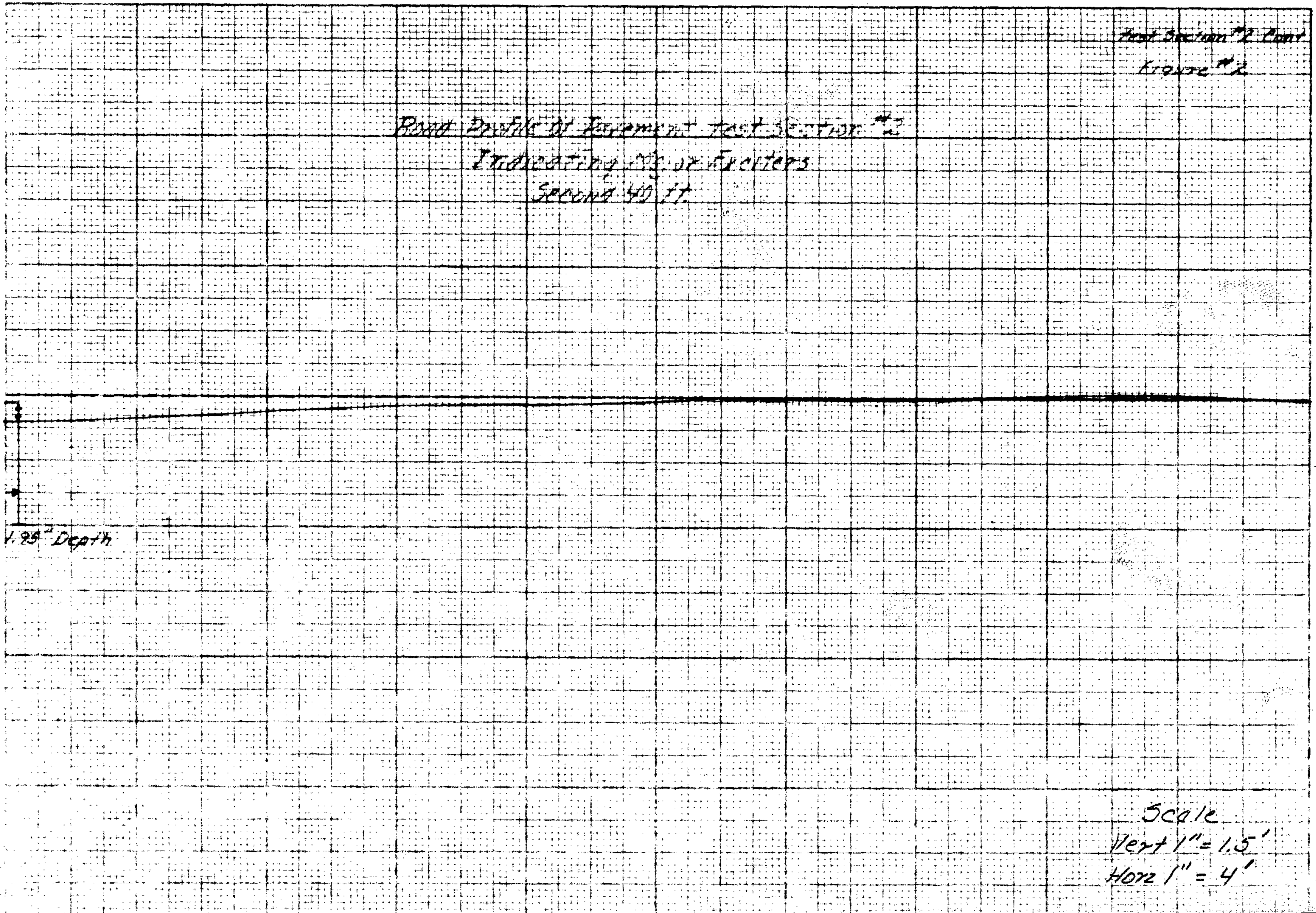
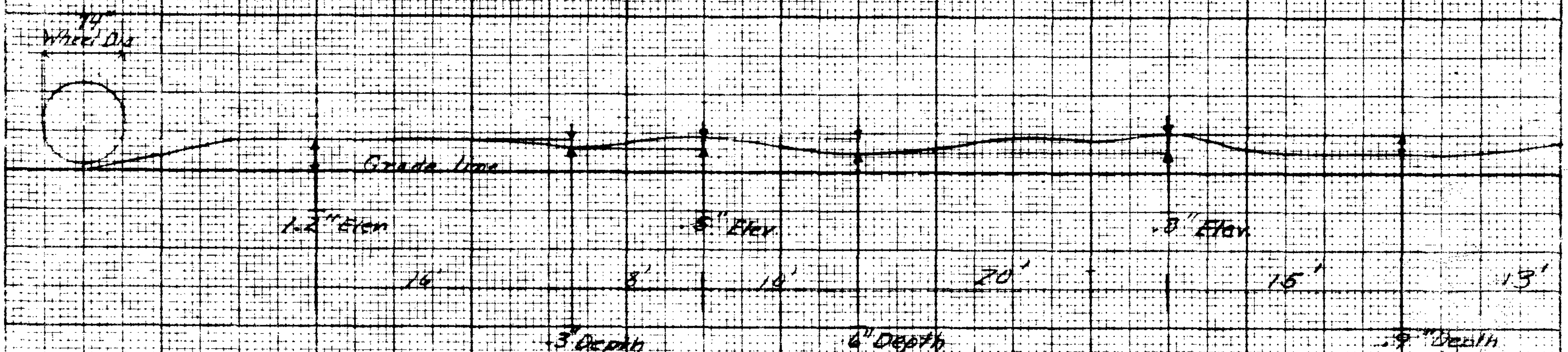

Test Section #2 Cont
Krause #2
Road Profile of Pavement Test Section #2
Indicating Scour Craters
Second 40 ft
1.95" Depth
Scale
Vert 1" = 1.5'
Horz 1" = 4'

Figure #3

Road Profile Of Secondary Test Section #3
Indicating Major Exciters
First 100 Ft

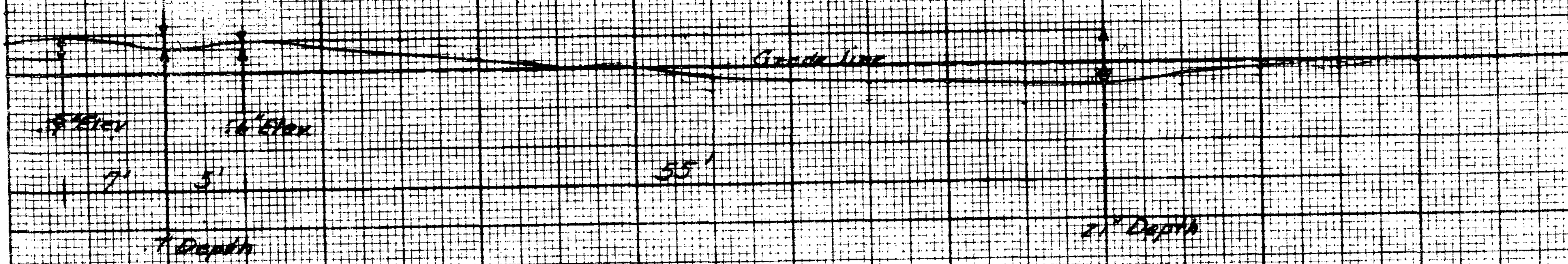


Scale
Vert 1" = 6"
Horz 1 = 10"

Test Section #3 Cont

Figure #4

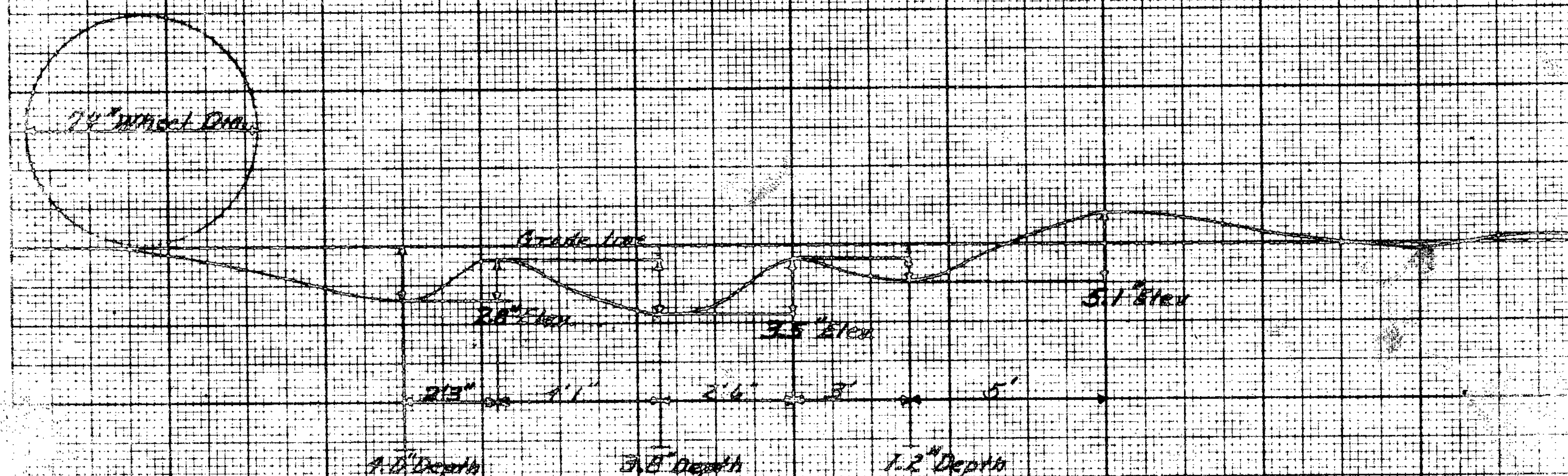
Road Profile Of Secondary Test Section #3
Indicating Major Excuters
Second 100 Ft



SCALE
VERT. 1" = 6"
HORZ. 1" = 10'

Figure #5

Road Profile Of Cross Country Test Section
Indicating Major Exciters



SCALE
VERT. 1" = 8"
HORZ. 1" = 4'

Test Vehicles

One Model "C" Tournapull

One "Goer" Tanker XM438E2

Test Tires

Two of the five groups which ran on the tread wear and durability evaluation (Groups D and E) were subjected to the "ride" study. The Groups A, B and C tires were not available but a Group A and a Group F were substituted and were of similar design and construction as the Group A and Group B tires. Thus the following test groups were subjected to the "ride" evaluation:

Group A, Conventional construction directional tread.

Group D, Conventional construction non-directional tread.

Group E, Radial ply construction directional tread.

Group F, Radial ply construction non-directional tread.

Test Procedure

To evaluate comparative vehicle "ride" a vibration pickup location common to both Model "C" Tournapull and the "Goer" Tanker vehicle was chosen (approximately on centerline and 2 feet 7 inches ahead of the front axle). An average of two runs plus reruns as required were made at each inflation pressure, under each test condition, for the three test courses, on each group of test tires.

To evaluate driver reaction to vehicle "ride" a lock-on helmet was instrumented with a vibration meter pickup.

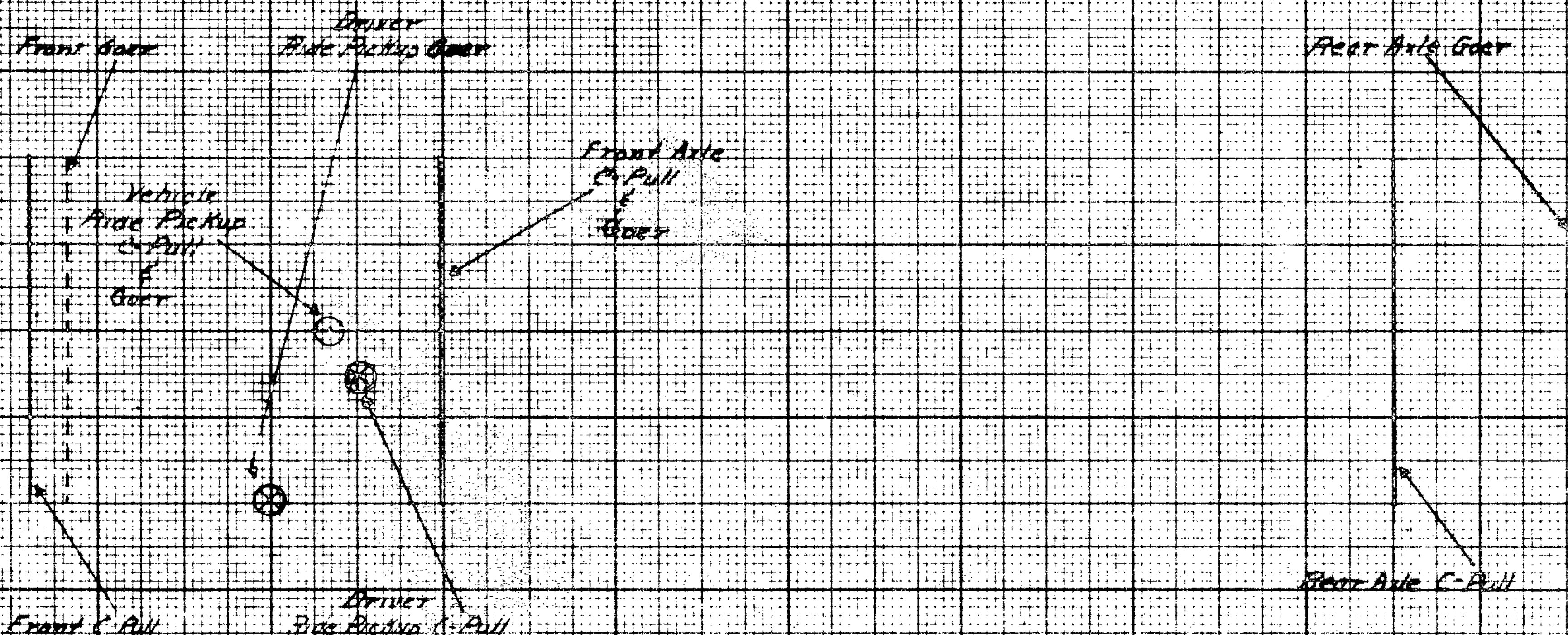
The following schematic shows the location of the Vibration Meter Pickups relative to the front axle position of both the Model "C" Tournapull and the "Goer" Tanker vehicle.

"Ride" Survey

Placement Of Vibration Meter Pickup

In Relation to Front Axle Center line

Comparing C-Pull & Goer Vehicles



Scale
1/4" = 1'

APPENDIX B

FINAL REPORT

Project 20-1-110

Shallow Mud Traction of
Tire Groups A and B Type

July 1963

Nevada Automotive Test Center
A Division of Hodges Transportation Inc.
Box 234 Carson City, Nevada

APPENDIX [illegible]

FINAL REPORT

Project [illegible]-1-11[illegible]

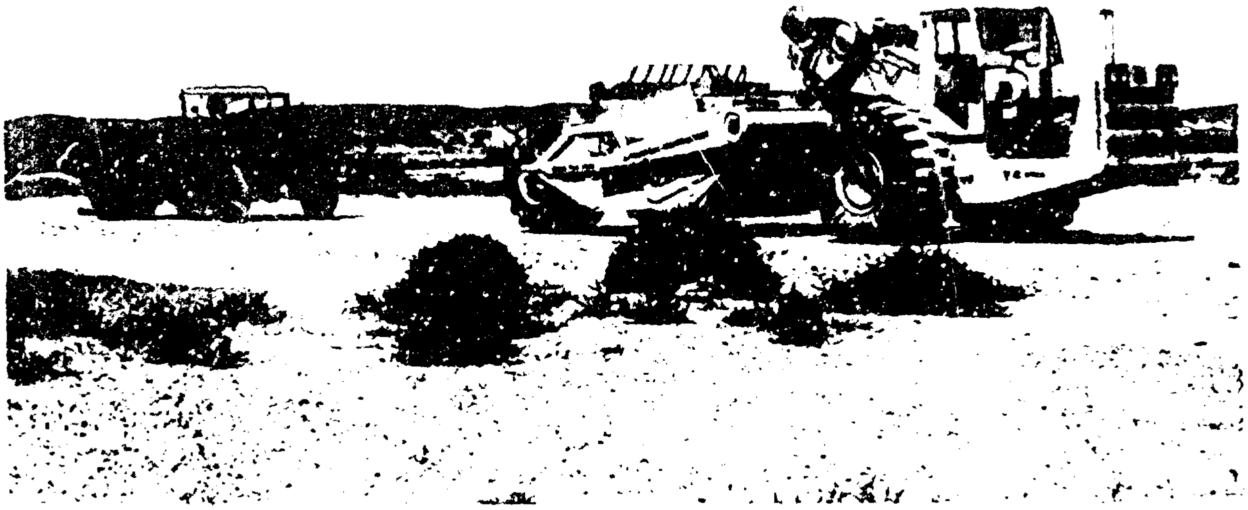
Upper Photograph

Mud Test Area

Lower Photograph

Mud Test Equipment Convoy

Best Available Copy



APPENDIX A

HISTORY

Shortly after the inception of the tire tread wear and durability evaluation, Project 20-1-110, it became obvious that the "ride" severity of the "test bed" Model "C" Tournapull on the pavement, secondary and cross-country courses was limiting the desired vehicle speed. Adjustment of test tire inflation pressures was made to improve pavement "ride", but by necessity secondary and cross-country terrain was negotiated at the pressure established as the most reasonable optimum for pavement.

The tire manufacturers' representatives and the vehicle manufacturer's representative had previously observed certain "ride" characteristics of the ATAC "Goer" Tanker unit which were influenced differently by the performance of non-directional radial ply tires (Group B) when compared with the directional conventional construction tires (Group A). These observed differences were not confirmed by the performance of the Model "C" Tournapull "test beds" mounted on similar tires. The seriousness of the Model "C" Tournapull's "ride" problem was climaxed by the failure of the paved test course, Route #1, due in part to the high dynamic loads imposed by the tires during periods of random cyclic excitation which developed progressively larger areas of pavement deterioration.

The secondary road courses also suffered under these dynamic loads but the absence of public traffic on these roads provided the operators a certain latitude in avoiding known exciters.

On pavement the most sensitive tires in terms of "lope" generation were the non-directional radial ply, Group B. On secondary road surfaces the Group B tires were difficult to excite, but once excited, rate of decay was exceptionally slow compared with the directional conventional tires (Groups A and C). In cross-country the non-directional radial ply Group B tires could negotiate "rough" single impacts at a higher rate of speed than Groups A or C, but if a combination of three or more closely spaced impacts was present, the Group B tires would achieve a compound amplitude quickly reaching the intolerable limit for both driver and vehicle. The Group A and C, on the contrary, would transmit a higher initial "jerk" force but would require a considerably greater number of closely spaced impacts before an intolerable compound reaction resulted.

As the Group A and C tires became severely worn and the directional tread elements were significantly reduced, the operator's subjective "ride" experience improved, whereas the Group B tires reacted essentially without change throughout the test.

TEST RESULTS

Figure 1 indicates the maximum traction developed by the two groups tested at each inflation pressure under investigation. Also shown on this graph at two inflation pressures is a profile of tire penetration in the test track. From these profiles the portion of the tread surface providing the most aggressive traction is apparent.

Figure 2 illustrates the complete Group A traction curve for each inflation pressure tested.

Figure 3 illustrates the complete Group F traction curve for each inflation pressure tested.

TEST PROGRAM

Test Course

A test course area was selected to provide high natural compaction affording minimal tire penetration and low coefficient of friction (.17-.25) when wet. The character of this course may be compared with wet grass matted slopes.

Separate test courses were constructed and used each day of test operation. Each test course was approximately 65 feet in length and 20 feet in width.

Test Vehicle and Dynamometer Unit

A Model "C" Tournapull was used as the "test bed" unit and an M-34 2 1/2 ton 6x6 vehicle, fully instrumented for this study, was used as the dynamometer unit.

Test Procedure

With the "test bed" vehicle attached to the Emery Load Cell System installed in the dynamometer unit the two vehicles, "test bed" vehicle leading, moved down the test course approach apron and stabilized at test speed with essentially zero pounds tractive force before entering the mud pit. After the "test bed" vehicle had entered the mud pit, the dynamometer vehicle slowly applied a resisting force inducing "test bed" wheel slip until zero forward motion or vehicle stall condition was achieved although the wheel speed of the "test bed" vehicle was maintained constant. Ground speed was recorded by means of a fifth wheel instrumented with a Weston DC tachometer generator. Two signals being produced simultaneously (pounds drawbar force and ground speed) were integrated and plotted by means of HTI function plotting recorder. This provided a recording of the complete traction curve for each run. An average of six runs was made at each inflation pressure for each group tested.

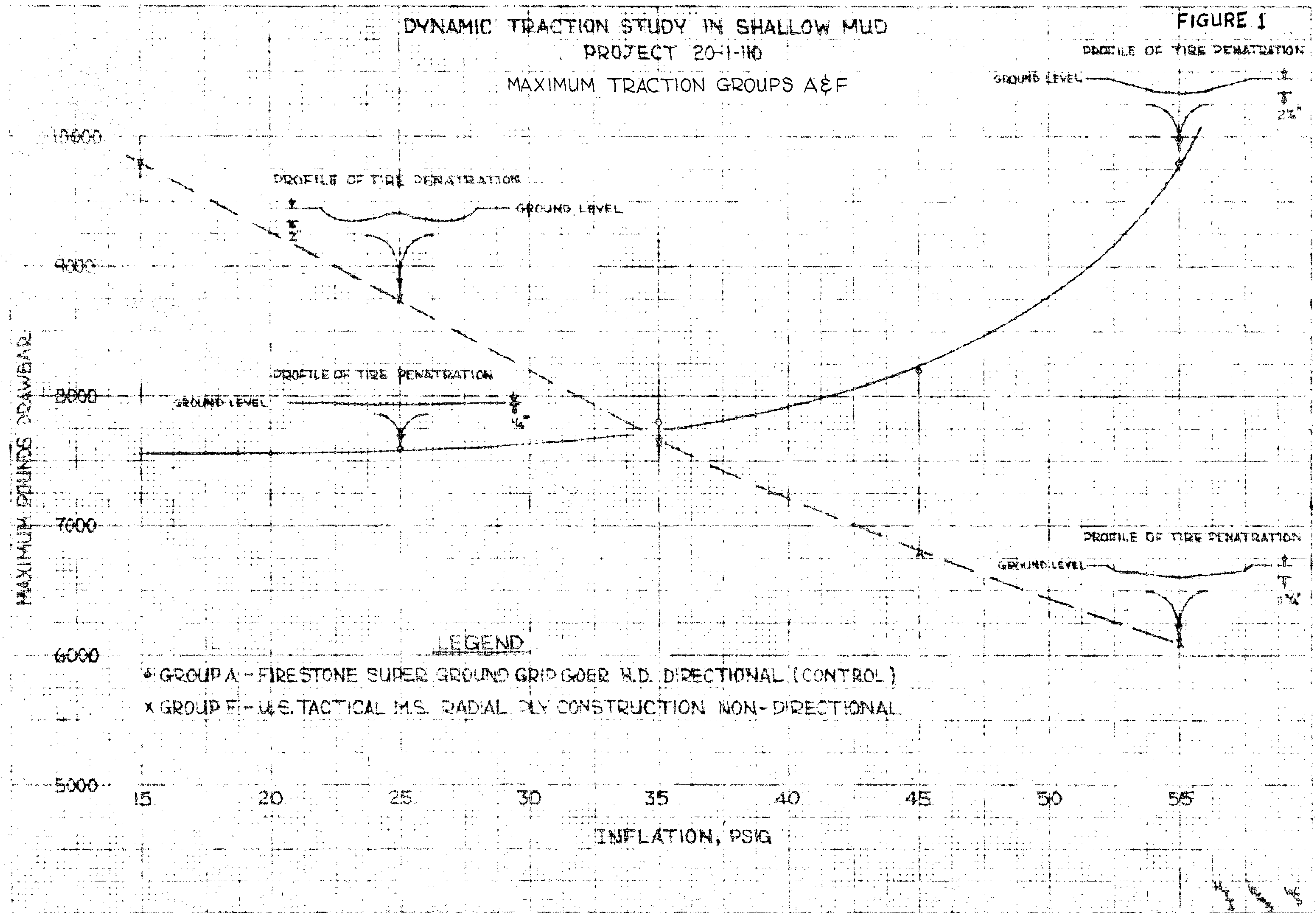


FIGURE 1
DYNAMIC TRACTION STUDY IN SHALLOW MUD
PROJECT 20-1-110
MAXIMUM TRACTION GROUPS A&F
PROFILE OF TIRE PENATRATION
GROUND LEVEL
PROFILE OF TIRE PENATRATION
GROUND LEVEL
PROFILE OF TIRE PENATRATION
GROUND LEVEL
PROFILE OF TIRE PENATRATION
GROUND LEVEL
10000
9000
8000
7000
6000
5000
MAXIMUM POUNDS DRAWBAR
15
20
25
30
35
40
45
50
55
INFLATION, PSIG
LEGEND
GROUP A - FIRESTONE SUPER GROUND GRIP G0ER H.D. DIRECTIONAL (CONTROL)
x GROUP F - U.S. TACTICAL M.S. RADIAL PLY CONSTRUCTION NON-DIRECTIONAL

FIGURE 2

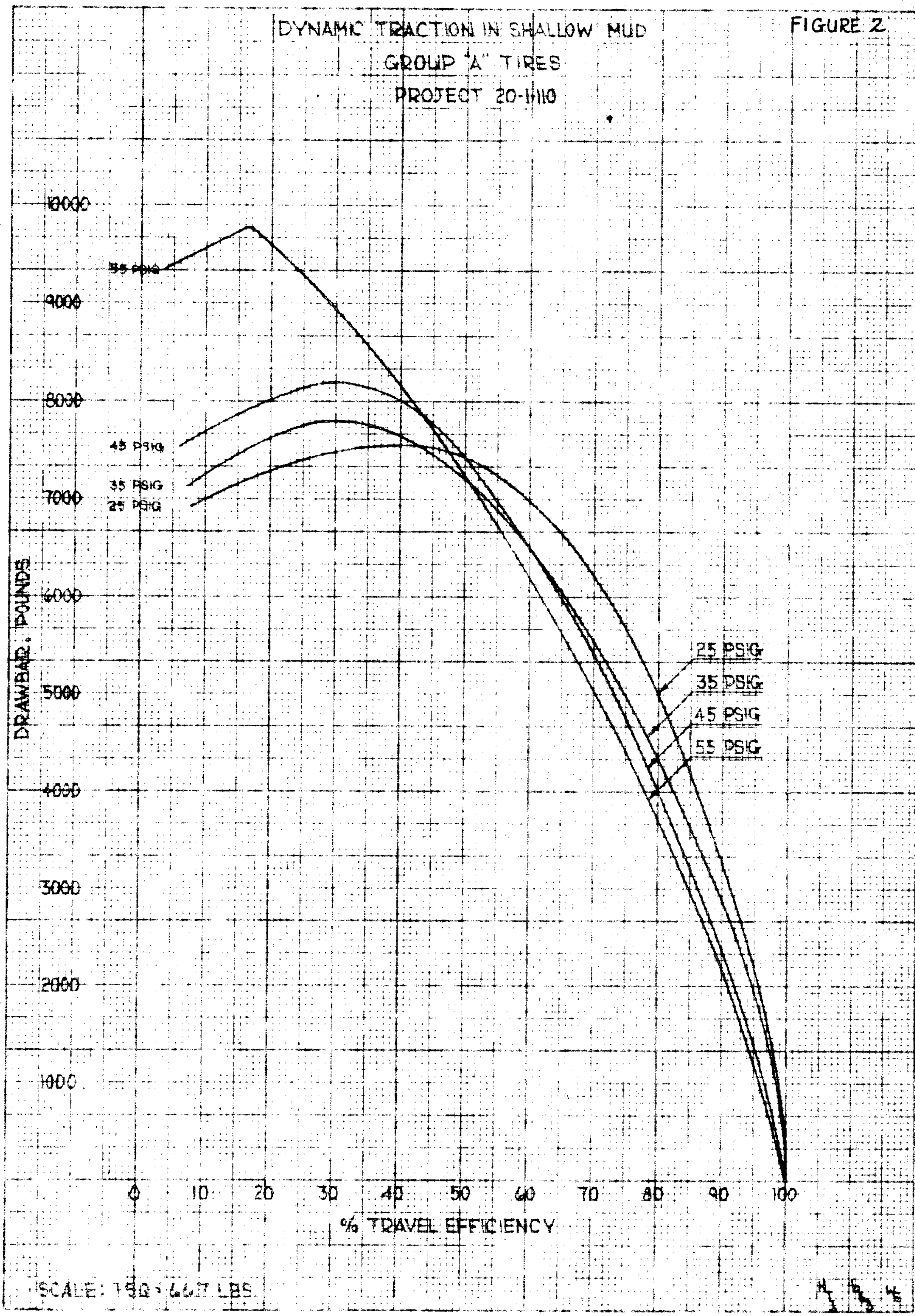
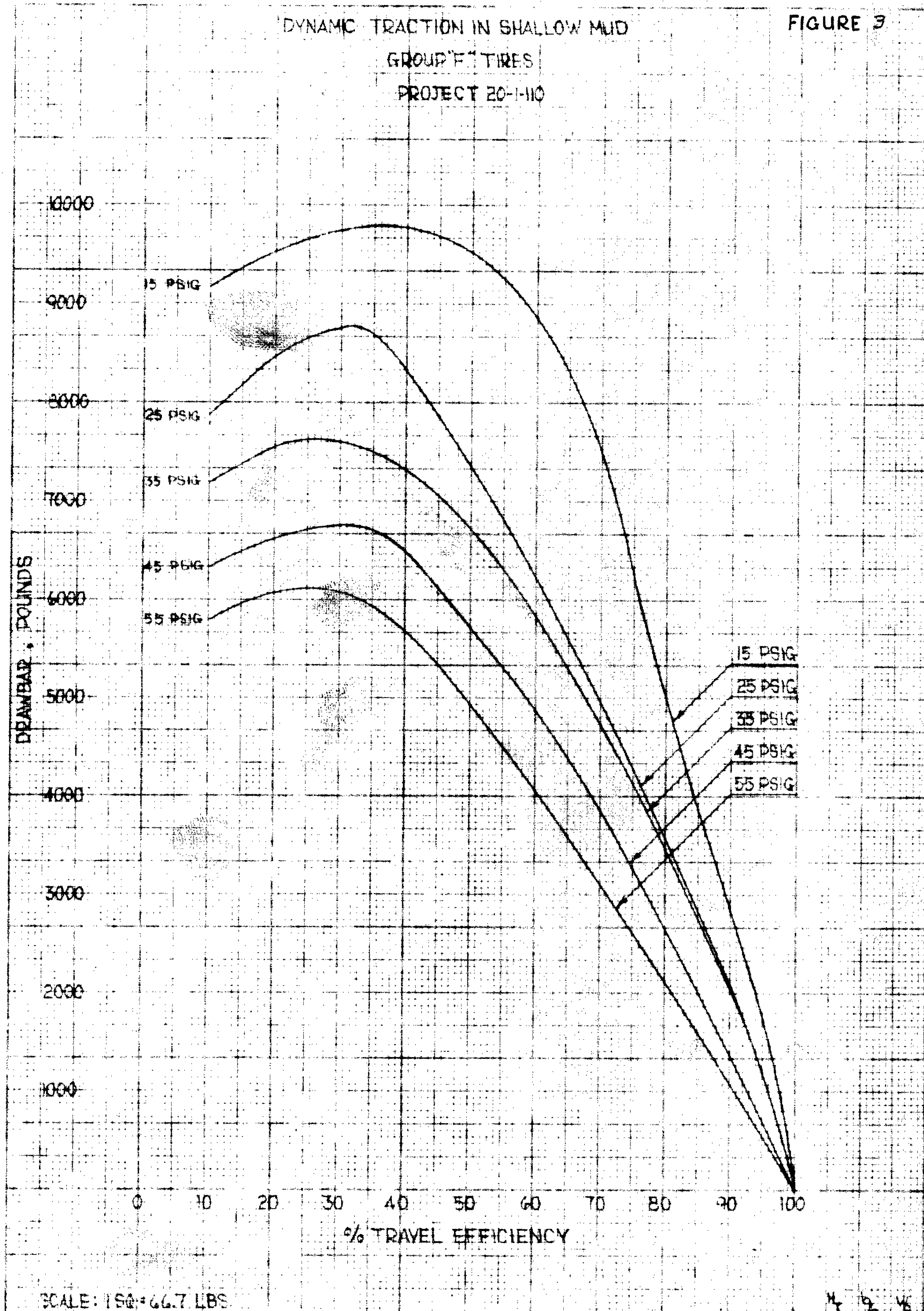

DYNAMIC TRACTION IN SHALLOW MUD
GROUP "A" TIRES
PROJECT 20-1110
DRAWBAR, POUNDS
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
55 PSIG
45 PSIG
35 PSIG
25 PSIG
25 PSIG
35 PSIG
45 PSIG
55 PSIG
0
10
20
30
40
50
60
70
80
90
100
% TRAVEL EFFICIENCY
SCALE: 1SQ = 667 LBS

FIGURE 3


DYNAMIC TRACTION IN SHALLOW MUD
GROUP "F" TIRES
PROJECT 20-1-110
15 PSIG
25 PSIG
35 PSIG
45 PSIG
55 PSIG
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
DRAWBAR - POUNDS
0
10
20
30
40
50
60
70
80
90
100
% TRAVEL EFFICIENCY
SCALE: 1 SQ = 66.7 LBS

DEEP MUD TEST

Discussion

A specially constructed pit was required in which the depth of mud was 12 inches, the length of the pit was 220 feet and the width 40 feet. The consistency of the mud was maintained to a state wherein the vehicle would become immobile before the 220 feet distance was reached. The evaluation of one tire versus the other was made on the basis of distance traveled versus time. The vehicle remained in the same transmission gear throughout all tests, and when it became immobile the tires would spin out and not stall out. The test bed vehicle was such that only the front drive axle could be used; therefore, throughout all tests the rear axle was non-driving and the same set of tires remained on the rear axle throughout all tests. Experiments were conducted in respect to what effect inflation would have, and since there was no effect, all tests were conducted at a standard setting of 40 psi per tire. The depth of mud was determined to be the maximum allowable depth without high centering the vehicle. Inasmuch as no torque was transmitted to the rear axle, it was observed throughout each test that these tires would slide and in turn build up a large quantity of mud directly in front of each wheel. By the resistance created at this point, it increased the drag on the vehicle and in turn the front driving tires were called upon to do more work than would be expected if both axles were driving. Therefore, these tests are only a comparative type test of the three experimental groups as compared with the control group. By reviewing the attached data it will be noticed that the control tires, along with the experimental tires, have operated through the pit a total of three runs each, alternating from the control to the experimental, etc. After each run, the pit was floated down with a leveling device.

Due to a test bed vehicle breakdown, we were unable to compare the Ground Grip Directional Grooved Lugs.

TEST RESULTS:

FIRESTONE GROUND GRIP DIRECTIONAL DESIGN

(Control)

Time	Distance	Rating
1. 41 Sec.	98'10"	
3. 42 Sec.	101' 3"	
5. 43 Sec.	94'10"	
Total..126 Sec.	294'11"	
Average..42 Sec.	98' 3"	100

SUPER GROUND GRIP GOER

Time	Distance	Rating
2. 91 Sec.	177'10"	
4. 82 Sec.	165' 9"	
6. 79 Sec.	161' 1"	
Total..252 Sec.	504' 8"	
Average.. 74 Sec.	168' 2"	171

FIRESTONE GROUND GRIP DIRECTIONAL DESIGN

(Control)

Time	Distance	Rating
1. 54.5 Sec.	86' 9"	
3. 58 Sec.	86' 1"	
5. 54.5 Sec.	85' 1"	
Total..167 Sec.	257'11"	
Average..55.6 Sec.	85'11"	100

ND-CC GOER

Time	Distance	Rating
2. 26 Sec.	48' 3"	
4. 24 Sec.	47' 3"	
6. 26 Sec.	48' 7"	
Total...76 Sec.	144' 1"	
Average...25.3 Sec.	48'	56

APPENDIX

APPENDIX I

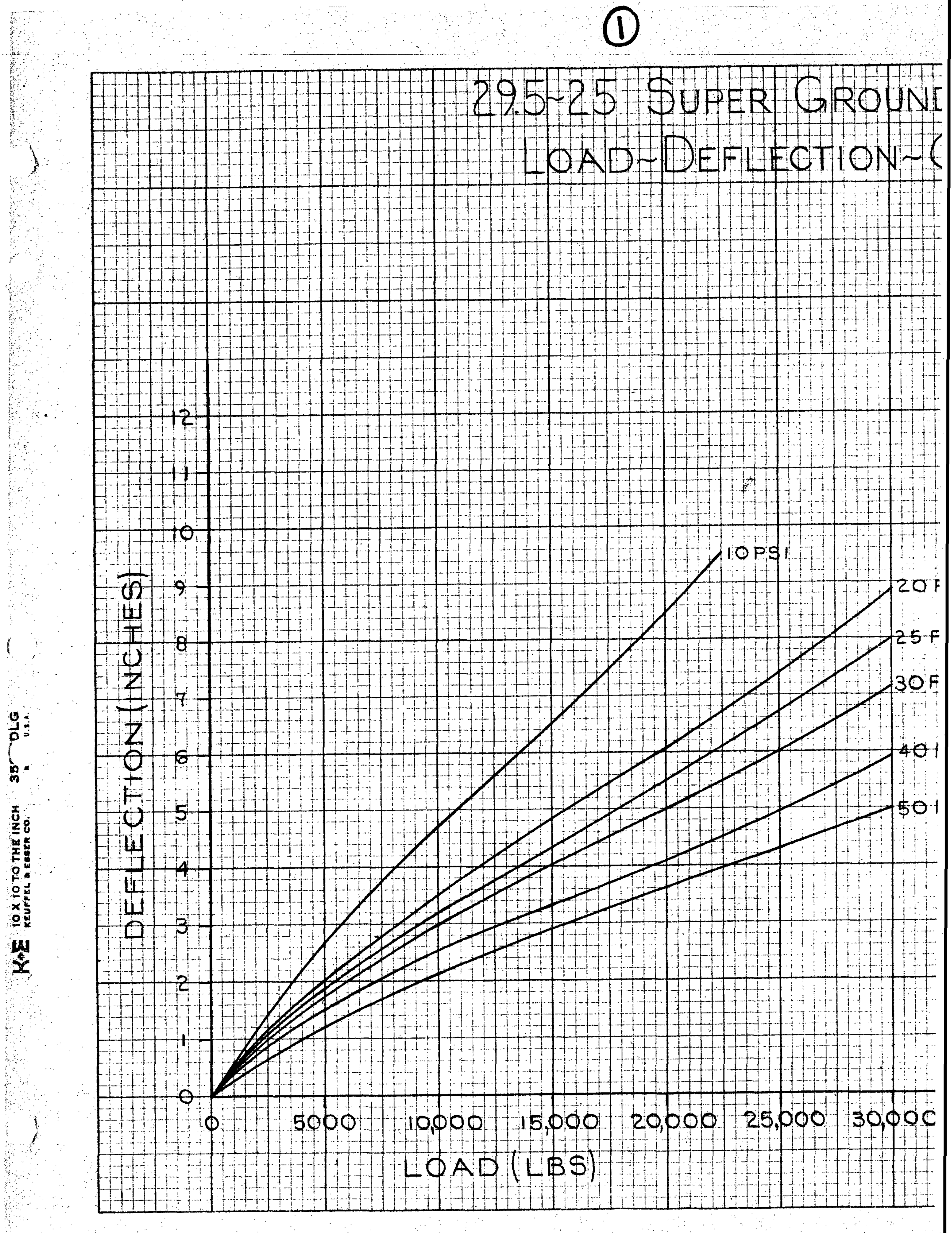
ABBREVIATIONS AND SYMBOLS

°C	Degrees Centigrade
°F	Degrees Fahrenheit
FR-S	Firestone Rubber - Synthetic (styrene-butadiene type)
in	Inches
lb	Pounds
NR	Natural Rubber
psi	Pounds per square inch

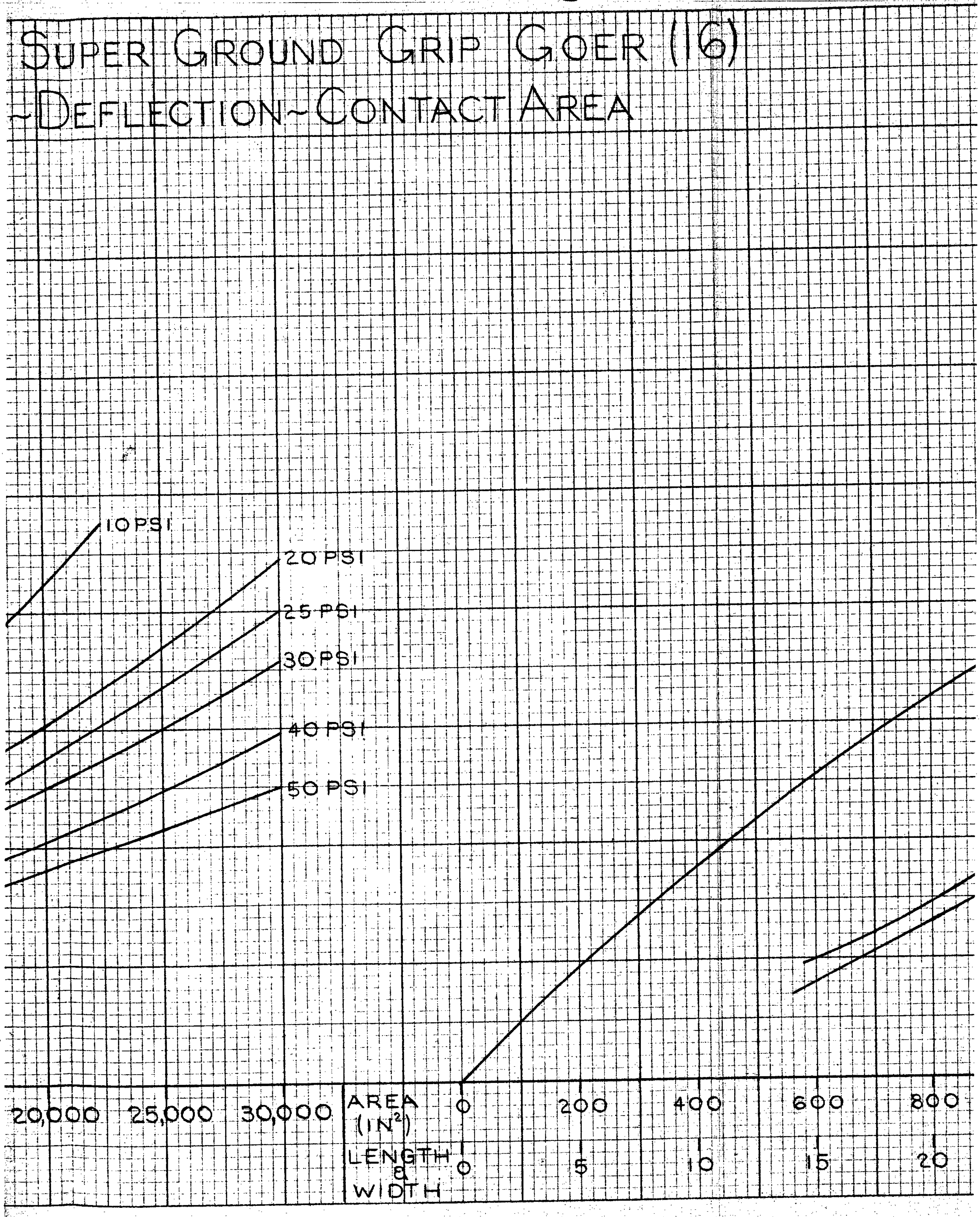
APPENDIX II

GLOSSARY OF TRADE NAMES

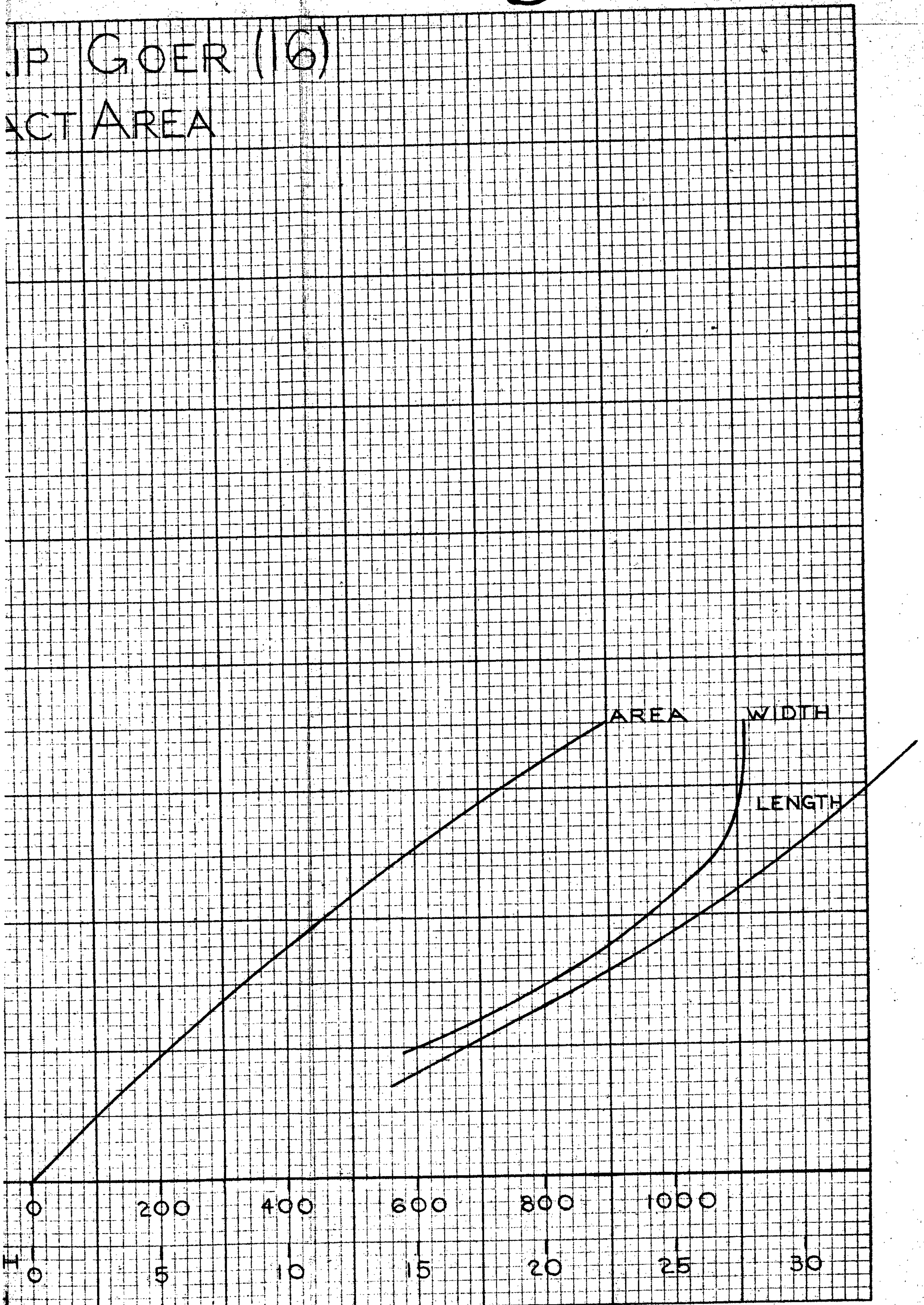
TRADEMARK OR DESIGNATION	COMPOSITION	USE	SOURCE
Isoprene	polyisoprene	Elastomer	Shell Chemical
Diene	polybutadiene	Elastomer	Firestone Tire & Rubber Co.
FR-S 123	butadiene-styrene copolymer oil masterbatch-31 phR oil	Elastomer	Firestone Tire & Rubber Co.
Hypalon	chlorosulfonated polyethylene	Elastomer	duPont
Neoprene	polychloroprene	Elastomer	duPont



①
295-25 SUPER GROUND
LOAD-DEFLECTION-(
DEFLECTION (INCHES)
0
1
2
3
4
5
6
7
8
9
10
11
12
10 PSI
20 P
25 P
30 P
40 P
50 P
0
5000
10,000
15,000
20,000
25,000
30,000
LOAD (LBS)
K+E 10 X 10 TO THE INCH 35 DLG
KEUFFEL & ESSER CO. U.S.A.

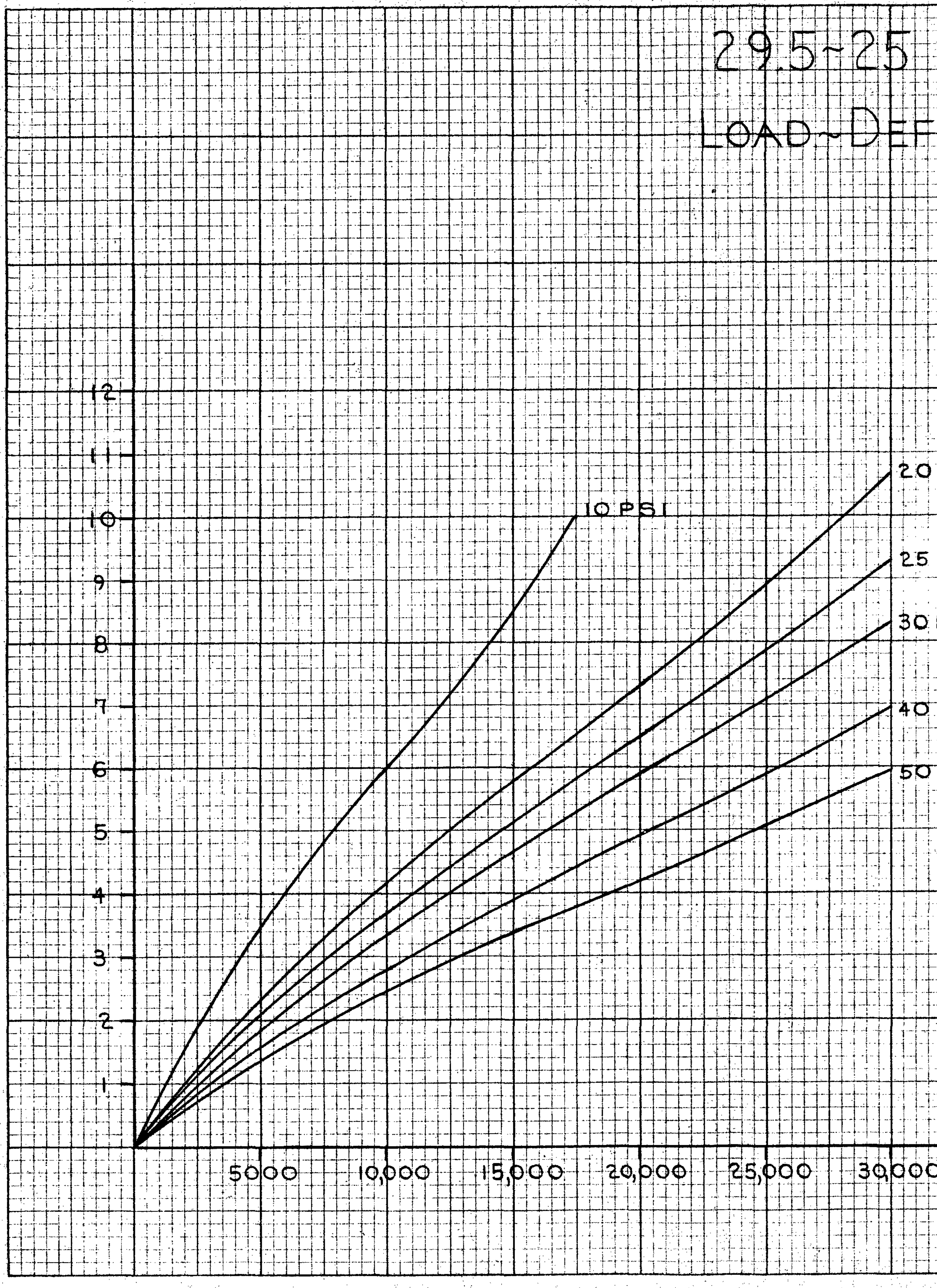

SUPER GROUND GRIP GOER (16)
~DEFLECTION~CONTACT AREA
10 PSI
20 PSI
25 PSI
30 PSI
40 PSI
50 PSI
20,000
25,000
30,000
AREA (IN²)
0
200
400
600
800
LENGTH & WIDTH
0
5
10
15
20

③



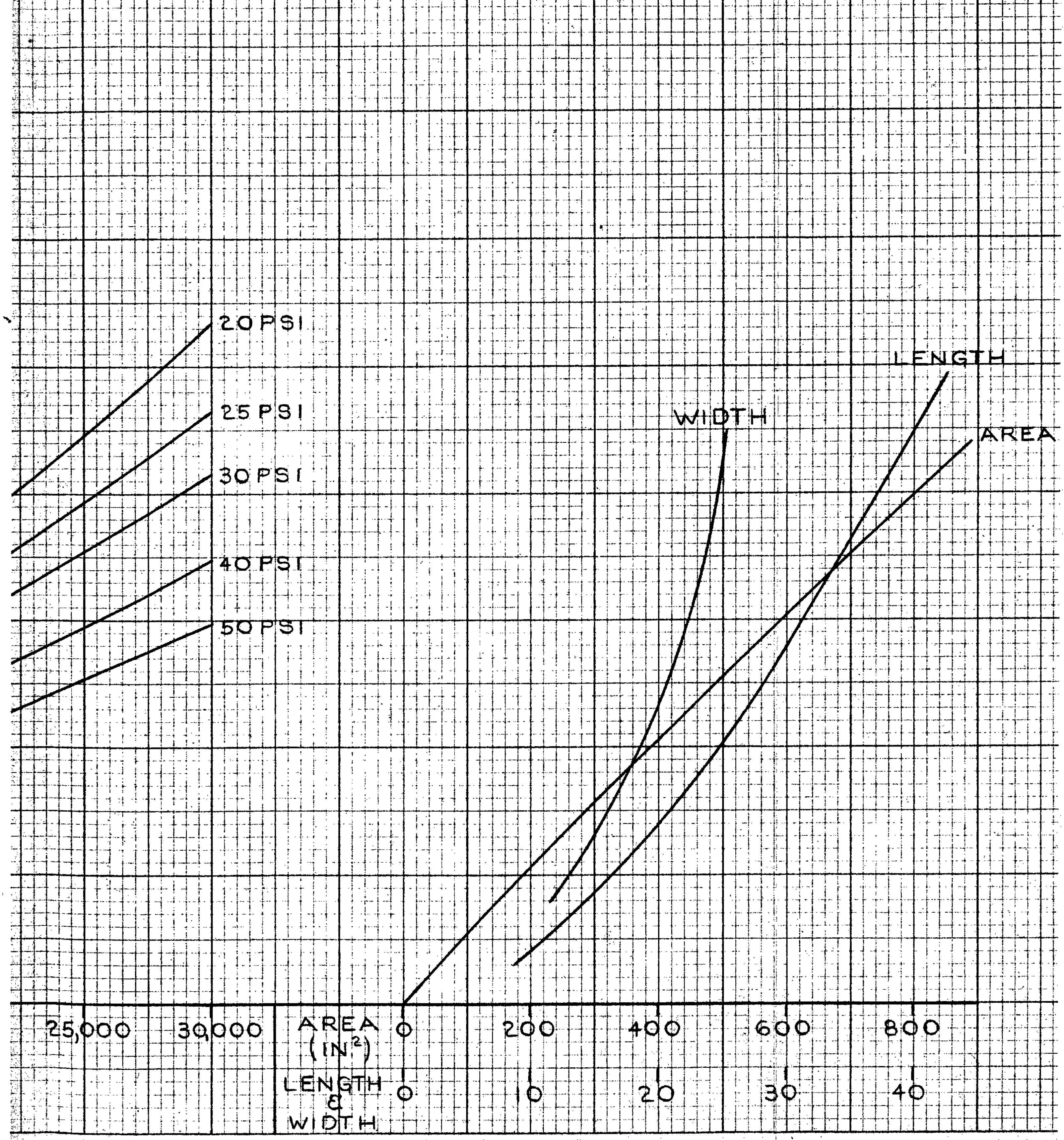
P GOER (16)
ACT AREA
AREA
WIDTH
LENGTH
0
200
400
600
800
1000
H
0
5
10
15
20
25
30

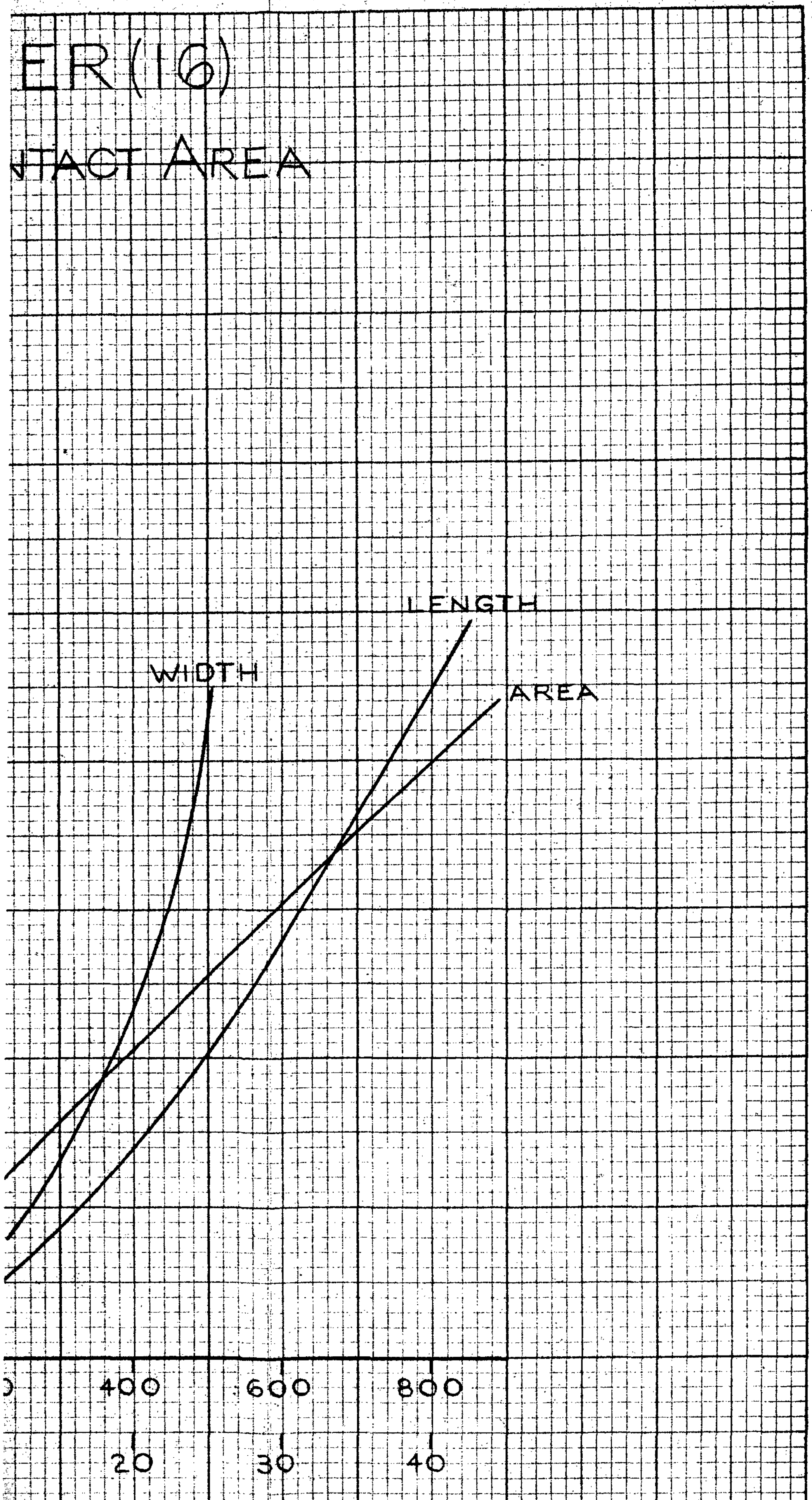
①


29.5-25
LOAD~DEFL
10 PSI
20
25
30
40
50
12
11
10
9
8
7
6
5
4
3
2
1
5000
10,000
15,000
20,000
25,000
30,000

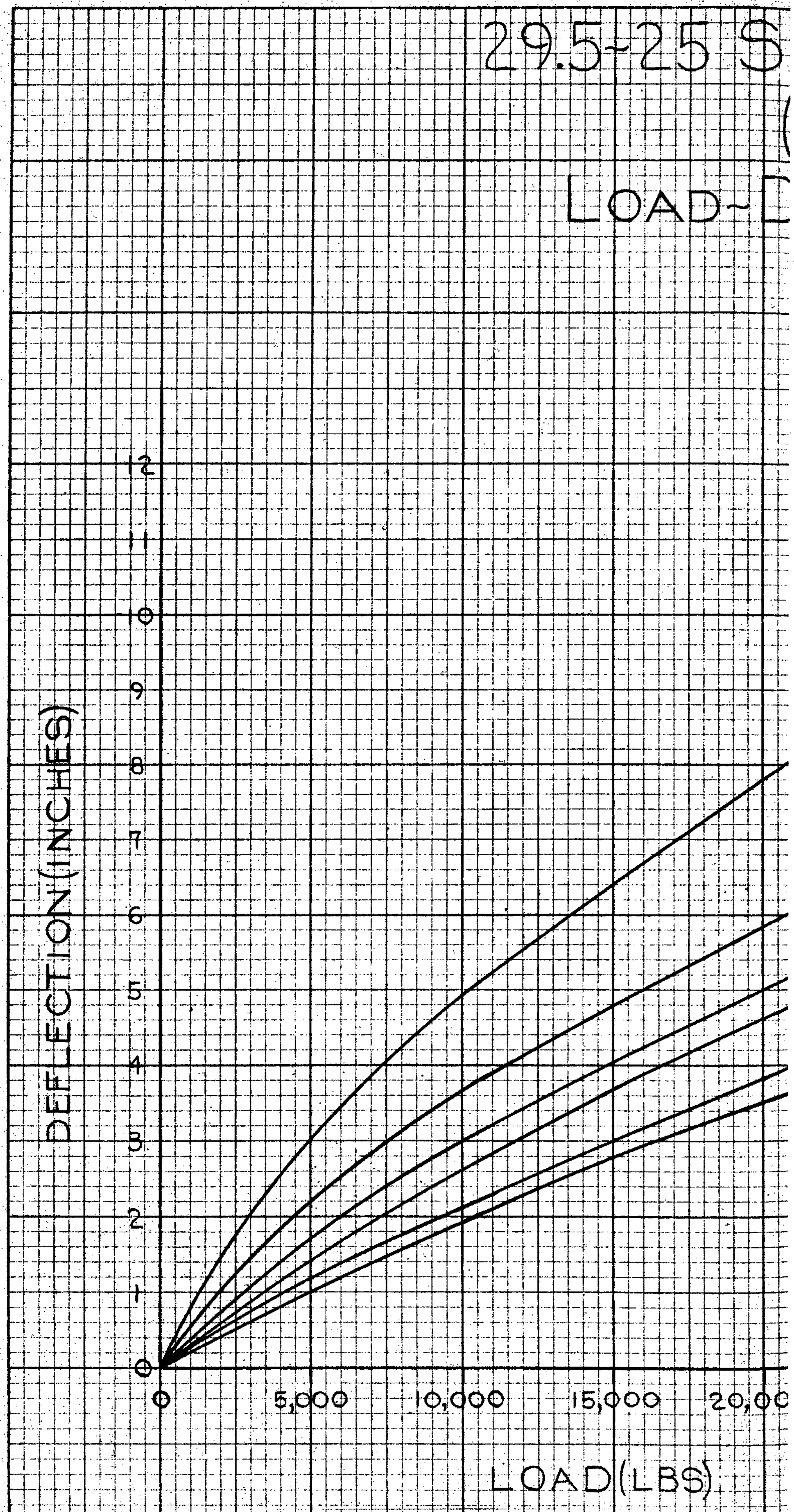
29.5~25 ND-CC GOER (16)

LOAD~DEFLECTION~CONTACT AREA



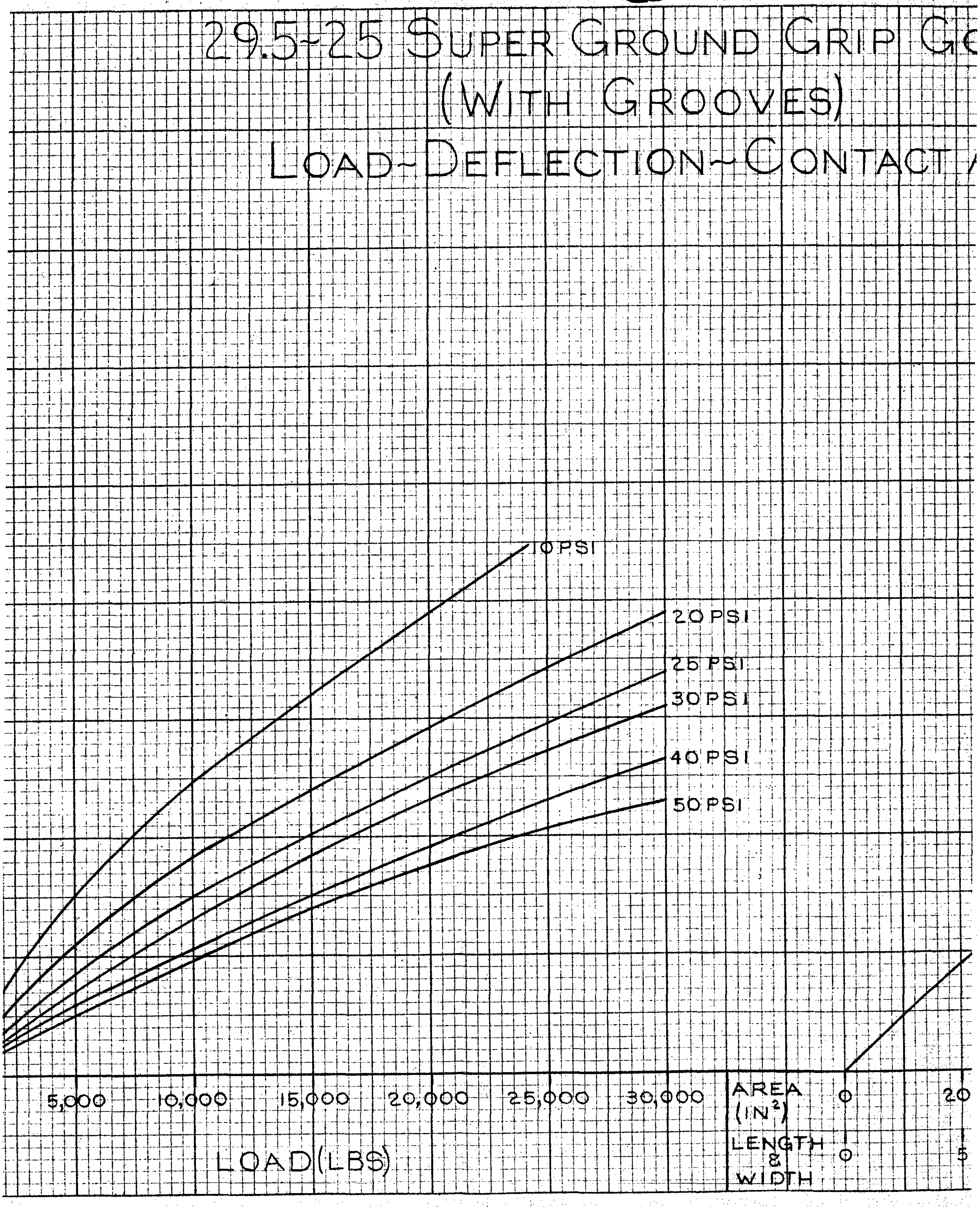

ER(16)
NTACT AREA
LENGTH
WIDTH
AREA
400
600
800
20
30
40

①

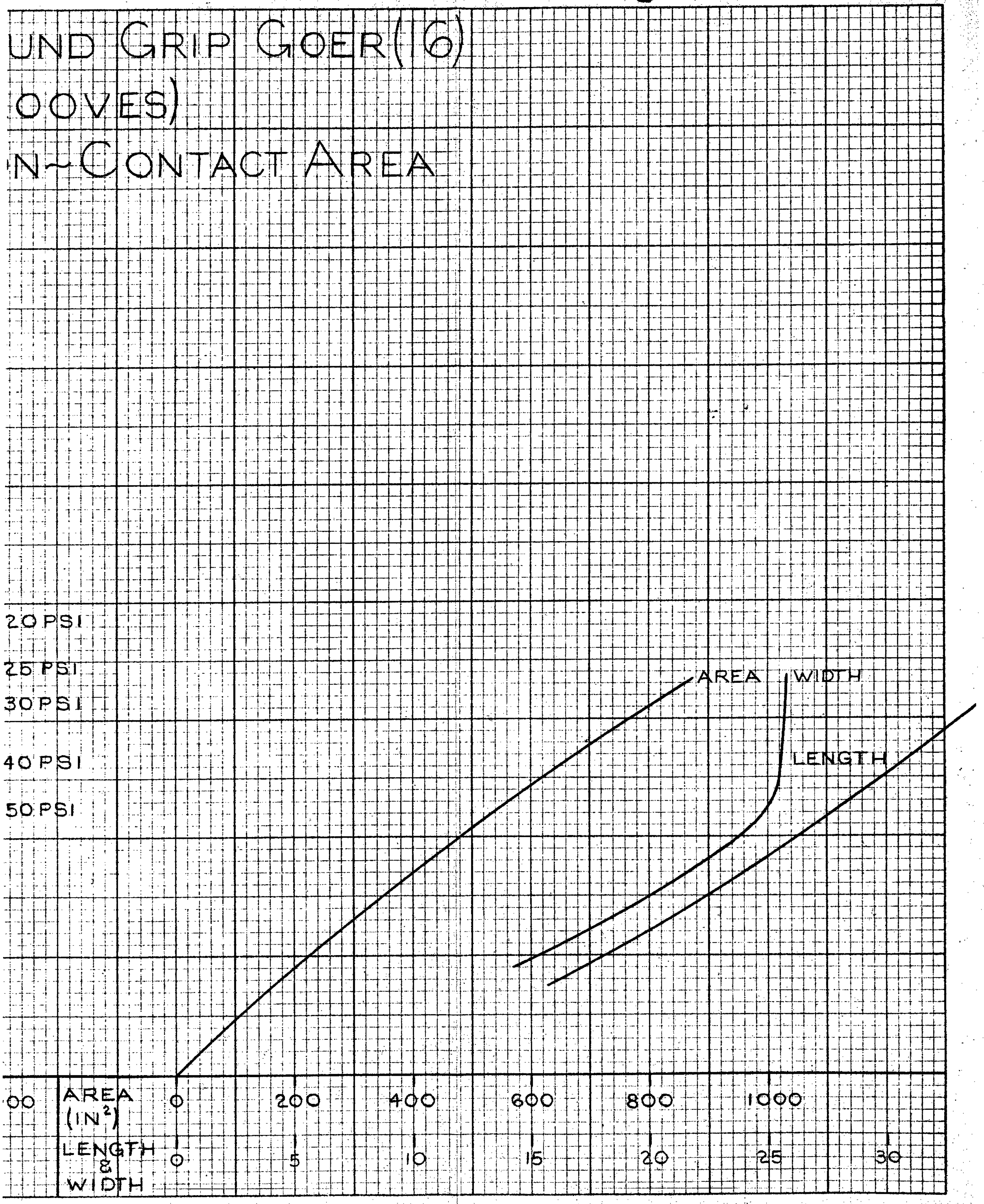


29.5-25 S
(
LOAD-D
DEFLECTION (INCHES)
12
11
10
9
8
7
6
5
4
3
2
1
0
0
5,000
10,000
15,000
20,00
LOAD (LBS)

2



29.5-25 SUPER GROUND GRIP G
(WITH GROOVES)
LOAD-DEFLECTION-CONTACT
10 PSI
20 PSI
25 PSI
30 PSI
40 PSI
50 PSI
5,000
10,000
15,000
20,000
25,000
30,000
LOAD (LBS)
AREA (IN²)
0
20
LENGTH & WIDTH
0
5


UND GRIP GOER (16
OOVES)
N~CONTACT AREA
20 PSI
25 PSI
30 PSI
40 PSI
50 PSI
AREA
WIDTH
LENGTH
00
AREA (IN^2)
0
200
400
600
800
1000
LENGTH & WIDTH
0
5
10
15
20
25
30

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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13. ABSTRACT

Earthmoving tires were specifically developed for use on the GOER vehicle. This development work included the design of various tread configurations and use of maximum feasible synthetic content. Tires were produced in three different tread designs, and two different levels of synthetic content. These tires were than tested for running temperature, traction, and mobility. Durability tests of 40% highway, 40% secondary roads, and 20% cross country were conducted. These tests showed that tires could be produced to provide at least 15,000 miles without any premature failures for this type of service.

These tires are more suited to the requirements of the GOER Vehicle than any commercially available tire. The major areas of improvement includes the capacity for continuous highway operation and improved performance in mud.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Rubber Tires						
Synthetic Rubber						
Tubeless Tires						
Non-Destructive Testing						
Traction Testing						
Highway Operation						
Tire Tread Designs						
Off-Road Mobility						