REPORT NO. FRA/ORD-77/41

PB 275166/AS

LATERAL RESISTANCE OF RAILROAD TRACK

AUGUST 1977

FINAL REPORT

Prepared for
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION
Office of Research and Development
Washington, D.C. 20590

NOTICE

Technical Report Documentation Page

1. Report No. FRA/ORD-77/41	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Lateral Resistance of Railroad Track		5. Report Date August 1977 6. Performing Organization Code
7. Author(s) I. A. Reiner		8. Performing Organization Report No. S
9. Performing Organization Name and Address Chessie System, Inc. 2 North Charles Street Baltimore, Maryland 21201		10. Work Unit No. (TRAIS) 11. Contract or Grant No. DOT-FRA-20015
12. Sponsoring Agency Name and Address Federal Railroad Administration U. S. Department of Transportation 2100 2nd St., S.W. Washington, D. C. 20590		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Within the broader scope of research activities dealing with lateral track resistance sponsored by the Federal Railroad Administration, the Sabot test carried out by Chessie on its main line track furnishes specific data on the variability of lateral track resistance.

Track panels were constructed with all new wood ties, old and new wood ties and new concrete ties for lateral load testing under various degrees of ballast settlements such as freshly tamped, mechanically compacted and trafficked.

17. Key Words panel, concrete, wood, resistance, yield force, displacement, transducer	18. Distribution Statement Document is available to the Public from National Technical Information Service 5258 Port Royal Rd. Springfield, VA 22161

19. Security Classif. (of this report) None	20. Security Classif. (of this page) None	21. No. of Pages 124	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

PREFACE

It has long been observed that lateral stability is the weak link of conventional track structure. From the beginning of railroading, considerable effort has been made to counteract this undesirable characteristic. Among the first remedial actions were the track superelevation, the insertion of spirals between straight lines and curves and the construction of wider ballast shoulders.

During the twenties and thirties, several tests were conducted in here and abroad with the aim of determining lateral wheel/rail forces and lateral track stability. The purpose of the lateral force measurements carried out by the Pennsylvania Railroad in 1933/34[1] was to guide various research projects such as improving locomotive suspension and developing limits of irregularities in track geometry tolerable for various operating speeds.

The European tests had other motives. Shortly after World War I, when the French, German and other railroads began their experiments with long welded rail, it appeared that lateral stability - which was adequate for tracks with jointed rails - is either marginal or insufficient for tracks with long welded rails. The subsequent investigations sponsored by several IEV member roads and conducted by Blondel, Amman, Gruenewaldt, Martinet, and Nemesdy[2] were designed and carried out with the objective of preparing recommendations for the construction and maintenance of tracks with continuous welded rail. In the corresponding field tests, longitudinal forces were applied to the rails of the test tracks which were built with different tie spacing, ballast section and irregularities in geometry, and the force/displacement data were measured and recorded until the track buckled. The results, among other things, revealed that the weight of track was incompatible with the longitudinal compressive forces in the rails. To increase lateral track stability, wider and higher ballast shoulders and reduced tie spacing were recommended.

Post-war activities indicate a considerable evolution in the application of highly sophisticated procedures and, more importantly, an accelerated and wide-spreading research for better understanding the mechanics of lateral track stability. Testing methods of recent past are characterized by the use of electronic measuring/recording equipment and computerized data processing. The results of theoretical approaches come closer to reality through the developments of more complex mathematical models.*

Stability of Today's Track

Conventional wood tie track in the United States has served the industry very well over the years until about the late fifties, without the need for any major change in its basic structural design. Since then, however, the operation of newly built cars, with axle loads of nearly twice as high as in the past, provided many evidences that conventional wood tie track no longer performs well. The inadequacies of

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*Due to the large number of tests recently conducted and theoretical work published, it seems inappropriate to list them individually within the frame of this report.

stability and supporting capability manifested themselves as more frequent need for the rehabilitation of track geometry (surfacing and lining) and also the accelerated physical wear of track components, particularly in lines where large quantities of bulk materials are shipped in jumbo car-unit trains. Based on these observations, one can draw the conclusion that today's traffic loads imposed on the track cannot be handled economically.

As trends point toward further increases in car size and capacity as well as in percentages of their usage, railroad officials recognized the obligation to support ideas and methods directed toward the improvement of the structural properties of track with the benefits of greater stability and also a longer term retention of this desirable characteristic.

Current track related research activities with the common objective of improving stability are advancing on three major fields. These are (1) increase the cohesive forces between ballast particles via mechanical compaction or by treating the ballast with a glueing agent, (2) the investigation of the feasibility of using other material than wood in making crossties, and (3) the development of non-conventional track structures, such as longitudinal beams and slab tracks.[3]

Lateral Stability Provided by the Ballast

Conventional railroad track has a load distributing layer of granular material (ballast) resting on the subgrade. The ballast provides also some resistance to lateral track displacement. This resistance depends, to a large extent, on the degree of mechanical interlocking between the ballast particles. Consequently, large area of contacting surfaces and small volume of voids are desirable.

Mechanical interlocking varies not only with the surface roughness and size distribution of the ballast material, but also with time. Ballast, in newly constructed tracks or when it is freshly tamped, has a larger volume of voids and a smaller area of contacting surfaces, thus, reduced lateral resistance. It is known from practice that the solid core of ballast under the ties and also to a certain extent in the cribs and shoulders, becomes loose after tamping. Furthermore, commercial tampers, to avoid centerbinding, compact the ballast beneath the ties in a length of about 5 feet ($2\frac{1}{2}$ ft. under each rail) creating pedestals of ballast on these areas and voids at the center of the ties with the result of reduced contact areas between the ballast and tie and decreased resistance to displacement

The degree of weakenings in track stability, particularly in lateral direction, could be considerable and could reach undesirably low levels. Although traffic exposure eventually restores track stability, the track is prone to buckling and also subject to rapid deterioration of its geometry during the interim period of unconsolidated condition. Until settlement, the rate of deterioration is accelerated by the unfavorable combination of low resistance and high wheel to rail forces.

The recently developed mechanical devices (ballast consolidators) are able to immediately restore a significant proportion of lateral track resistance. Best results can be obtained when these machines are used after tamping and before any traffic exposure occurs.

Numerous railroads abroad have experimented with after-tamping mechanical ballast consolidation and many of them adopted it as a standard procedure. There are reasons to believe that mechanical ballast consolidation has some merits also in domestic use. Benefits are visualized as increased safety and perhaps improved economy.

Based on the favorable foreign results with ballast consolidators, the Federal Railroad Administration acquired one unit of such trackwork equipment, primarily to be used at the Department of Transportation Test Center in Pueblo, Colorado to evaluate various methods in maintaining conventional type of tracks. Also, FRA felt that such equipment could be utilized outside of the Test Center, on U.S. railroad tracks as well, to demonstrate the effectiveness of the concept regarding crib and shoulder consolidation. Accordingly, on March 29, 1973, the FRA convened a meeting in Washington, D. C. on the subject of ballast consolidation, and in case of sufficient interest, to solicit railroad participation in demonstration projects. As a result, five railroads expressed interest and made committments to support the joint project entitled, "Machine Induced Ballast Consolidation Effectivenss Tests".[4] The project included track settlement surveys, track modulus measurements, lateral and longitudinal tie displacement tests and track geometry surveys for tracks with consolidated and unconsolidated ballast. Measurements were carried out immediately after tamping and/or ballast consolidating operations, then at various times until 10 MGT of traffic had been accumulated. The processed data indicated a marked increase of lateral, and some longitudinal, resistance during the interim period.

These encouraging results gave the impetus as to broaden the scope of the FRA/Chessie contract on the lateral load test of wood and concrete tie tracks at Sabot, Virginia by adding another objective to it. The new objective was the determination of the effect of mechanical ballast consolidation on the lateral track resistance.

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* (Ph) indicates photograph

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Digitized Data Sheets:

* (Ph) indicates photograph

1. REPORT ON THE SABOT TEST

1.1 Project Objectives

Several objectives were set to achieve with the lateral resistance test of vertically unloaded track. At Sabot, Virginia, we focused our attention on the following questions:

(1) What is the difference between the lateral resistances of concrete tie and wood tie track;

(2) What is the magnitude of weakening in lateral track resistance as a result of out of face surfacing;

(3) To what degree can mechanical ballast consolidation restore lateral track resistance when applied immediately after track surfacing; and

(4) How quick is the recovery of lateral track resistance after surfacing under the exposure of traffic.

1.2 The Selection of the Testing Method

The technique used at Sabot, unlike recent European pulling tests of individual crossties which are uncoupled from the rails, was the application of the lateral force on assembled track panels. Consequently, the measurements represent the total lateral resistance of the track panel including the following components:

(1) Frictional resistance between the bottom surface of ties and the ballast.

(2) Frictional resistance between the sides of ties and the ballast.

(3) Internal friction among the interlocked ballast particles.

(4) Resistance of ballast shoulder to displacement.

(5) Resistance of tie plates/fasteners to longitudinal rail movements.

(6) Resistance of rails to lateral bending.

When decision was made on the testing method to be applied at Sabot, it was felt that it is more appropriate to determine the total lateral resistance, which is the prime concern because of the following considerations:

(1) Track - as an integrated system of ballast, crossties, fasteners and rails - is subject to both shift and lateral bending in actual service, either during the passage of trains or under excessive thermal compression.

(2) There are substantial differences between concrete and wood tie tracks regarding not only weight and surface smoothness but regarding also the type of fasteners and the center to center tie spacing applied. These factors all influence the lateral resistance of track, and therefore, cannot be ignored when comparing the performance of the two systems.

1.3 Description of the Test Site

For test site, Chessie's mainline track was selected at Sabot, Virginia (Figs. 1 and 2), about 20 miles west of Richmond.

Fig. 1 - TEST SITE AT SABOT, VIRGINIA
(Western tangent, looking West)

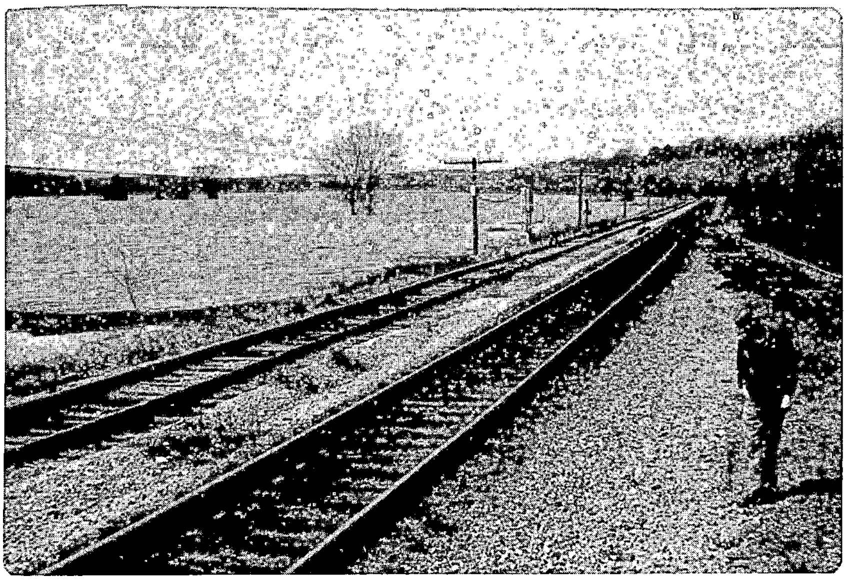
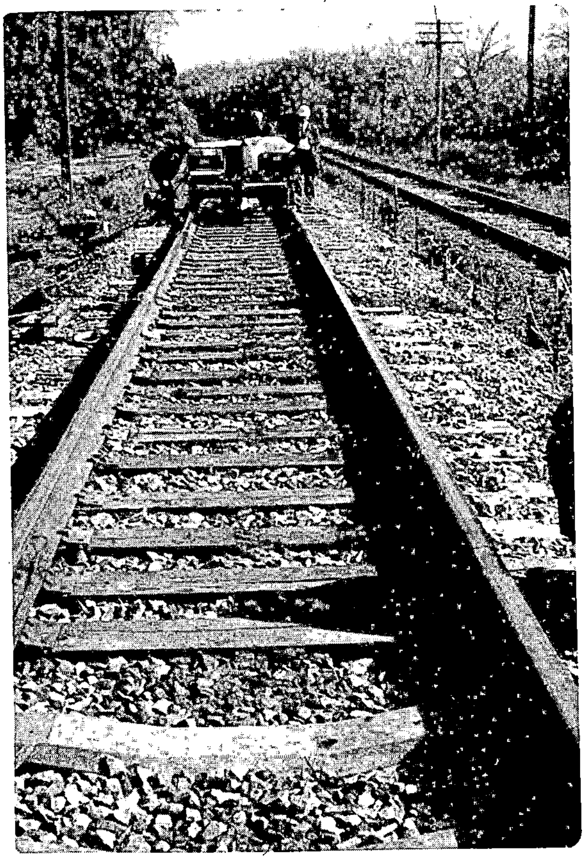


Fig. 2 - TEST TRACK
(Eastern tangent, looking East)



Here, the railroad runs on the northern bank of the James River. Current road and operating characteristics and climatic conditions are as follows:

Gradient	Level
Horizontal Alignment	Straight
Subgrade	Clay and Sand
Ballast	Crushed Limestone
Wood ties (Exc. for the conc. test ties)	7 in. x 9 in. x 8.5 ft.
Wood tie spacing	20 in.
Rail	132 lb. RE, jointed, rolled and laid in 1956
Plates, fasteners	14 in. double shoulder, cut spikes, Woodings anchors
Annual traffic	25 MGT
Operating speed	50 MPH
Annual precipitation	44 inches
Average Temperatures - Annual	58 degrees F.
- January	40 degrees F.
- July	78 degrees F.

1.4 Layout, Construction and Preparation of the Test Panels

The lateral load test was carried out on ten, 39 ft. long (each) track panels in two phases (Fig. 3). The panels were located near the Sabot depot in three separate groups. Within the groups, the number of panels were three-four-three, in that sequence. Since the track is approximately in an East-West direction, we will call the outside three-panel groups Eastern and Western groups referring to their location and also discerning them from the third group in the middle containing four panels.

The panels of the Eastern and Western groups were built similarly. In East-West direction, the first panel contains 22 new wood ties, the second panel 6 new and 16 old wood ties, while the third panel has 17

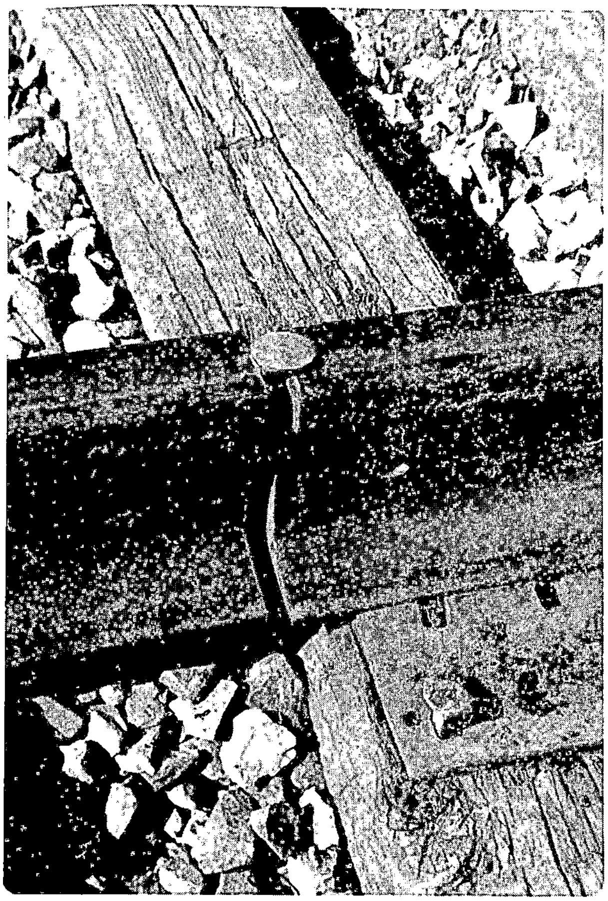
Fig. 3 - TEST LAYOUT AND TESTING PHASES

PANEL NO.	TEST SEQUENCE	PANEL		
		CODE	CONSTRUCTION	PREPARATION
PHASE I				
1	1	A- East	22 New Wood	Two inches raise with additional ballast and tamping
2	2	B- East	16 Old Wood 6 New Wood	
3	3	C- East	17 New Concrete	
4	4	A- West	22 New Wood	Two inches raise with additional ballast tamped and mechanical ballast compaction
5	5	B- West	16 Old Wood 6 New Wood	
6	6	C- West	17 New Concrete	
PHASE II				
1	7	A- East	22 New Wood	Two inches raise with additional ballast and 7 MGT traffic
2	8	B- East	16 Old Wood 6 New Wood	
3	9	C- East	17 New Concrete	
4	10	A- West	22 New Wood	Two inches raise with additional ballast, tamping ballast compaction and 7 MGT traffic
5	11	B- West	16 Old Wood 6 New Wood	
6	12	C- West	17 New Concrete	
7	13	D-1	16 Old Wood 6 New Wood	None (Control Panels)
8	14	E-1	22 Old Wood	
9	15	D-2	16 Old Wood 6 New Wood	
10	16	E-2	22 Old Wood	

concrete ties (Gerwick RT-7 with Pandrol fastener and Fabreka pads) and two wood ties, one at each end of the panel. The middle group consisted of panels with a mixture of new (6) and old (16) wood ties and all old ties two panels of each arrangement in alternate sequence. Rail joints for all of the ten test panels were shifted from the standard staggered position to opposite each other. Before the test began, the joint bars were removed (Figs. 4 and 5) and provision was made to avoid load transfer between panels.

Fig. 4 - REMOVING THE JOINT BARS

Fig. 5 - SEPARATED RAIL JOINTS



Additional ballast was unloaded along the Eastern and Western test panels, then the track was raised by about 2 inches and the ballast was tamped under each tie (Fig. 6, p. 14).

Fig. 6 - TAMPING OF THE TEST PANELS

A runoff (transition) has been made at each end of these groups with the length of about 78 feet to provide a one inch per rail length (39 feet) change in track elevation. The four panels in the middle group have not been tamped to obtain information on settled track condition.

The three panels of the Western groups were subject to further preparation. The ballast between the ties and at the shoulders has been mechanically compacted with a new type of machine, the ballast consolidator (Figs. 7, 8, 9 and 10) in order to increase to a certain degree the mechanical interlocking of ballast particles, which became relatively loose as a result of track raising and tamping operation.

Fig. 7 - FRONT VIEW OF THE BALLAST CONSOLIDATOR

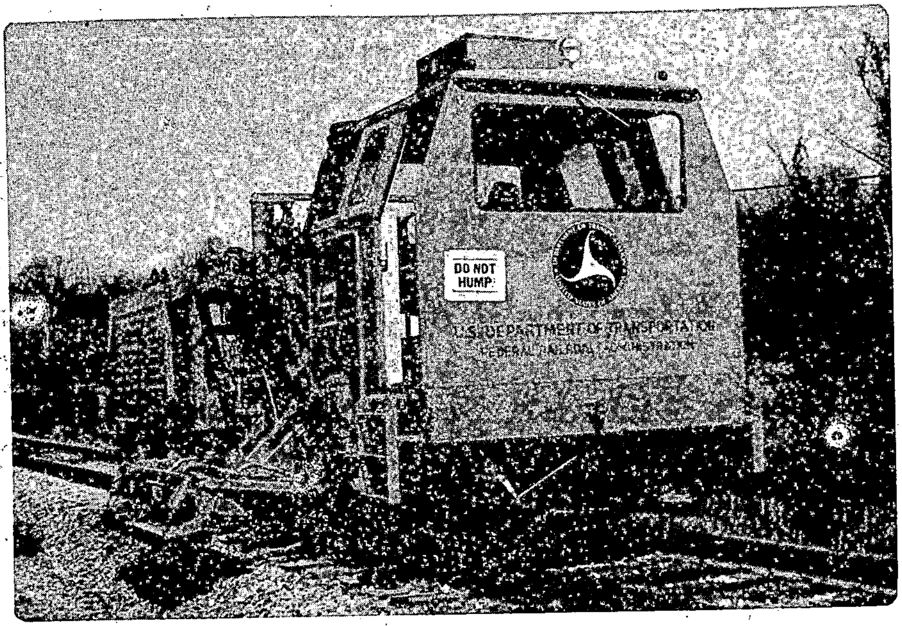


Fig. 8 - SIDE VIEW OF THE COMPACTING HEADS

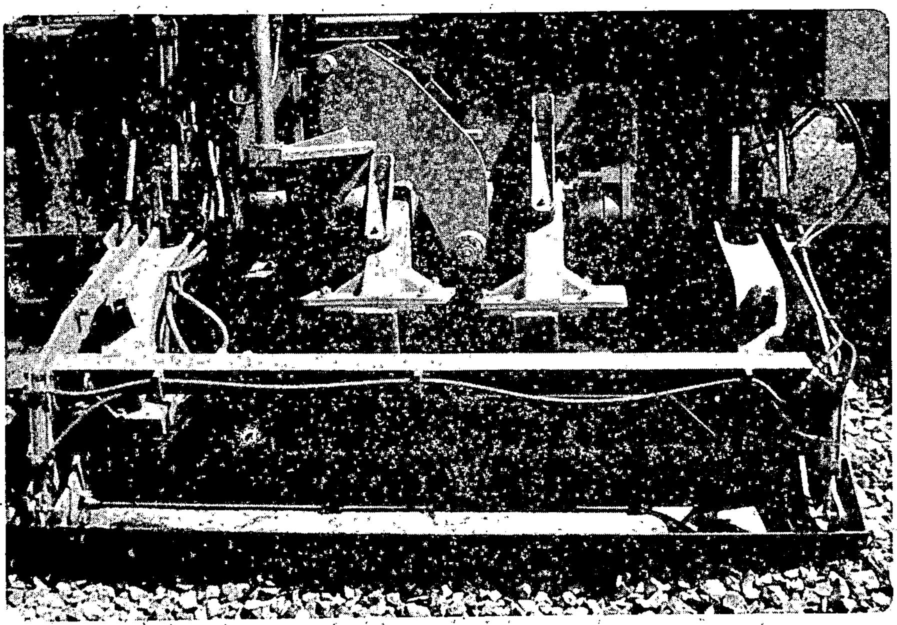


Fig. 9 - REAR VIEW OF THE BALLAST CONSOLIDATOR

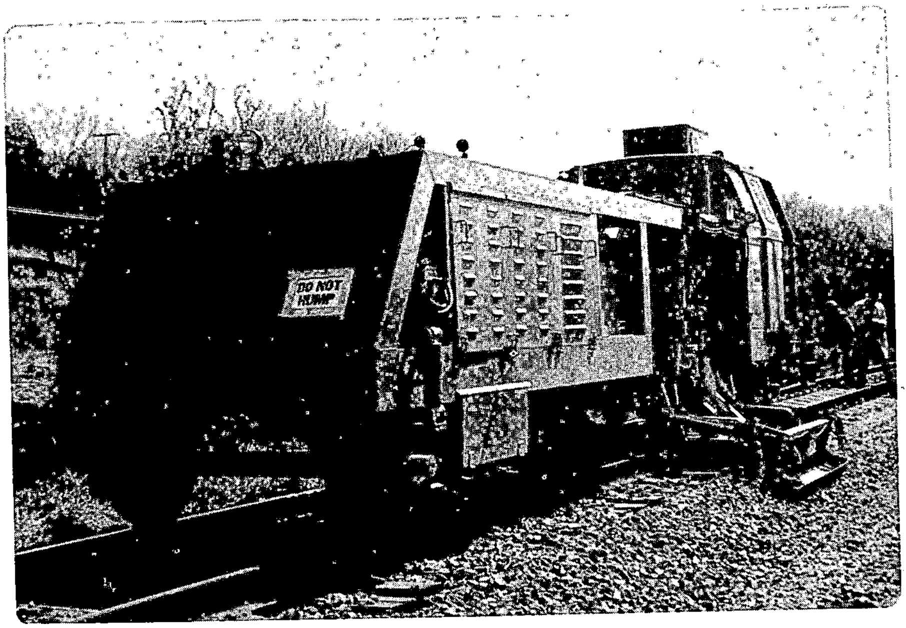
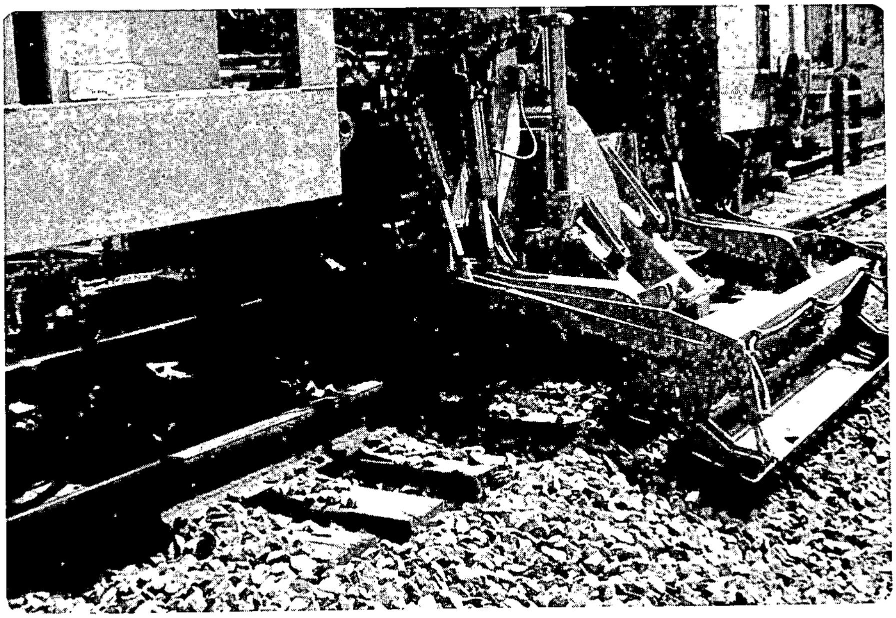


Fig. 10 - CLOSE UP OF THE COMPACTING HEADS



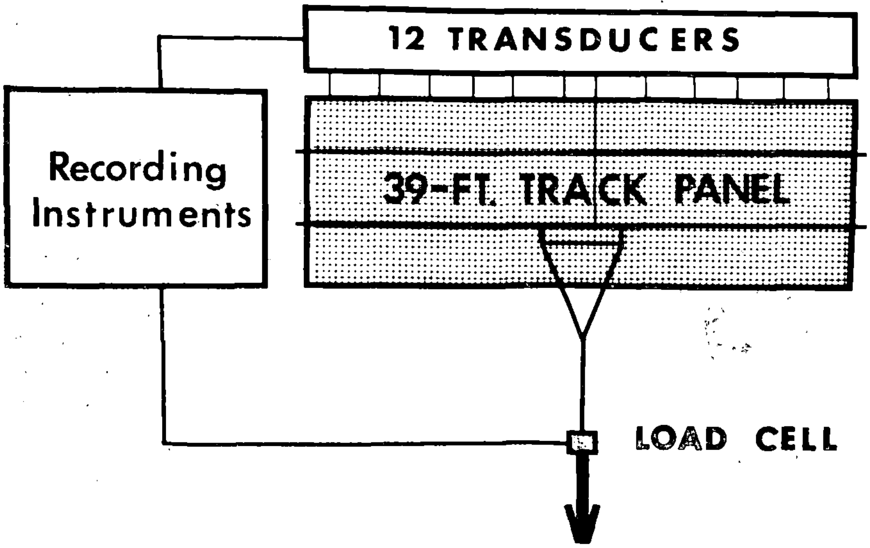
1.5 Test Schedules

The lateral load testing of the prepared track panels was scheduled and carried out in two phases. Some delay was encountered due to the flood of the James River in March, 1975. In the first phase in April, six panels, the Eastern and Western groups, were tested, one at the time. After completing the first phase, the track alignment and surface was restored along the test panels and the track was exposed to the regular traffic for about four months. During this time period, a total of about 7 million gross tons of traffic has been accumulated. In the second testing phase, in August, all ten panels were pulled including the four control panels.

1.6 Data Acquisition

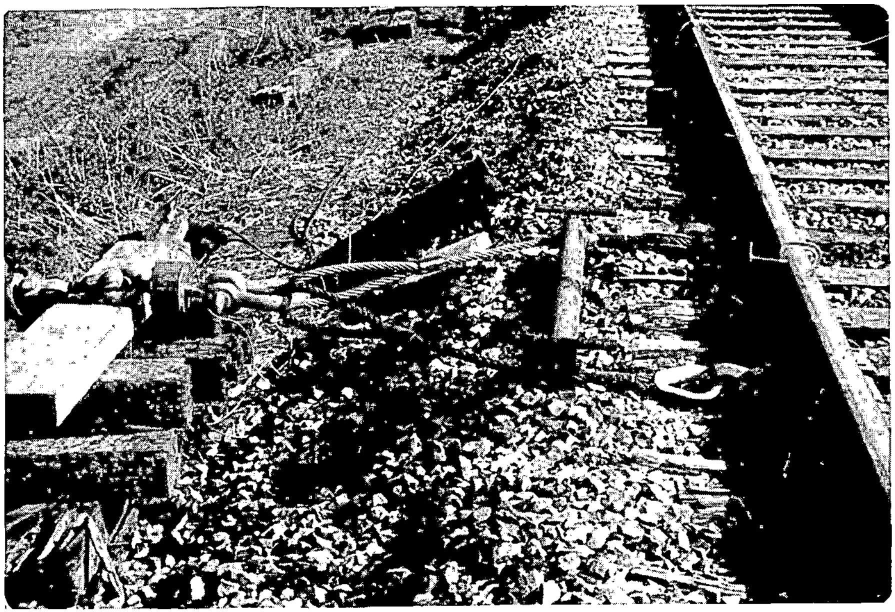
The instrumentation and data recording has been performed by Reaction Instruments as sub-contractor. His task was of selecting/ designing and assembling the hardware capable of exerting the lateral forces to move the track and of continuously measuring and recording these forces as well as the resulting and corresponding displacements. Each track panel, one at the time, was instrumented to produce analog records on stripcharts depicting the lateral force, a displacement on the mid-point of the rail and the movements of ten selected ties along the panel (Fig. 11, p. 18 and Appendix A, pages 58-62).

Fig. 11 - THE SCHEME OF INSTRUMENTATION



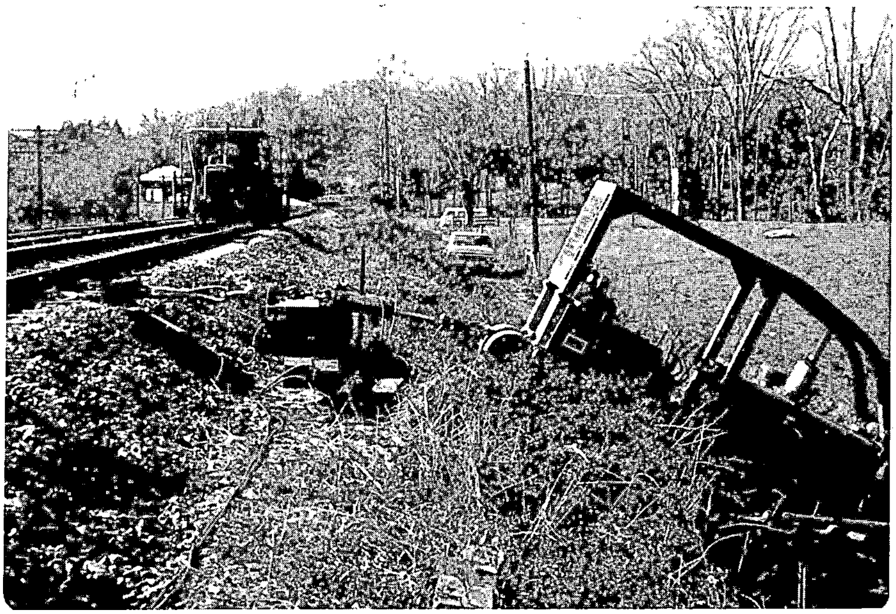
The lateral force, generated by hydraulics, was applied at two points on the rail base, 5 ft. apart, symmetrically located to the centerline of the panel through a 5 ft. low bridle (Fig. 12).

Fig. 12 - THE LOAD CELL (ON THE LEFT) AND
THE BRIDLE (ON THE RIGHT)



The purpose of load-splitting was to simulate the actual load transfer of a standard two-axle truck. The bridle was cable-connected to an axial strain gage load cell, then in line to a double acting hydraulic cylinder with 15 inch stroke. At the other end of the cable, a firmly anchored bulldozer (Model D9 Caterpillar) provided the reaction force (Fig. 13).

Fig. 13 - FORCE APPLICATION SHOWN FROM LEFT TO RIGHT: TRACK, BRIDLE, LOAD CELL, HYDRAULIC JACK AND BULLDOZER



A double acting hydraulic system applying an electrically driven gear pump and a hand pump was used to energize the hydraulic cylinder and exert the load. A strain gage load cell measured the load. The output of the load cell was amplified and passed through a signal conditioning chassis, which converted the load cell output into a voltage signal.

The movements of the rail and of the selected ties were measured by displacement transducers attached to metal posts driven into the subgrade along the panel (Figs. 14, 15 and 16).

Fig. 14 - CONNECTING THE TRANSDUCERS TO THE CONCRETE TIES

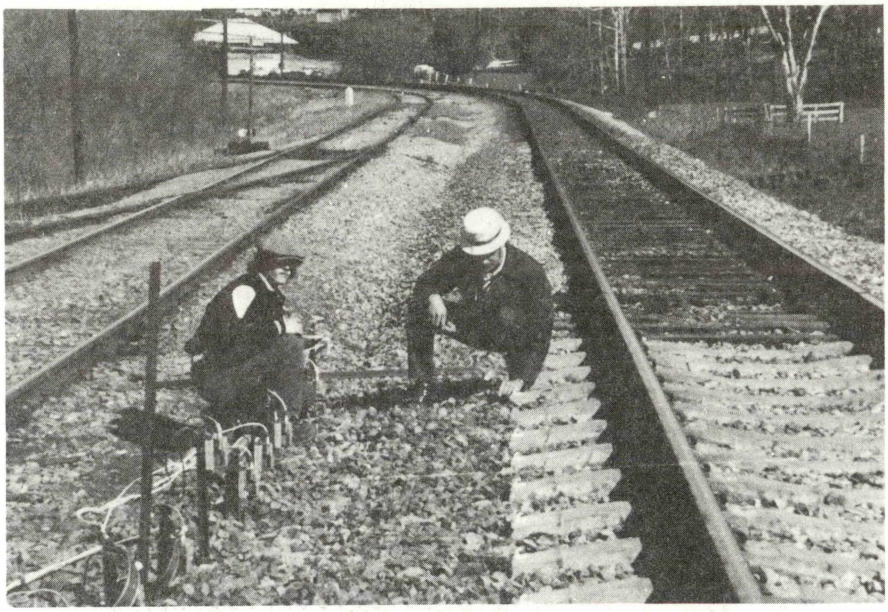


Fig. 15 - DISPLACEMENT TRANSDUCERS, INSTALLED

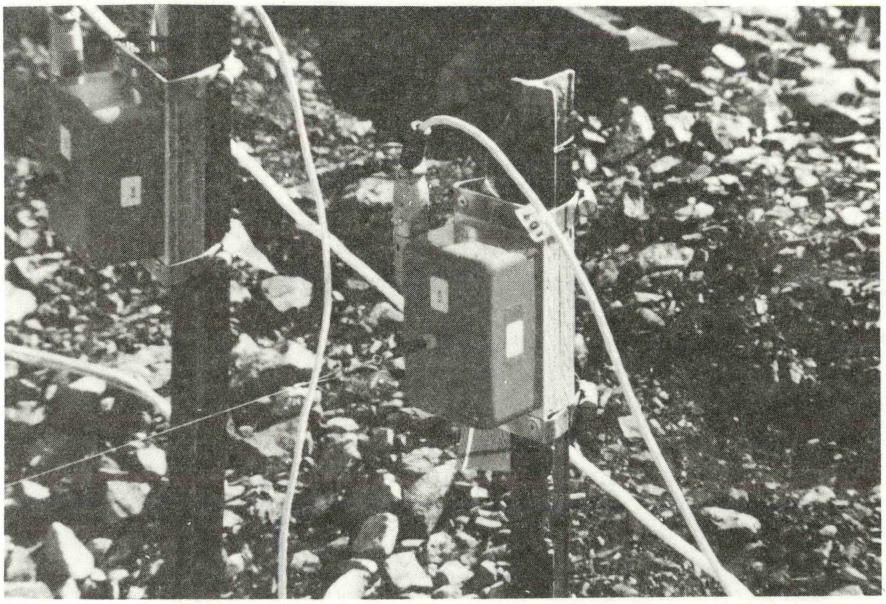
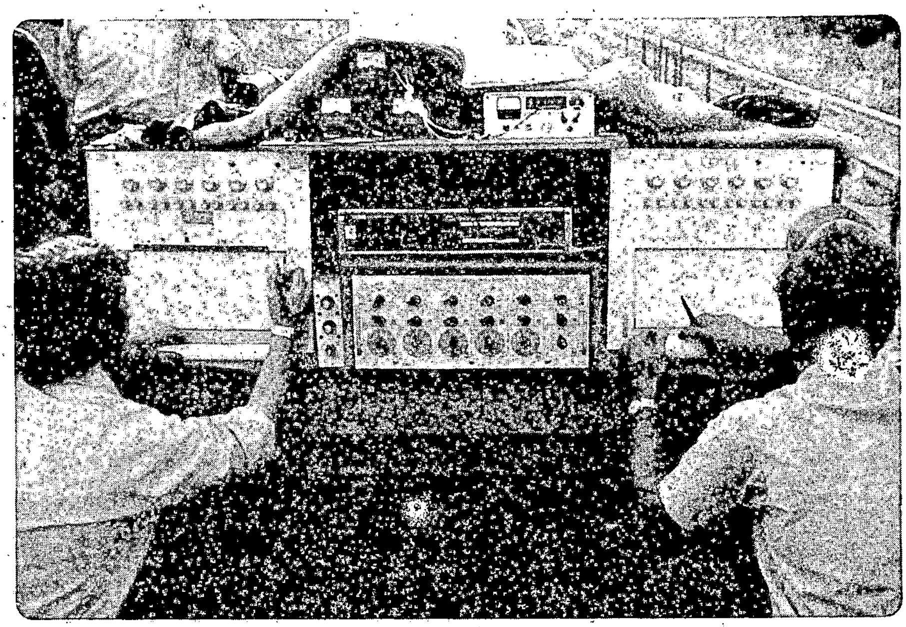


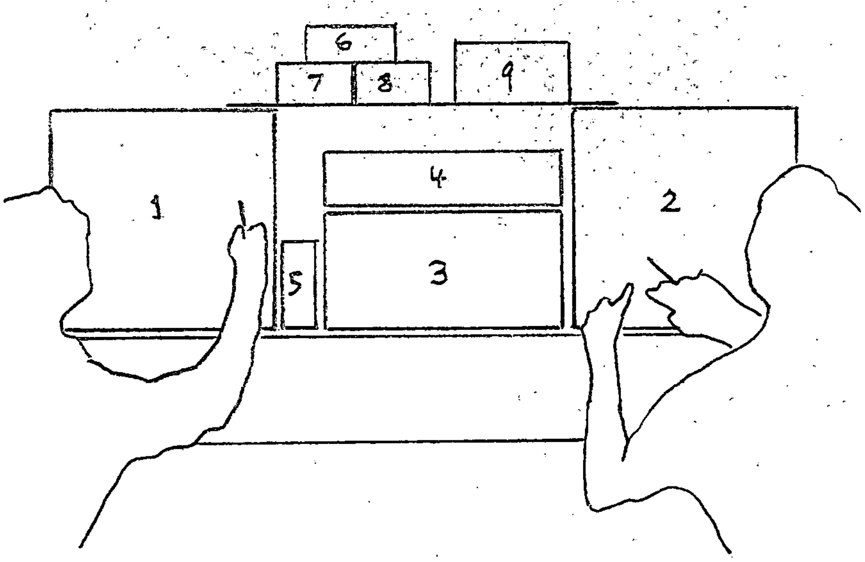
Fig. 16 - CONCRETE TIES WIRE-CONNECTED WITH THE DISPLACEMENT TRANSDUCERS

All electronic signals generated by the displacement transducers and the load cell were recorded on two, six-channel each, analog strip chart recorders whose channel sensitivities have been set in accordance with the scale factors of the load cell and transducers (Fig. 17, p. 22). (More details about the instrumentation are in Appendix A on pages 49-51).

In operation (Fig. 18, p. 23), the hydraulic cylinder was gradually pressurized to increase the lateral load on the track panel. Loads and displacements, then, were simultaneously and continuously recorded

Fig. 17 - INSTRUMENTS IN OPERATION





1, 2 --- Six-Channel Brush Recorders
3 --- Signal Conditioner
4 --- Digital Voltmeter
5 --- Load Cell Amplifier
6, 7, 8, 9 --- Power Supply

Fig. 18 - PULLING THE TRACK PANEL

on the strip charts. After the track panel yielded (motion without force increment or with force decrement), the hydraulic cylinder was depressurized and the test was terminated for that panel. Two of the displaced track panels are shown in Figs. 19.1 and 19.2 (p. 24), after they yielded under the exposure of lateral forces during the first phase of the test procedure.

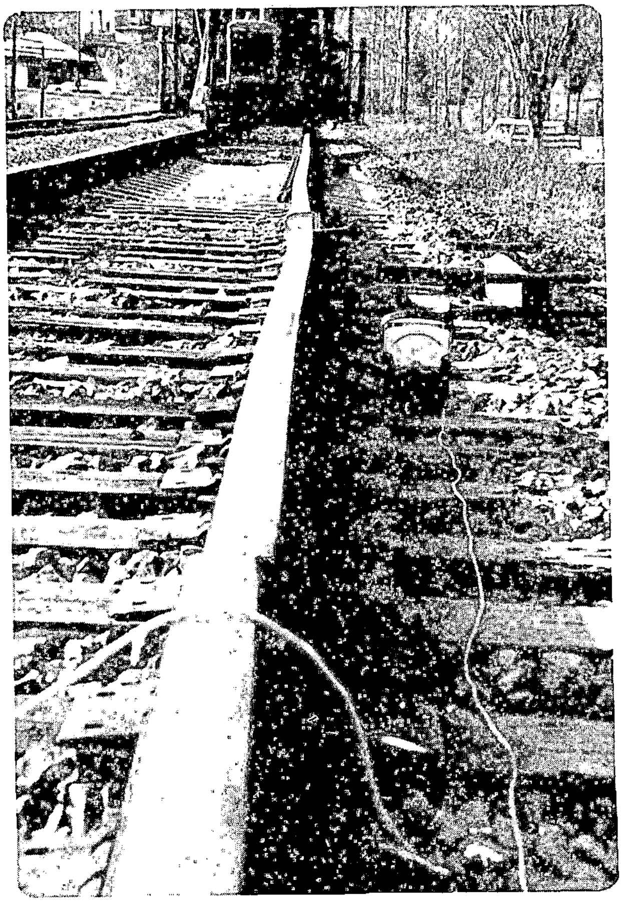


FIG. 19.1 - DISPLACED WOOD TIE PANEL

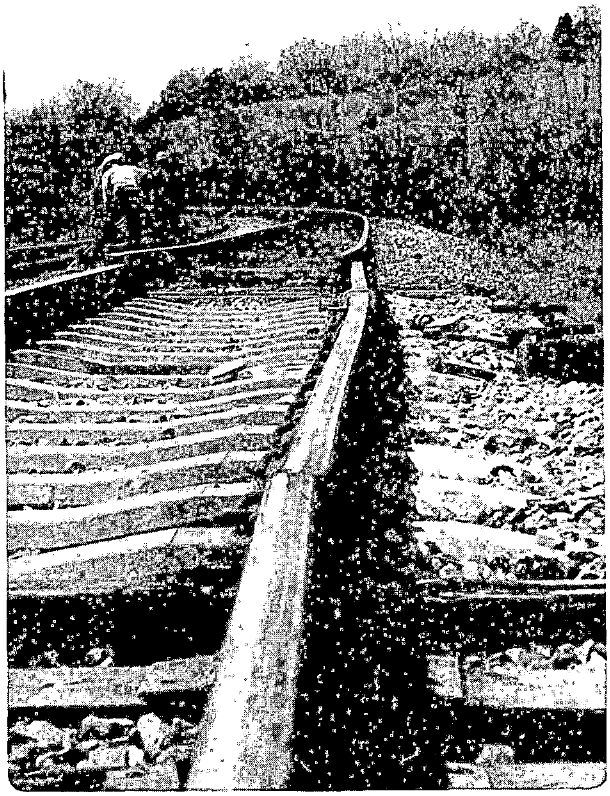


FIG. 19.2 - DISPLACED CONCRETE TIE PANEL

2 - RESULTS IN BRIEF

The test results verified the earlier findings [5], [6] that there are substantial differences in lateral track resistance (Figs. 20.1, and 20.2, p.26). As we mentioned, part of the reasons for these findings are the different physical characteristics of track structures. Lateral track resistance also varies with time on the same track. An example for the time dependency of lateral resistance is its lower value observed after track raising and tamping and its higher value later on during the service. Furthermore, the Sabot test <u>furnished quantitative answers</u> to the questions listed in the "Project Objectives" on page 7. Based on the yield forces:

(1) The difference in lateral resistance between concrete and wood tie track on partially settled track is about 16 per cent in favor of the concrete ties.

(2) Track raising and tamping operation reduces lateral track resistance from a well settled level (100%) to about 40%, measured on the same scale.

(3) Mechanical ballast compaction applied immediately after track raising and tamping operation restores part of the lateral resistance by increasing it from the 40% level up to a 46% level.

(4) Traffic exposure of three months totalling about 7 million gross tons without mechanical compaction increases lateral track resistance from the 40% level up to a 49% level.

Figs. 20.1 and 20.2 - YIELD FORCES AND DISPLACEMENTS AS A FUNCTION OF TRACK PREPARATION

Fig. 20.1 - BY GROUP OF THREE PANELS

Group and Phase	Track Preparation		Yield Force (lbs.)	Displacement (in)	
	Code	Description		At Yield Fce.	At 12,000 lbs.
			Average Per Group		
East, I	S(1)	Freshly Tamped	13,700	1.72	1.00
West, I	S(2)	Compacted After Tamping	16,100	1.13	0.24
East, II	S(3)	Exposed to 7 MGT of Traffic After Tamping	16,900	0.97	0.15
West, II	S(4)	Compacted and Trafficked (7MGT) After Tamping	16,300	0.65	0.15

Fig. 20.2 - BY TYPE OF CROSSTIE

Group and Phase	Code of* Track Preparation	Yield Force (lbs)		Displacement (in) at Yield Force		Displacement (in) At 12,000 lbs.	
		Wood	Concrete	Wood	Concrete	Wood	Concrete
East, I	S(1)	13,000	15,100	1.64	1.88	1.16	0.70
West, I	S(2)	14,250	20,000	0.78	1.84	0.33	0.12
East, II	S(3)	16,100	18,500	0.82	1.29	0.20	0.19
West, II	S(4)	16,750	15,400	0.33	1.25	0.08	0.06

* Code of Track Preparation is the same as for Fig. 20.1

In addition, panels constructed with all new wood ties exhibited lower lateral resistance than panels containing mostly old wood ties under similar conditions of ballast.

The lateral resistance of track as a function of ballast settlement for the full range of force levels is displayed on Fig. 21 (p. 28), where the force/displacement curves (FD curves) represent the average behavior of panels in each category, including two wood tie panels and one concrete tie panel in the "freshly tamped", "compacted" and "trafficked" groups and four wood tie panels in the "control panels" group. The intersections of the FD curves with the 12,000 lb. force line (the lowest yield force found was 12,000 lbs.), which represent the corresponding track displacements at that force level, indicate a wide range of track stiffness values between the "freshly tamped" and "settled" conditions.

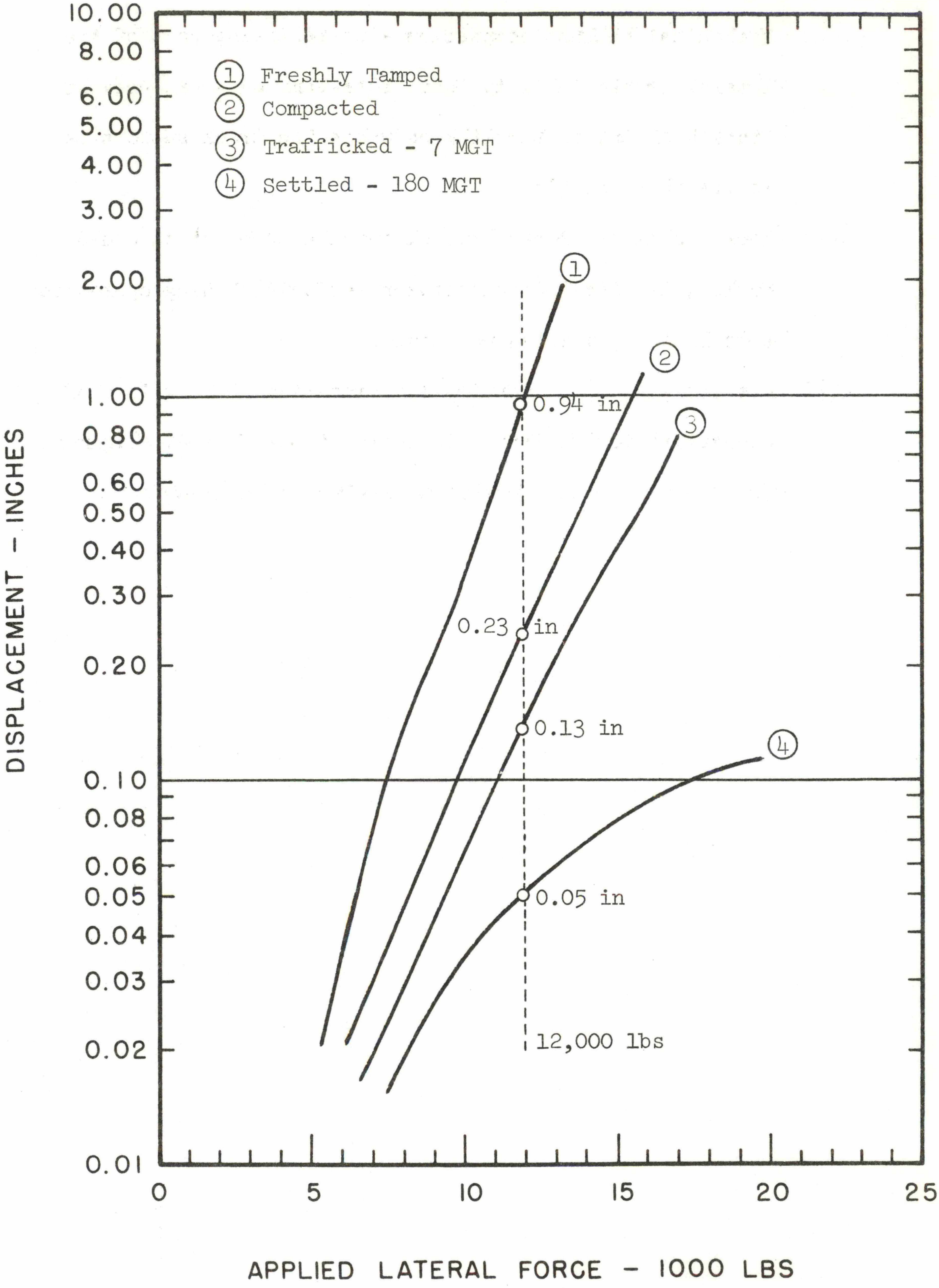
The results can be accepted with the reservation of the following things:

(1) They are valid only within the conditions either prevailing at Sabot or prepared for this specific test.

(2) The findings with regard to the resistance of concrete tie tracks are confined to cases when the ballast is partially settled.

(3) Because of the small number of panels tested at Sabot, and the relatively broad scatter found in resistance values, it appears that the data obtained do not lend themselves for multiple correlation analyses with the aim of determining the various components of the total panel resistance.

Fig. 21 - FORCE/DISPLACEMENT CURVES BY BALLAST PREPARATION



Conclusions Regarding the Ballast Consolidator

Based on the test results, it appears that the use of ballast consolidator has some benefits. These are:

(1) Mechanical ballast compaction - by restoring part of the lateral track stability lost after tamping - can prevent track buckling in territories where the track support is inherently unstable.

(2) There is also a reason to believe that compaction could prolong the time period between surfacing/lining operations, thus reducing maintenance costs.

(3) Finally, it can be assumed that localized peak values of irregularities occurring in the horizontal track alignment would be lower as a result of ballast consolidation.

Fig. 22 - SUMMARY OF RESULTS

Track Panel Designation		Displacement (in) At Force (K lbs.)		Yield Force (K lbs)	Displacement (in) At Yield Force	Maximum Force (K lbs)	Maximum Displacement (in)
		12	15				
PHASE I (COMPLETED IN APRIL, 1975)							
East	A	1.74	-	12.00	1.74	12.00	2.29
	B	0.59	-	14.00	1.53	14.00	3.00
	C	0.70	1.88	15.10	1.88	15.10	2.12
West	A*	0.36	-	13.50	0.63	13.50	2.37
	B*	0.29	0.94	15.00	0.94	15.00	1.82
	C*	0.12	0.33	20.00	1.84	20.00	2.05
PHASE II (COMPLETED IN AUGUST, 1975)							
East	A	0.20	0.47	15.00	0.77	15.00	2.10
	B	0.19	0.35	17.00	0.87	17.00	2.30
	C	0.06	0.20	18.50	1.29	18,50	2.13
	D1	0.03	0.05	Yield Forces Have Not Been Reached When Testing The Control Panels		27.00	0.48
	E1	0.02	0.03			26.00	0.10
	D2	0.09	0.11			26.00	0.22
	E2	0.08	0.11			28.50	0.31
West	A	0.11	0.20	16.00	0.25	16.00	1.00
	B	0.06	0.11	17.50	0.42	17.50	1.92
	C	0.29	1.10	15.40	1.28	15.40	2.80

* Track Panels Tested Immediately After Ballast Compaction.

3 - DISCUSSION OF THE RESULTS

3.1 Summary of the Results

The analog records of forces and displacements on the strip charts were identified and manually digitized* for each panel. The numerical data obtained are in Appendix D, on pages 80-101 . The summary of the measurements is tabulated in Fig. 22. The data obtained during testing Phase I for six panels are shown on the upper part. The results of testing Phase II, carried out four months later on the same six track panels, and also the data of the four control panels, are on the lower part of the figure. In addition to the measured yield forces and yield displacements, Fig. 22 contains other data too; such as, track displacements at the middle of the panel at selected force levels (12K and 15K). These displacements readily indicate the flexibility of the corresponding panel (or their reciprocals show the stiffness of the panel). The 12K and 15K force levels represent the minimum yield forces found for the freshly tamped, and for the trafficked (7 MGT after tamping) panels, in that order. The measured yield forces and displacements by panel are graphically shown in Figs. 23 and 24, (pages 32 and 33).

3.2 Concrete Ties vs. Wood Ties

A generally higher resistance was observed for concrete tie panels than for wood tie panels at all force levels as it is indicated on Fig. 25 (pg. 34). This shows the complete band of force/displacement

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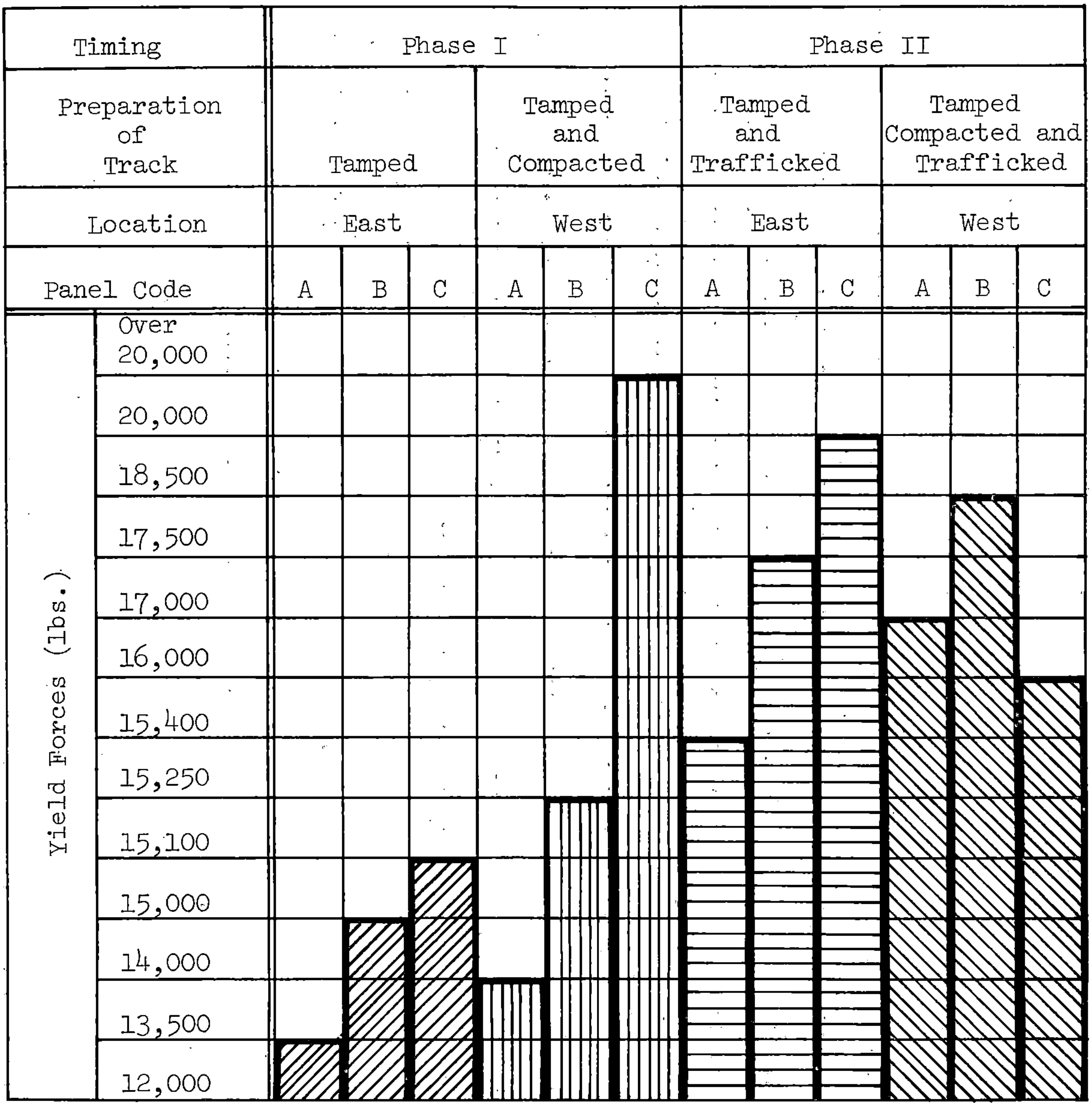
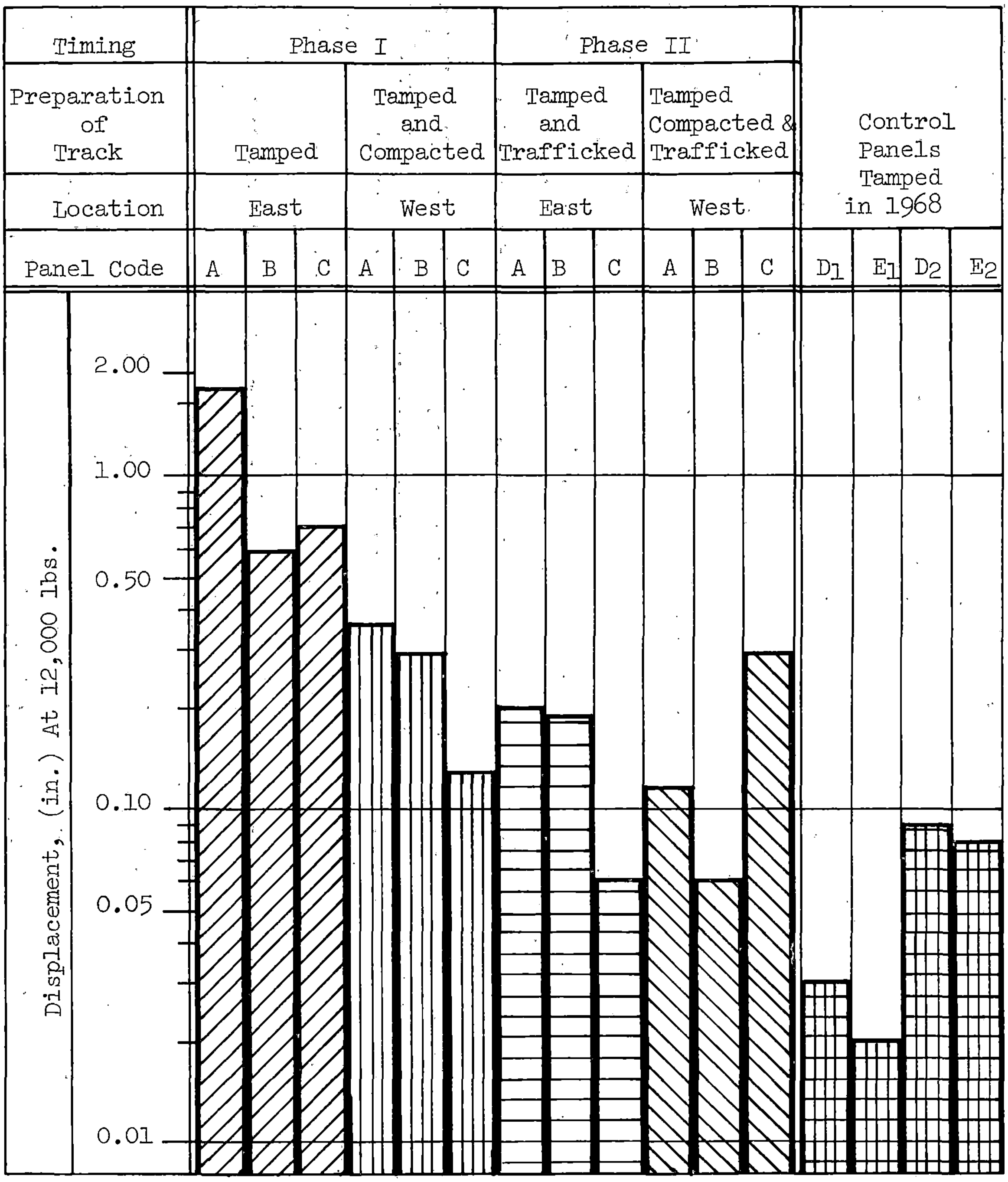
* A 12-bit digital data acquisition system was rejected by the subcontractor on the grounds of high price and lack of portability.

Fig. 23 - YIELD FORCES BY PANEL*



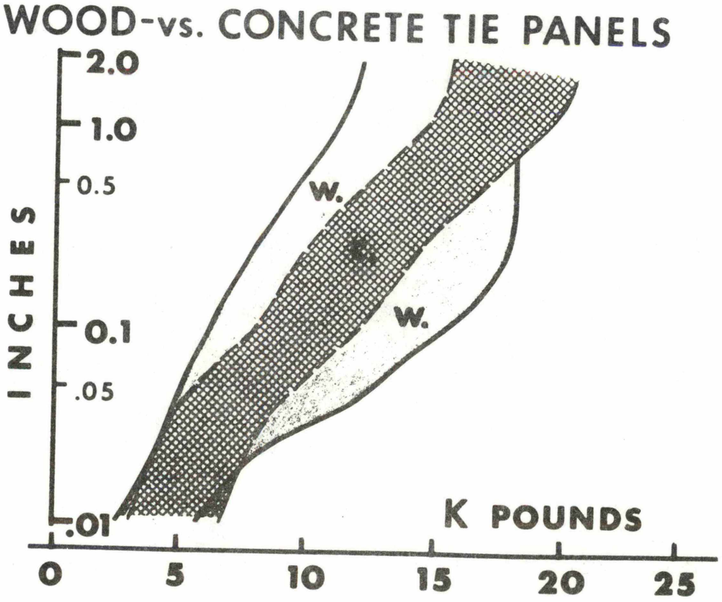
* The four control panels are not included.

Fig. 24 - DISPLACEMENTS BY PANEL AT SELECTED FORCE LEVEL



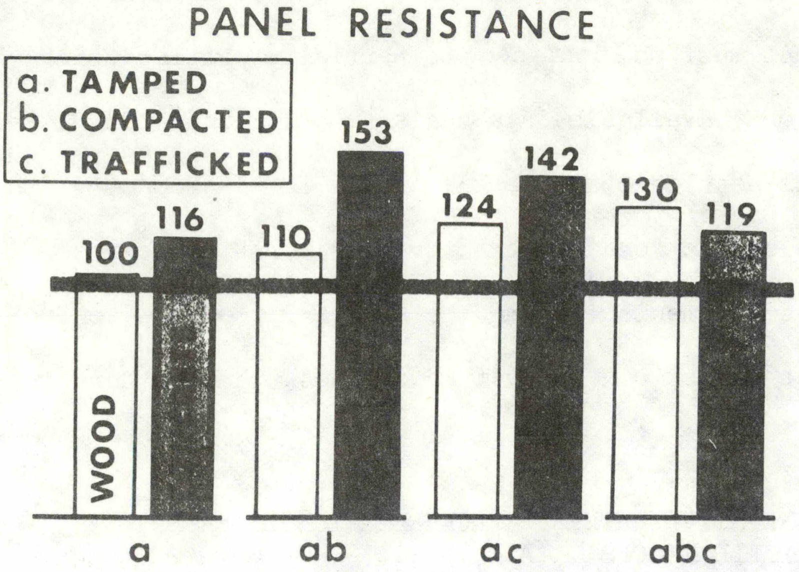
(or FD) curves by type of crosstie, including the six test panels and both testing phases. The narrower inner band - outlined with dashed lines and marked with C - represented the range of FD curves obtained for concrete tie panels, while the other, wider band marked with W on each side, is the measured range of wood tie track resistance. As the band width of FD curves is narrower for concrete ties than for wood ties, one may conclude that concrete tie tracks are less susceptible (thus less vulnerable) to changes in lateral stability caused by certain maintenance activities such as track raising and tamping, than wood ties are. Concrete tie tracks may have a somewhat higher degree of permanence than wood tie tracks. It can also be seen in Fig. 25 when comparing the left-hand side boundaries of the FD curves, that wood tie tracks have a lower value of minimum-resistance than concrete tie tracks.

Fig. 25 - THE RANGE OF FORCE/DISPLACEMENT CURVES BY TYPE OF CROSSTIE
(Control Panels Excluded)



Concrete tie panels gave proof of higher ultimate resistance in three out of the four test series conducted, each with different ballast preparation as it can be depicted on Fig. 26.

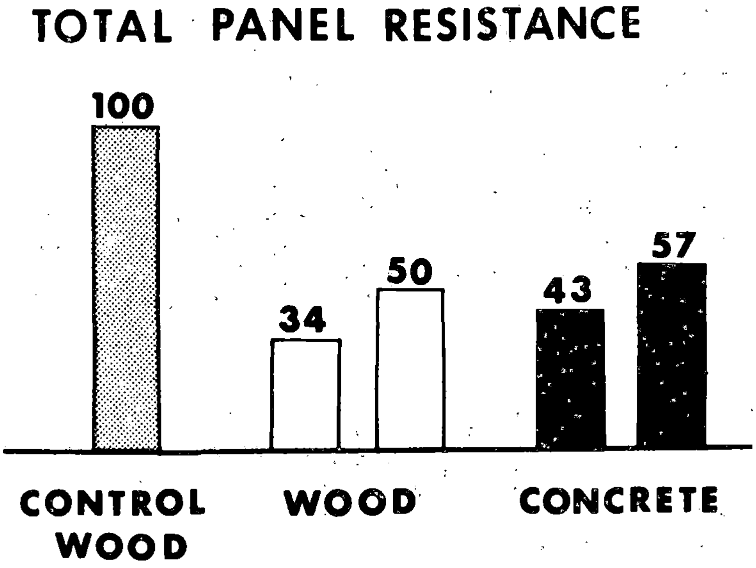
Fig. 26 - RELATIVE TRACK RESISTANCE VALUES BY BALLAST PREPARATION AND TYPE OF CROSSTIE BASED ON YIELD FORCES (Control Panels Excluded)



Each of the four groups (a, ab, ac and abc) representing a different ballast preparation, shows the resistance of panels in terms of relative yield forces. Note that the numbers indicating the wood tie tracks are the average values of two wood tie panels. The relative resistance values shown on the figure look reasonable with the exception of the resistance of the concrete tie panel in the last (abc) group. This figure (119) indicates a lower value of lateral resistance after 7 MGT traffic exposure than without traffic (153) for the same panel. This decrease in lateral resistance can perhaps be explained by the hot weather prior to and during the second phase of the test which may have resulted in - by local concentration of longitudinal compressive rail forces - a minor sunkink, which created voids in the ballast along this panel before testing.

Although the Sabot test results confirmed that concrete tie track is more stable in the lateral direction than wood tie track, this statement must be confined to partially settled tracks since this is the only available data basis. Until conducting lateral load tests on well settled concrete tie tracks in this country, their ultimate resistance remains unknown. The relative degrees or percentages of settlements (taking the settlement of the control panels as 100) for the test panels by type of crosstie are shown in Fig. 27.

Fig. 27 - RELATIVE LATERAL TRACK RESISTANCES BASED ON YIELD FORCES (All Panels)

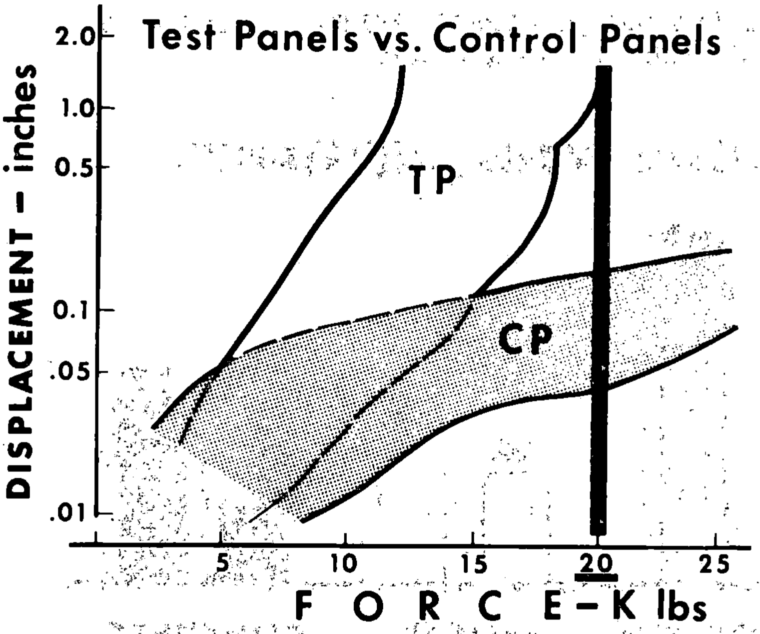


The percentages of settlements depict lows and highs and are in direct proportion to the measured yield forces on the six test panels. A yielding force of 35,000 lbs. was hypothesized for the well settled control panels. Based on this assumption and using a 100 point scale, when the control panels are set at 100 it appears that the settlement was between 34 and 50 for the wood tie tracks and between 43 and 57 for the concrete tie tracks.

3.3 The Effect of Track Preparation on the Lateral Track Resistance

The higher lateral resistance of the control panels at all force levels is demonstrated on Fig. 28.

Fig. 28 - THE RANGE OF FORCE/DISPLACEMENT CURVES
(For All Panels)



All of the FD curves obtained for the six test panels, each measured twice (Phase I and Phase II), are within the upper band marked with TP. Similarly, the lower, cross-hatched band marked with CP represents the control panels. As this figure indicates, track displacements of 0.1 inch and higher shown are associated with much lower forces applied on the test panels (TP) than on the control panels (CP). Consequently, the same forces resulted in greater displacements in the test panels. This phenomenon becomes more obvious at higher force levels as manifested by the vertical line at 20K force, which was the highest yield force reached on the test panels. Accordingly, the stiffest test panel moved about 2 inches at this force, while the displacement on the control panels was apparently restricted to rail-on-tie movement in the range from a few hundredth of an inch to about little over one-tenth of an inch.

Fig. 29 - MECHANICAL BALLAST COMPACTION IMPROVES STABILITY

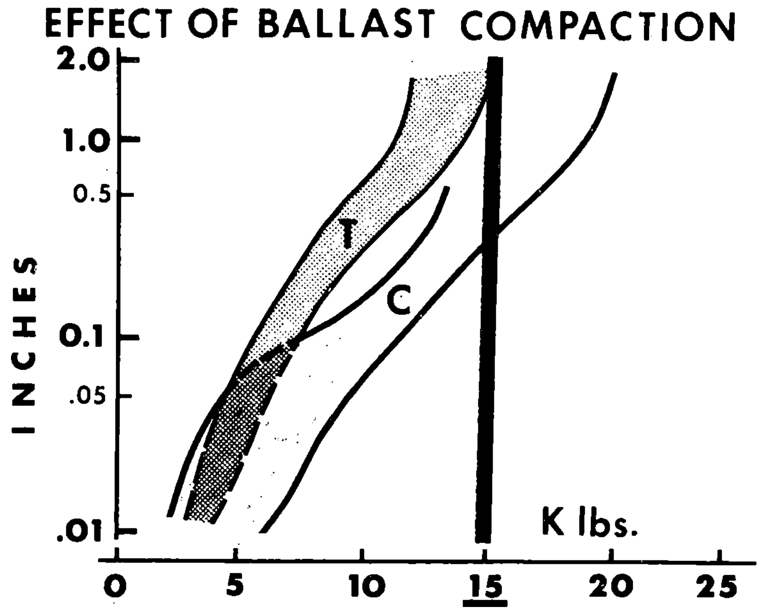


Figure 29 renders the immediate effect of mechanical ballast compaction. The two bands of FD curves shown marked with T and C represent the data obtained for "freshly tamped" and "freshly tamped and immediately compacted" conditions in that order. (Each band includes the data of three panels). The shift of band C relative to band T indicates the gain in lateral resistance followed by mechanical ballast compaction. Also, it can be seen that at 15K lateral force, which was the maximum yield force with 2 inches displacement for the freshly tamped panels, the compacted panels moved less than one-half of an inch.

Panels where the ballast was not compacted mechanically after tamping but, instead, the track has been exposed to traffic for a period of three months accumulating about 7 million gross tons over that period, also exhibited an increase of lateral resistance (Fig. 30, p. 40). The combined effect of mechanical ballast compaction and 7 MGT of traffic was nearly the same as their singular effect on the lateral resistance of track (Fig. 31, p.41). More details about the effects of various track panel preparations on the lateral resistance of track are in Appendix C, pages 68-76 .

Fig. 30 - THE EFFECT OF TRAFFIC

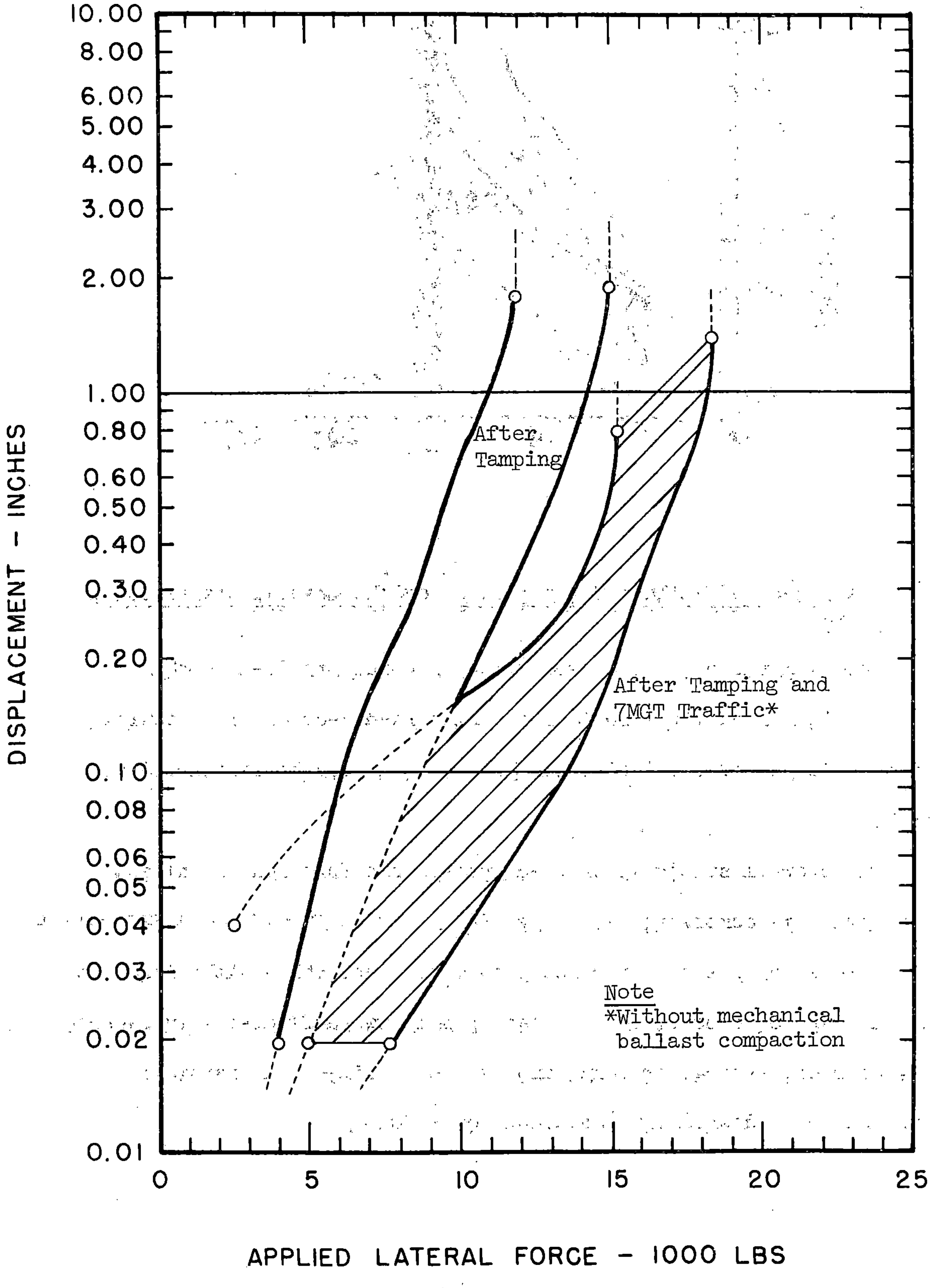
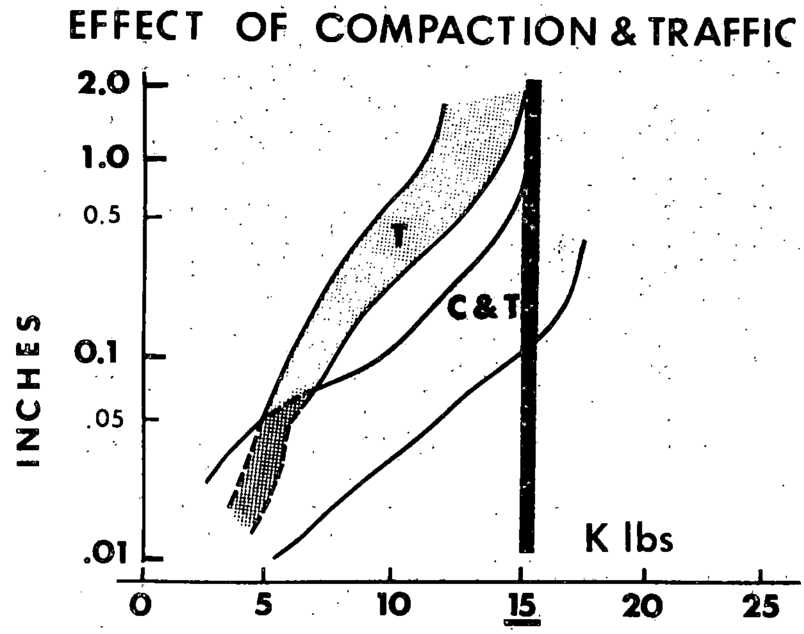


Fig. 31 - THE COMBINED EFFECT OF MECHANICAL BALLAST COMPACTION AND TRAFFIC INCREASES LATERAL RESISTANCE

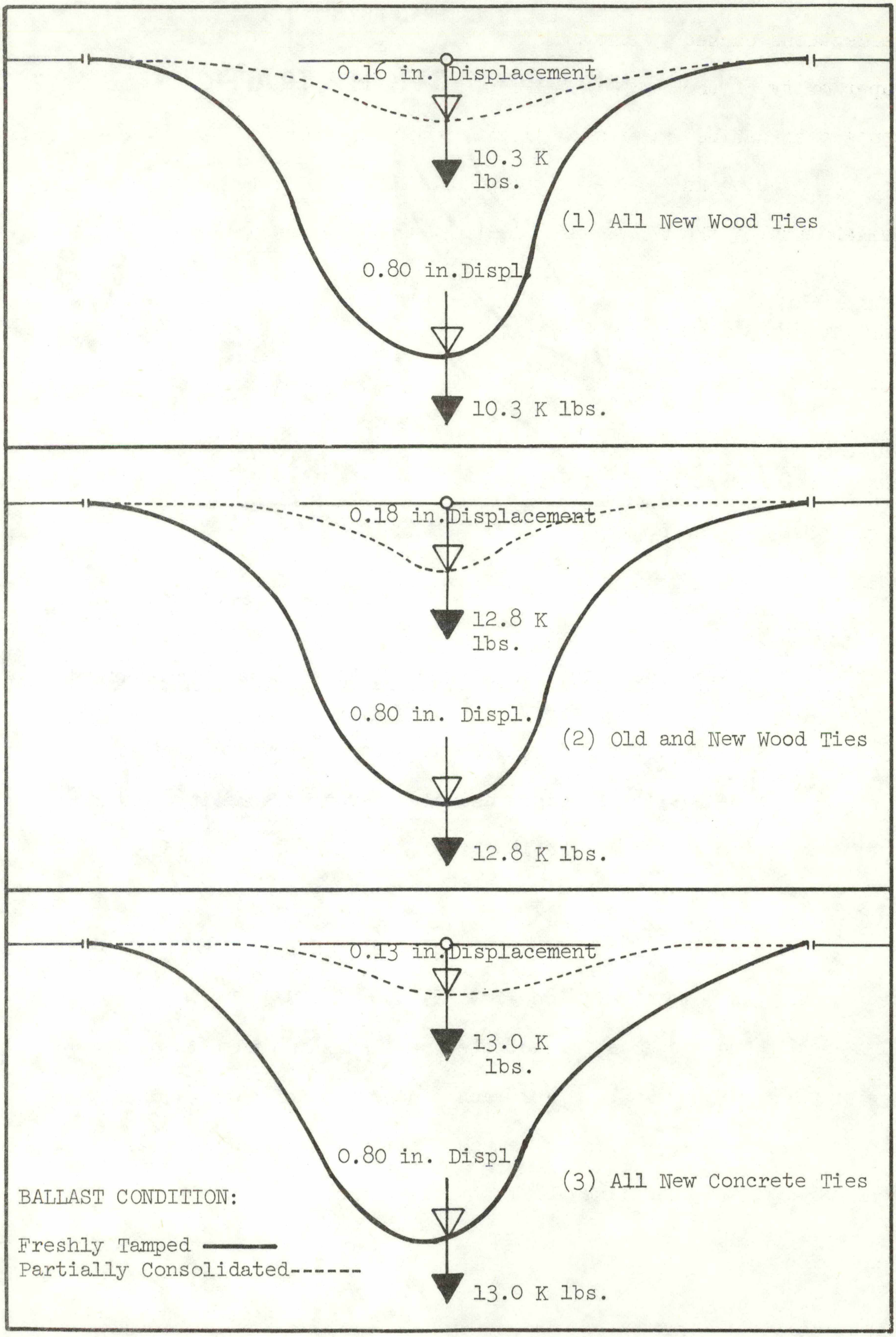


3.4 The Effect of Ballast Consolidation on the Lateral Displacement Curve

The analysis of track displacement records provided further verification of earlier findings and also revealed some interesting characteristics of the deflection lines, which may be considered as novel.

The overall stiffness of track panel as a function of ballast preparation is demonstrated on Fig. 32, p.42. Three pairs of deflection lines are shown prepared for selected panels assembled with different age and type of crossties. For each panel, two deflection lines were plotted representing "freshly tamped" (solid line) and "partially consolidated" (dashed line) ballast conditions.

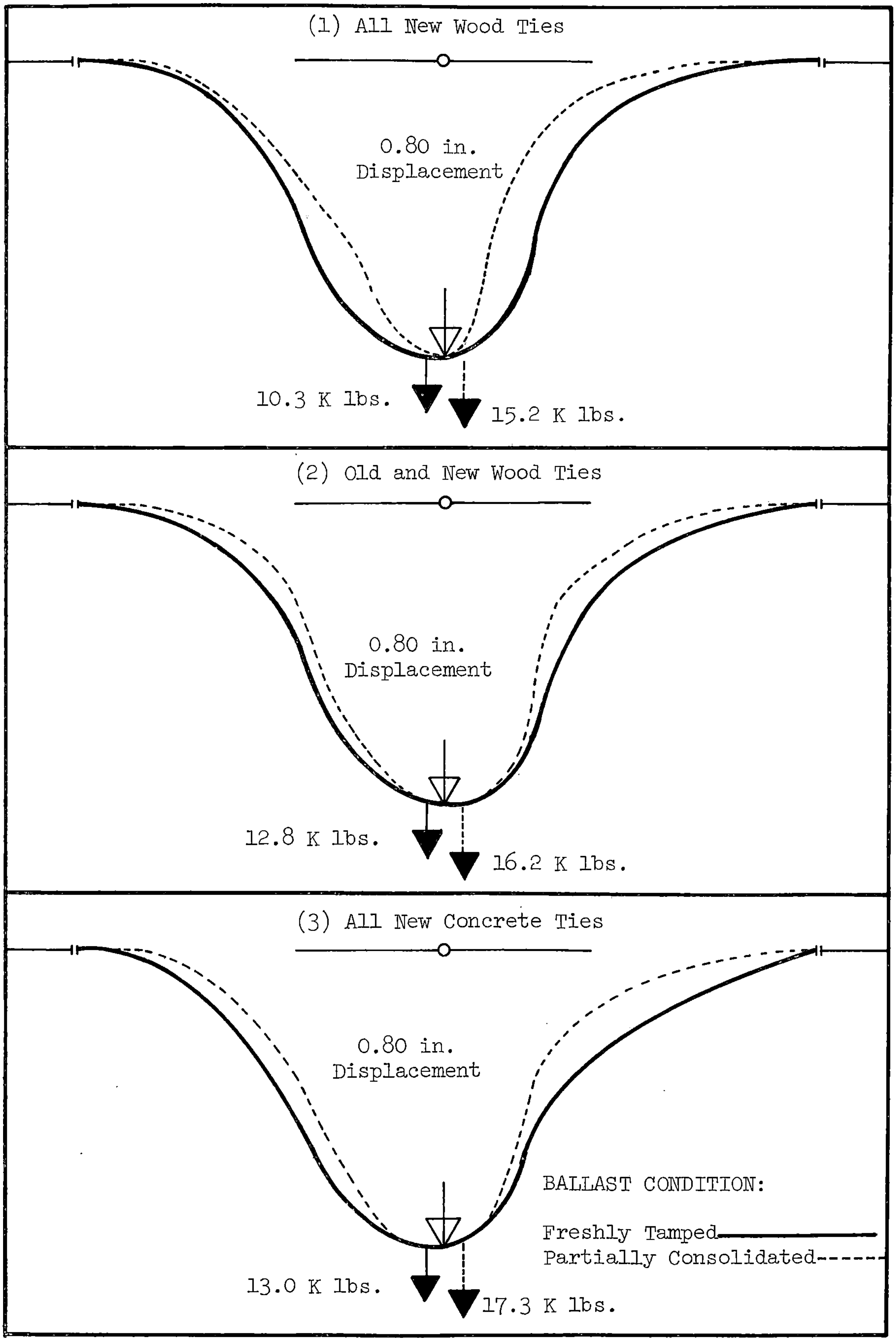
Fig. 32 - THE EFFECT OF BALLAST CONSOLIDATION ON LATERAL TRACK DISPLACEMENT.



The figure indicates striking differences between track deflections caused by the same lateral force, emphasizing the superiority of the more consolidated ballast. Although the same conclusion can be drawn by analyzing the yield forces, the displacement data being in tune with the yield force measurements attest the reliability of the measurement technique and its results as well.

Figure 33, p.44, displays the characteristic differences found in the shape of the displacement curves. It appears that the sharper curvature of the displacement curve is a corollary of the increased ballast resistance provided by its higher degree of settlement. The resulting increment in rail bending moment could be, along with the higher ballast resistance, a contributing factor to the greater overall resistance of the track panel.

Fig. 33 - THE EFFECT OF BALLAST CONSOLIDATION ON THE SHAPE OF LATERAL DISPLACEMENT CURVE.



APPENDIX A

DETAILED DESCRIPTION OF THE DATA ACQUISITION SYSTEM

Detailed Description of the Data Acquisition System

Meet Demand, Specifications [7]

The demands on measurement and recording equipment for the Sabot test expressed during the preliminary meetings and discussions in 1973 with the participation of sponsor, contractor and subcontractor were as follows:

(1) Medium to high resolution:
  - 100 lbs. of measuring forces
  - 0.01 in. for displacements at the middle section of the panel
  - 0.001 in. for displacements at the end sections of the panel

(2) Wide range:
  - up to 80,000 lbs.
  - up to 4 in. at the mid-section of the panel
  - up to 2 in. at the end sections of the panel

(3) Medium (1%) accuracy

(4) Accommodate temperature ranges between 35°F and 95°F.

(5) Portability, simplicity and moderate cost.

Digital systems were immediately rejected because of their high cost and lack of portability. Finally, an analog system using very stable transducers and voltage summing networks was chosen. It was felt that, by careful design, all the objectives listed above could be met. (Figs. 34, 35, 36 and 37, pp. 53, 54, 55 and 56).

The outputs from the measurement devices were scaled to provide desired scale factors and fed into summing amplifiers which provided a gain of (-1000). In addition, front panel controls all had the capability of zeroing in. The output of the amplifiers connected directly to the input of an analog chart recorder whose sensitivity was adjusted to obtain the desired resolution. The chart recorder sensitivities resolutions and full scale values are shown below by group of channel:

Channel	Sensitivity	Resolution	Full Scale
1, 2, 3, 10, 11	1.5 mV/0.001 in.	±0.0005	0.040 in.
4, 5, 6, 7, 8, 9	25 mV/0.01 in.	±0.005	0.04 in.
12	10 mV/100 lbs.	±50 lbs.	4,000 lbs.

By operating the recorder at relatively high sensitivities, it was quite easy to obtain the required resolution. However, since the chart trace was only fifty-division wide, some means of accommodating the very wide range of measurements was required. This was met by providing switch selectable voltage steps of opposite polarity which could be connected to the summing amplifier and used to cancel out signals representing fixed increments of displacements.

Circuit Considerations

Although the overall circuitry was quite simple, several points in the system design required attention regarding technique to obtain the required performance. In general, circuit demands required overall stabilities of 250 ppm and to overcome cumulative errors, individual stabilities of about 25 ppm. The key areas are discussed below:

Transducer Type and Method of Excitation - Transducers using infinite resolution, continuous wire type potentiometers had been required to avoid discrete steps in the output signal and make use of their low temperature coefficient of resistance. Even though the potentiometers were used as voltage dividers minimizing the effects of temperature changes, localized differences in temperature would have been sufficient to cause drift.

The 50-Ohm potentiometers applied to adjust the transducer scale factors to the specified values were kept to a maximum of 10% of the value of the transducer to avoid the effects of temperature. The potentiometers used were the infinite resolution, Cermet variety with a temperature coefficient of ±50 ppm. However, because their contribution was less than 10% of their rated resistance, the apparent temperature was less than 10% of 50 ppm, that is, less than 5 ppm.

Excitation Supply - The excitation supply for the high resolution channels 1, 2, 3, 10 and 11 was a precision supply with a thermal coefficient of ± 10 microvolt per centigrade of temperature. The supply was used to both excite the transducers and generate the zeroing and offset voltages so that effects due to voltage changes cancelled each other.

Voltage Divider Design - The front panel offset voltages demanded very precise and stable values. A precision voltage divider was used to obtain these values. An error in the offset voltage divider of ±100 ppm would have produced an error of 1/3 division on channels 1, 2, 3, 10 and 11. To obtain the required stability, 1 ppm/centigrade of temperature fixed resistors were applied in conjunction with 50-ohm potentiometers. Although the potentiometers had stabilities of ±50 ppm/centigrade of temperature, the constituted only 2% of the divider value, hence, the temperature coefficient was reduced to 1/ppm. Since the individual coefficients add in an RMS manner, the overall temperature coefficient for the entire divider was approximately ±5 ppm/centigrade of temperature and, therefore, satisfactory performance was encountered between the specified temperature extremes of 35°F and 95°F.

Recording Technique

Panel lateral stability was measured by applying a gradually increasing lateral load to the test panel and recording the resulting lateral panel displacement. The attached Block Diagram schematically illustrates the measurement technique used at Sabot.

At the center of the panel, a bridle split the lateral load in two components acting 5 feet apart on the base of the rail. The bridle was cable-connected to an axial, strain gage load cell and, in line, to a 15-inch stroke, double acting hydraulic cylinder via wire rope. At the other end of the wire rope a bulldozer, Caterpillar D9, furnished the reaction force. A double acting hydraulic system was applied, utilizing an electrically driven gear pump for high volume - medium pressure and a hand pump for low volume - high pressure in order to energize the hydraulic cylinder and generate the lateral force.

The applied load was measured with an accurate strain gage cell whose output was amplified and passed through a signal conditioning chasis which converted the load cell output into a voltage signal.

The displacement of selected ties and the rail at midpoint (Figs. 38.1, 38.2, 38.3, 38.4 and 38.5, pages 58 thru 62), was measured with potentiometric type displacement transducers. The transducers were affixed to steel posts driven into the subgrade through the ballast. With the exception of the center transducer connected to the rail, the transducers were connected to the end of the selected crossties via stainless steel cords. The transducer outputs were conditioned and scaled to provide the appropriate voltages. All electronic signals carrying the information about the forces and displacements were recorded on two, six-channel each, strip chart recorders whose channel sensitivities were set according to the corresponding scale factor. A common switch was used to energize the recording pens on the strip chart recorders and in order to synchronize data recordings on the two units.

A portable, gasoline powered generator was used to drive the electronic equipment and to recharge the storage battery of the electric pump.

Provision has been made to control certain conditions such as the geometry of the panel, the bridle and the bulldozer. Considerable attention was paid to insure that the lateral force is (1) acting at the middle of the panel, (2) horizontal, and (3) perpendicular to the panel. By accurately positioning the hydraulic cylinder, ±1 in. relative to the elevation of rail base which was approximately 100 inches from it, the applied force was nearly horizontal and its vertical component was not more than 1%. Changes in rail elevations as a result of pulling the panel were determined after the load was released. The transducers were installed with similar accuracy relative to the tie ends.

Operation

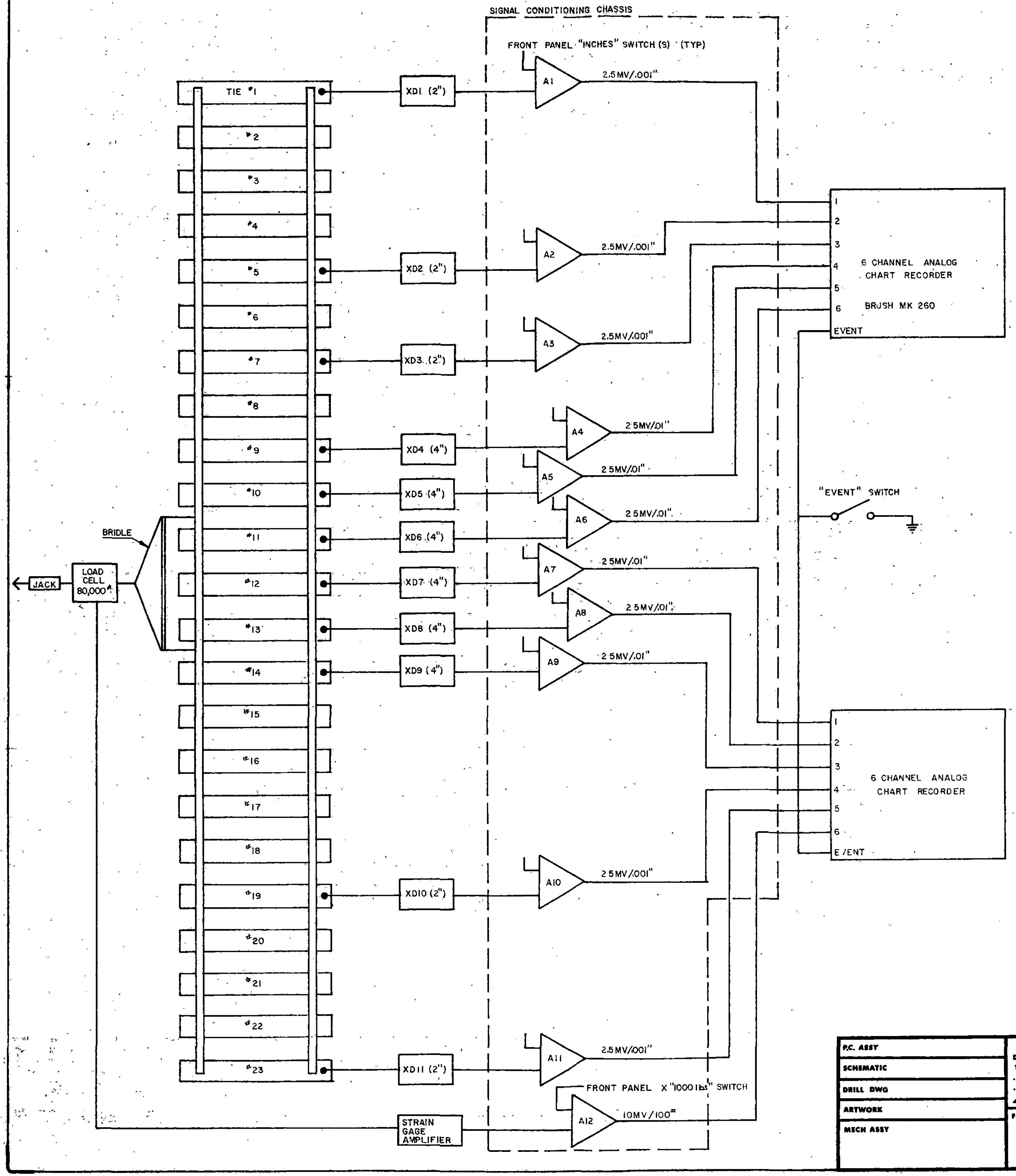
After setting the instruments, the operation, panel by panel, went like this: All recorder channels were zeroed, suitably annoted and the channel sensitivities were manually recorded on the paper tape of the strip chart recorders, and rail-end gaps were checked at the ends of the panel. Then, the technicians assumed their posts (two at the strip chart recorders, one at the hydraulic pump) and the operation began.

The hydraulic cylinder was gradually pressurized to increase the lateral load on the panel. The applied load was continuously measured by the load cell. When it reached about 2,000 lbs., a value needed to take up the slack on the bulldozer winch, the paper tapes were started on the strip chart recorders and the recording began.

The electric hydraulic pump was used to bring the load up to 6,000-8,000 lbs., and then the hand pump was used until the panel yielded. As the displacement/load tracing pens reached their maximum travel on the chart, the technicians re-zeroed them, and annoted the charts with the particular switch settings on the corresponding channel. The process of increasing the load and recording all channels was continued until one of the following phenomena was observed:

(1) The panel moved without force increment (yield).
(2) A transducer reached its maximum travel.
(3) The applied force approached the rated strength of the cable.

When one of these three phenomena was noticed, the load was released and the test was terminated for that panel.



NOTES:
1. XD — DISPLACEMENT TRANSDUCER
2. A – SUMMING AMPLIFIER
3. CONFIGURATION SHOWN FOR WOOD TIES

FIG. 34

P.C. ASSY	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOL: .XX : ± .01 $\frac{X}{X}$: ± $\frac{1}{32}$ .XXX : ± .005 BEND 'R' MIN ∠'s : ± 30' BEND RELIEF MIN	JOB NO. 7112	REACTION INSTRUMENTS McLEAN, VA FSCM 31887
SCHEMATIC		BY R Knox 4-29-75	BLOCK DIAGRAM DATA MEASUREMENT SYSTEM
DRILL DWG		CHK	
ARTWORK	FINISH	P.E.	
MECH ASSY		MATERIAL	SHEET 1 OF 1 C 30748

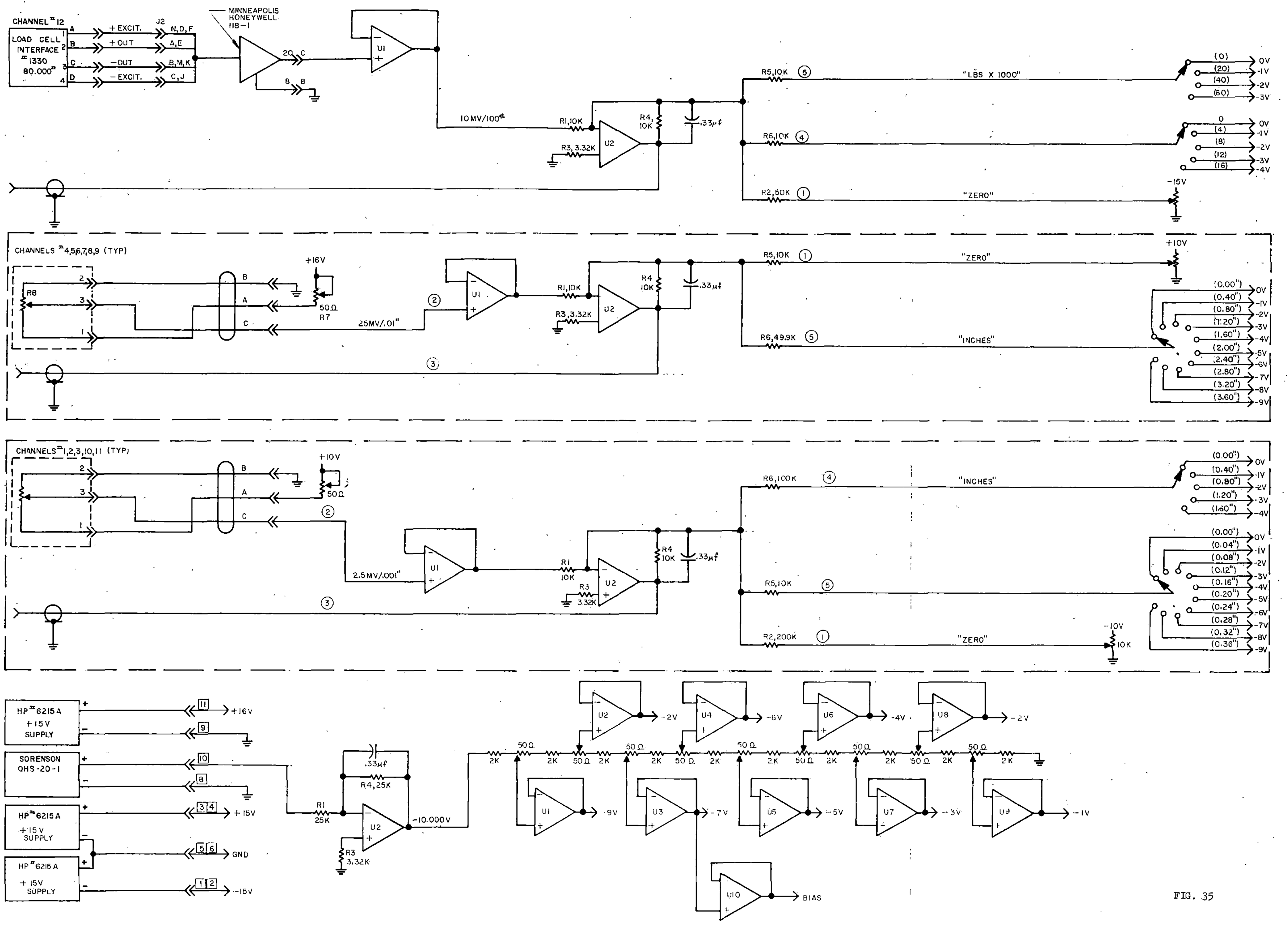


FIG. 35

NOTES

1. U1 & U2 FOR CHANNELS # 4,5,6,7,8,9,&12 ARE μ741.
RESISTORS ARE 100PPM/°C, 1% METAL FILM MATCHED TO PROVIDE EXACT RATIOS.

2. U1 & U2 FOR CHANNELS # 1,2,3,10,11,&12 ARE LM308. RESISTORS R1 & R4 ARE 25PPM/°C, 1% METAL FILM MATCHED TO PROVIDE EXACT RATIOS.

3. U1-9 IN VOLTAGE DIVIDER ARE LM310. RESISTORS ARE 1PPM/°C FILM RESISTORS.

4. ☒ —DENOTES PIN NO. ON TERMINAL STRIPS.

5. ⓧ —DENOTES PIN NO. ON PRINTED CIRCUIT BOARDS

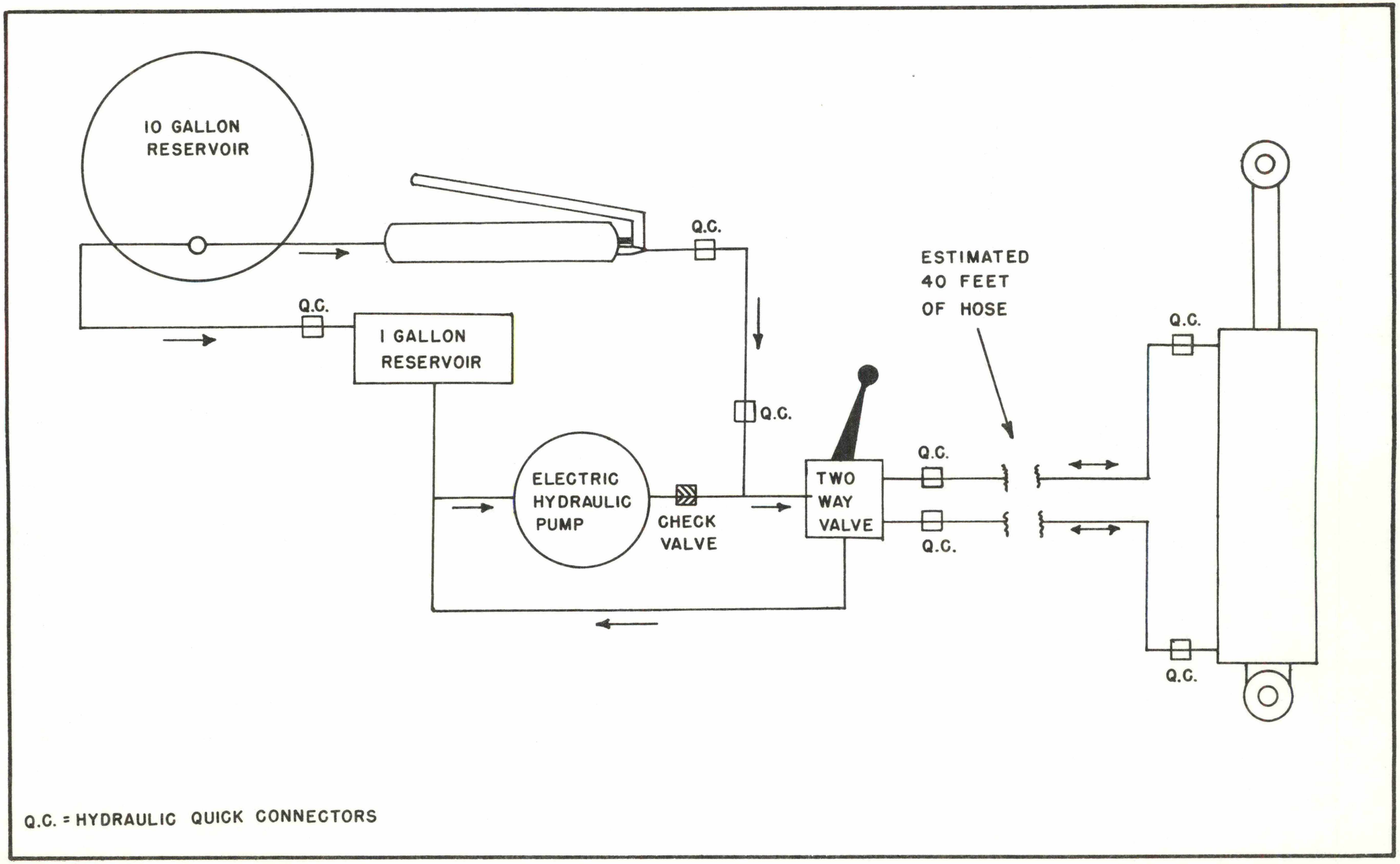
6 ALL VOLTAGE VALUES · TOL ± 500 μV

P.C. ASSY	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOL: .XX : ± .01 $\frac{X}{X}$: ± $\frac{1}{32}$ .XXX : ± .005 BEND 'R' MIN ∠'s : ± 30' BEND RELIEF MIN	JOB NO. 7112	REACTION INSTRUMENTS McLEAN, VA FSCM/31887
SCHEMATIC		BY R Knox 4-28-75	SCHEMATIC LATERAL STABILITY TEST EQUIPMENT
DRILL DWG		CHK	
ARTWORK	FINISH	P.E.	
MECH ASSY		MATERIAL	SHEET 1 OF 1 C 30747

Fig. 36 - Transducer Specification

Trans-ducer #	Model	Serial #	Range	Sensitivity	Excitation	Scale Factor	Linearity
XD1	Houston Scien-tific 1800	2357-001	2"	0.26208V/V/IN	9.539V	2.5MV/.001 in.	0.030%
XD2	↓	-002	↓	0.26027	9.605	↓	0.061%
XD3	↓	-003	↓	0.26081	9.585	↓	0.071%
XD4	↓	299-001	5"	0.16295	15.342	25MV/.01 in.	0.061%
XD5	↓	-002	↓	0.16224	15.409	↓	0.028%
XD6	↓	-003	↓	0.16247	15.387	↓	0.023%
XD7	↓	-004	↓	0.16288	15.348	↓	0.053%
XD8	↓	-005	↓	0.16251	15.383	↓	0.068%
XD9	↓	-006	↓	0.16163	15.467	↓	0.056%
XD10	↓	2357-004	2"	0.25853	9.670	2.5MV/.001 in.	0.068%
XD11	↓	-005	↓	0.26131	9.567	↓	0.076%
LC1	Interface, Inc. 1230-HK	1214	80,000#	0.003231V/V/FS	N/A	25MV/100 lb.	0.118%

FIG. 37 - SCHEMATIC OF HYDRAULIC COMPONENTS FOR LATERAL TRACK STABILITY TESTS



APPENDIX A (Cont'd.)

LOCATION OF TRANSDUCERS ALONG THE PANELS

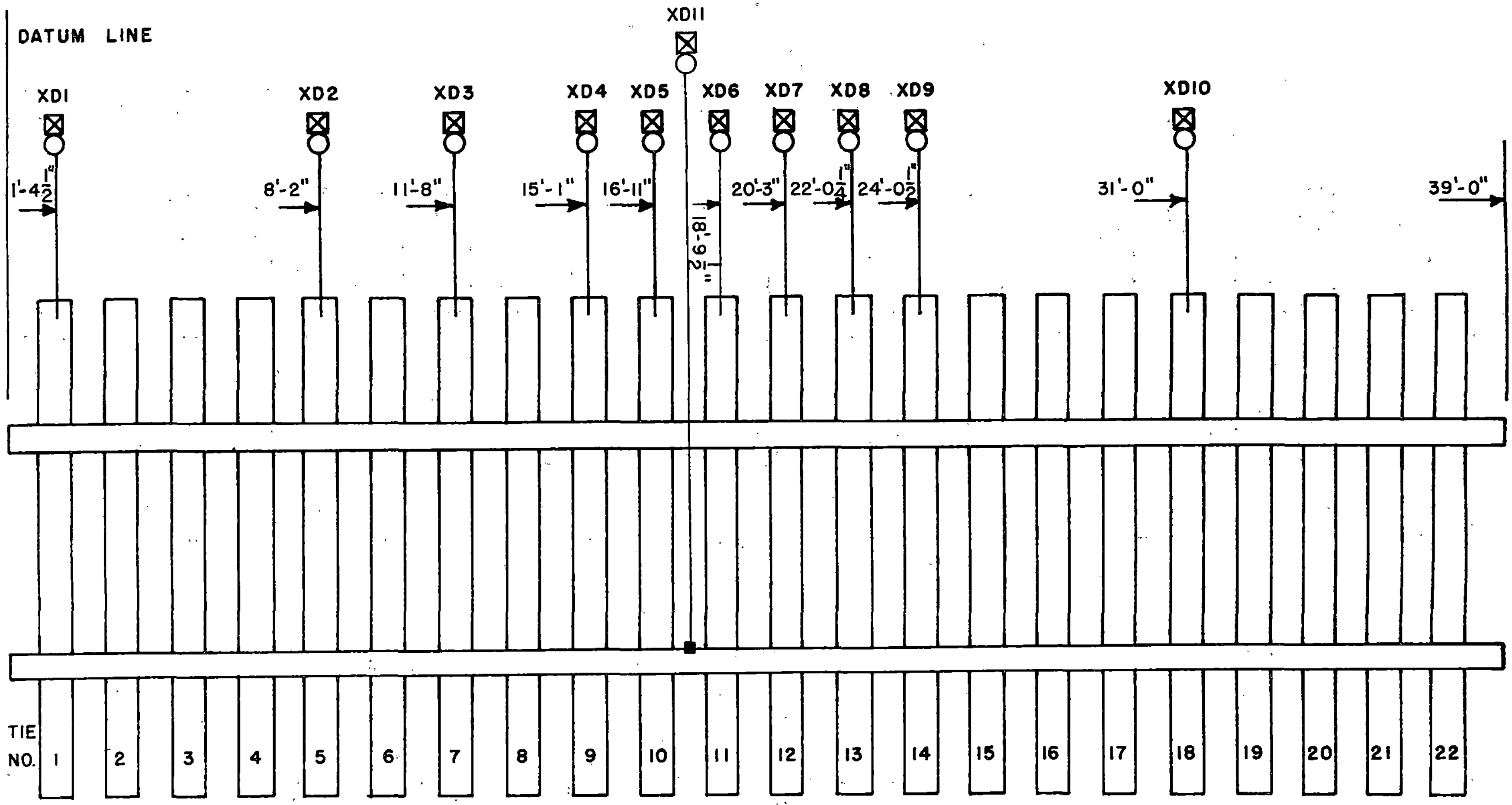


Fig. 38.1
PANEL A. EAST
TRANSDUCER LOCATIONS ALONG TRACK

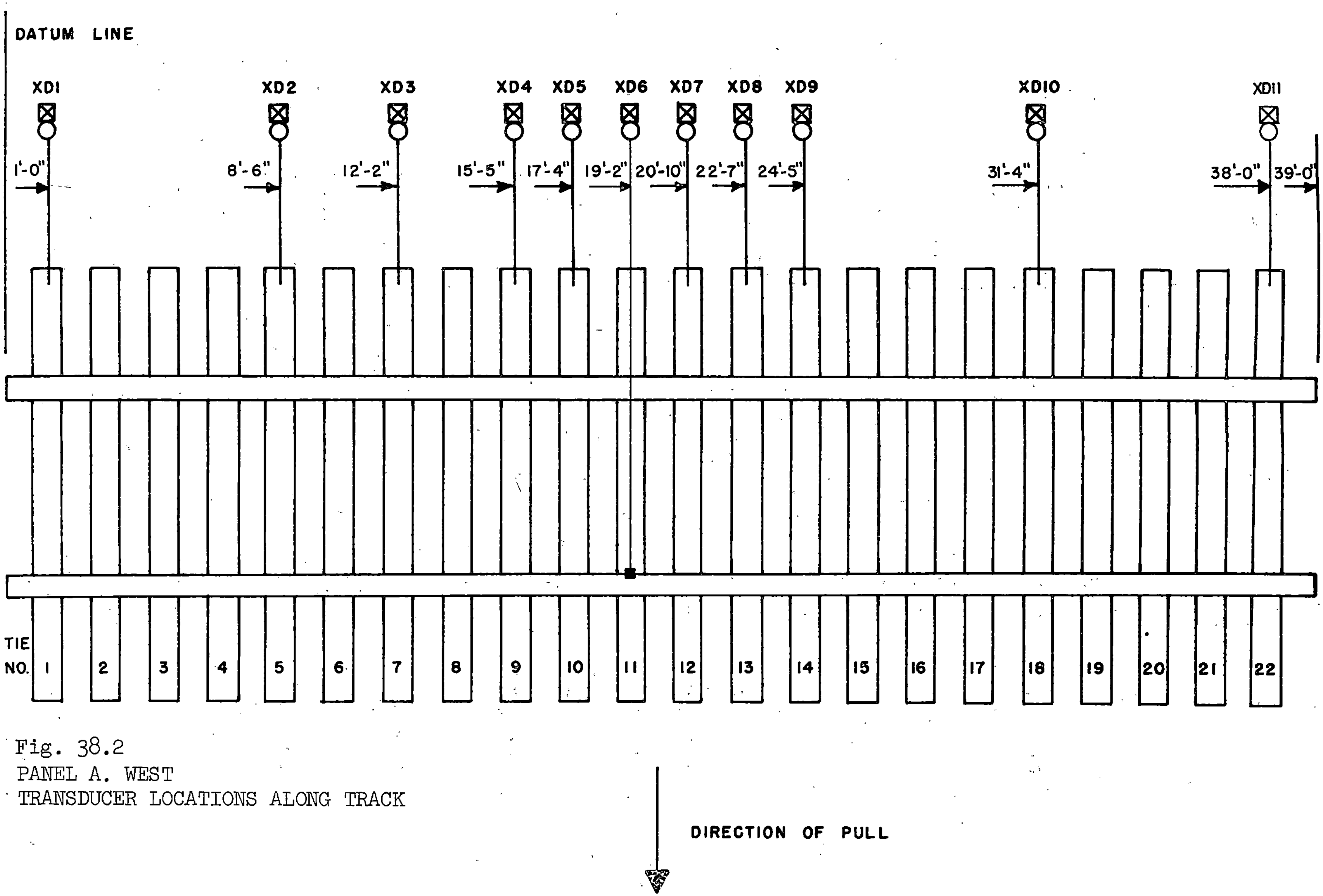


Fig. 38.2
PANEL A. WEST
TRANSDUCER LOCATIONS ALONG TRACK

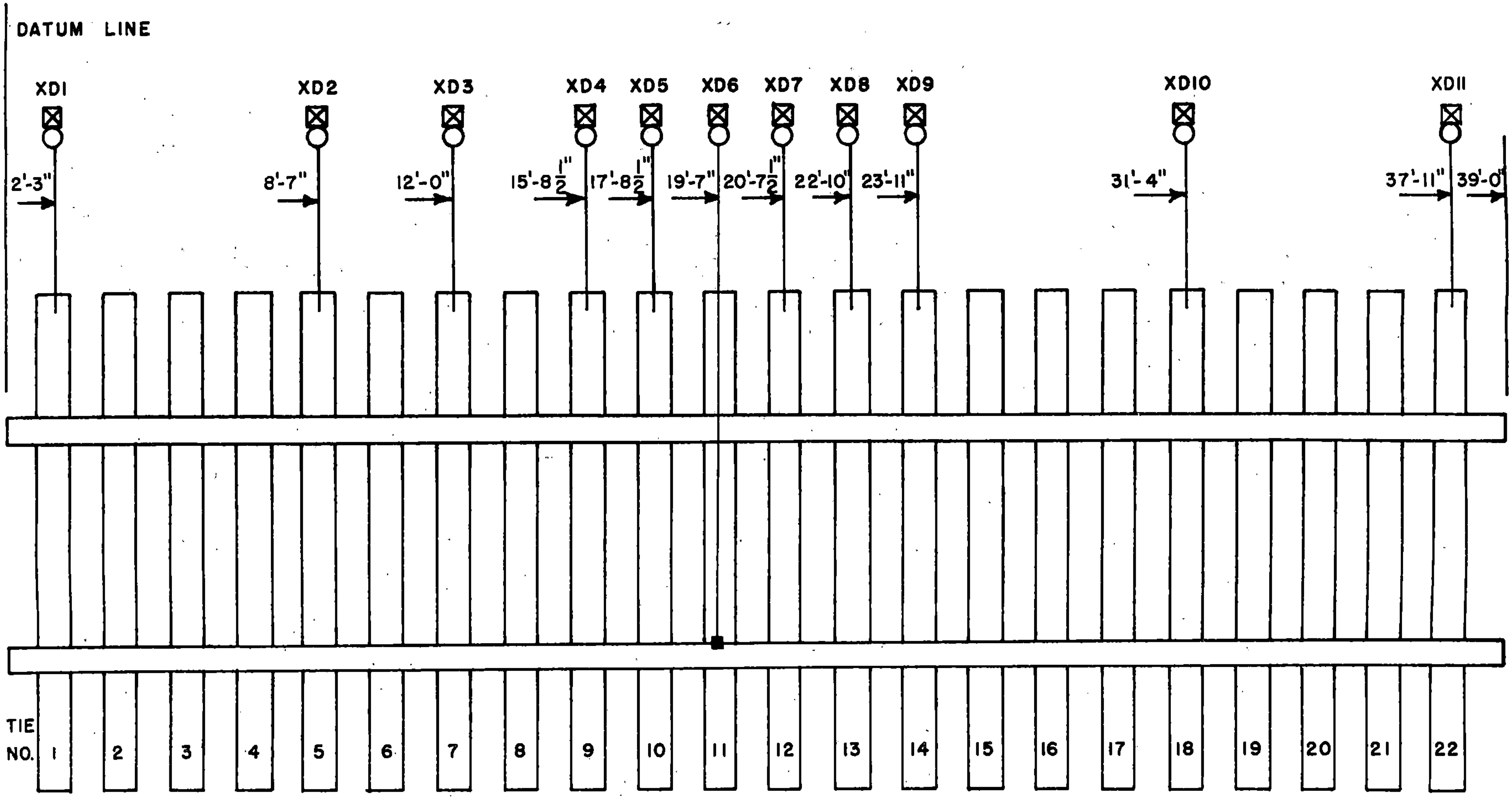


Fig. 38.3
PANEL B. EAST
TRANSDUCER LOCATION ALONG TRACK

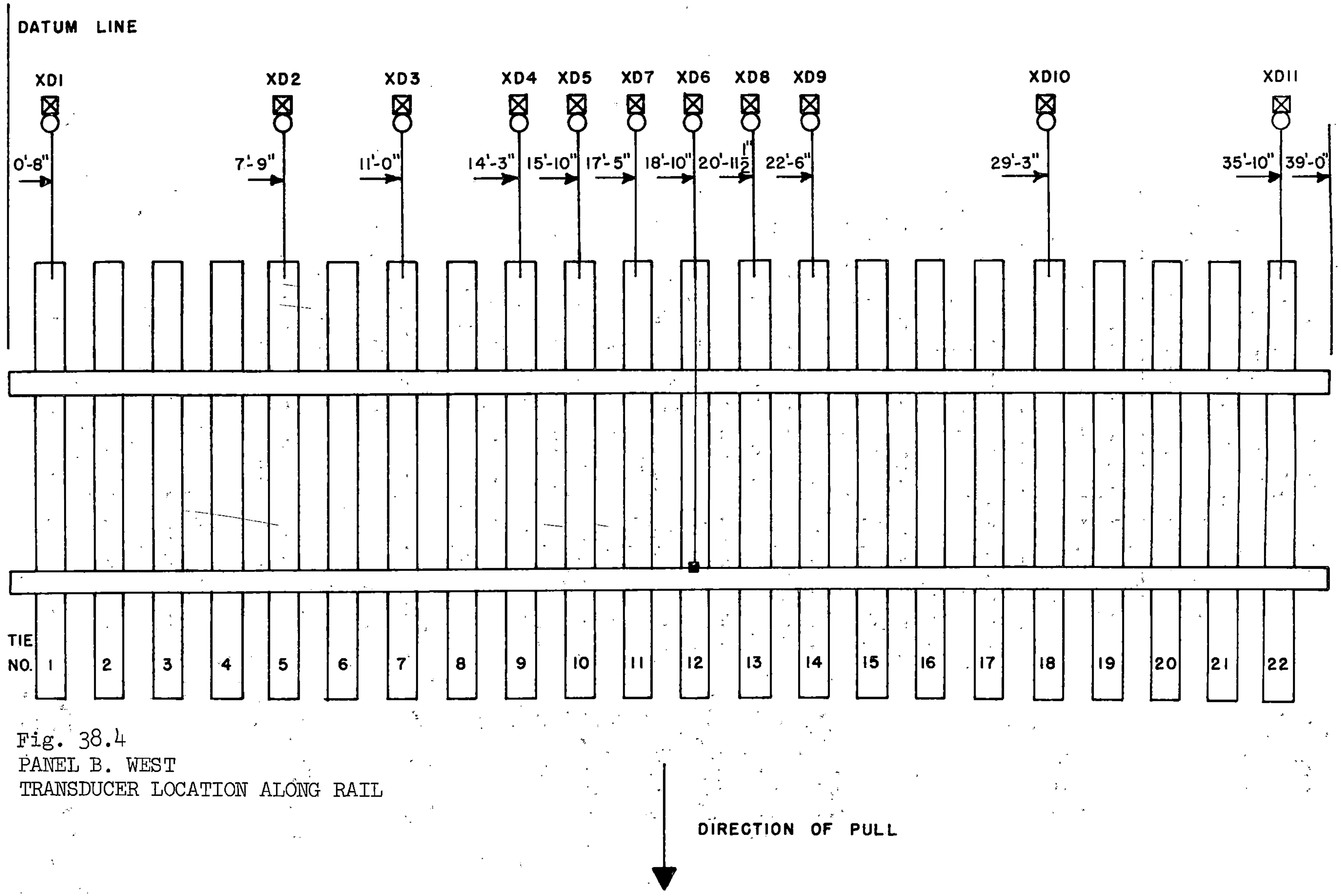


Fig. 38.4
PANEL B. WEST
TRANSDUCER LOCATION ALONG RAIL

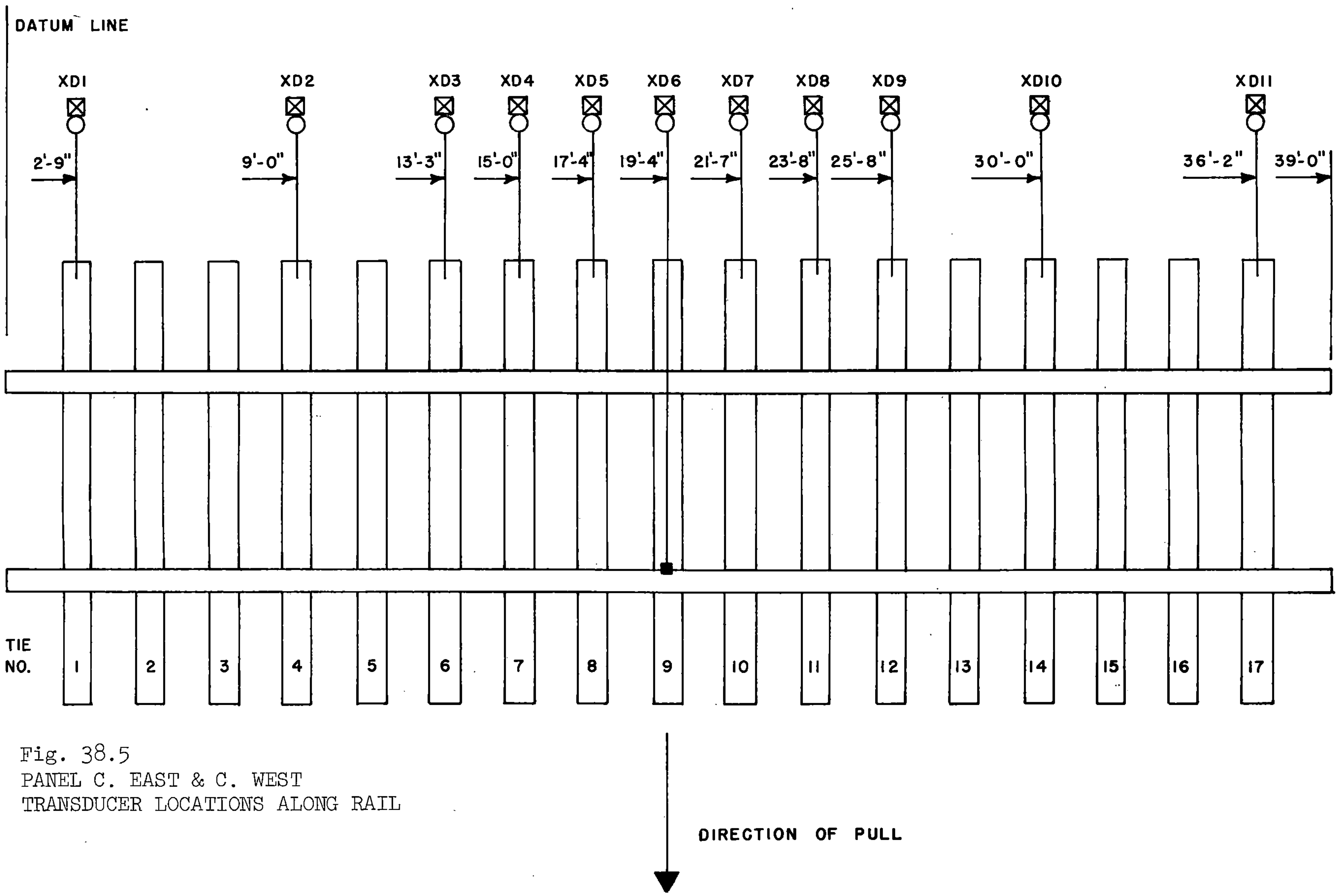
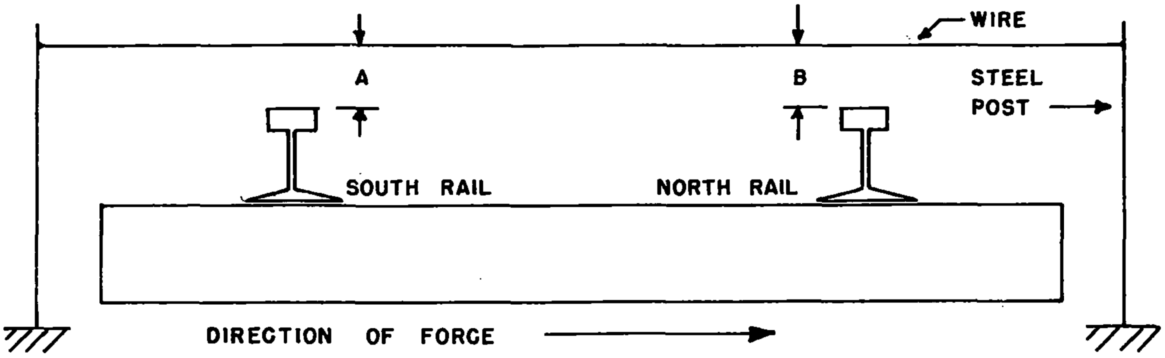


Fig. 38.5
PANEL C. EAST & C. WEST
TRANSDUCER LOCATIONS ALONG RAIL

APPENDIX B

MEASUREMENTS OF PANEL DISTORTION IN THE VERTICAL PLANE CAUSED BY THE LATERAL FORCE

Fig. 39.1 - MEASURING PANEL DISTORTION IN THE HORIZONTAL PLANE



RESULTS (in inches)

Panel Designation			Before Test		After Test	
			A_1	B_1	A_2	B_2
Phase I	1	East	1.00	1.00	0.85	0.90
	2		0.93	1.15	0.85	1.10
	3		1.00	0.90	0.88	0.81
	4	West	1.97	2.20	1.89	2.05
	5		0.95	1.70	0.70	1.50
	6		2.12	2.10	2.00	2.00
Phase II	1	East	1.62	1.38	1.38	1.00
	2		1.25	1.38	0.75	0.75
	3		0.75	0.75	0.50	0.50
	4	West	3.00	3.50	2.63	3.25
	5		2.88	2.63	2.38	2.00
	6		2.25	2.00	2.50	2.13
	7	Control Panels	2.13	2.63	1.63	2.00
	8		2.75	3.50	3.00	3.50
	9		2.00	1.88	2.00	1.88
	10		1.88	2.25	1.88	2.25

Fig. 39.2 - CALCULATED CHANGES IN RAIL ELEVATION AND ROTATION OF PANEL CAUSED BY PULLING

Panel Designation			Change in Elevation (in.)		Rotation of Panel (min.)
			South Rail	North Rail	
1	East	Phase I	+0.15	+0.10	+3.0
2			+0.08	+0.05	+1.8
3			+0.12	+0.09	+1.8
4	West		+0.08	+0.15	-4.2
5			+0.25	+0.20	-3.0
6			+0.12	+0.10	+1.2
1	East	Phase II	+0.24	+0.38	-8.4
2			+0.50	+0.63	-7.8
3			+0.25	+0.25	0.0
4	West		+0.37	+0.25	+7.2
5			+0.50	+0.63	-7.8
6			-0.25	-0.13	-7.2
7		Control Panels	+0.50	+0.63	-7.8
8			-0.25	0.00	-15.0
9			0.00	0.00	0.0
10			0.00	0.00	0.0

Note: + Sign means rise in rail elevation and a clockwise rotation (when looking at the panel from East).

- Sign means lowering of rail elevation and a counterclockwise rotation.

APPENDIX C

FORCE/DISPLACEMENT CURVES

(1) EFFECT OF MECHANICAL BALLAST COMPACTION ON:

- NEW WOOD TIES
- MIX OF OLD AND NEW WOOD TIES
- NEW CONCRETE TIES

(2) EFFECT OF 7MGT TRAFFIC ON:

- NEW WOOD TIES
- MIX OF OLD AND NEW WOOD TIES
- CONCRETE TIES

(3) EFFECT OF MECHANICAL BALLAST COMPACTION AND 7MGT TRAFFIC ON:

- NEW WOOD TIES
- MIX OF OLD AND NEW WOOD TIES
- CONCRETE TIES

Fig. 40.1 - EFFECT OF COMPACTION
(New Wood Ties)

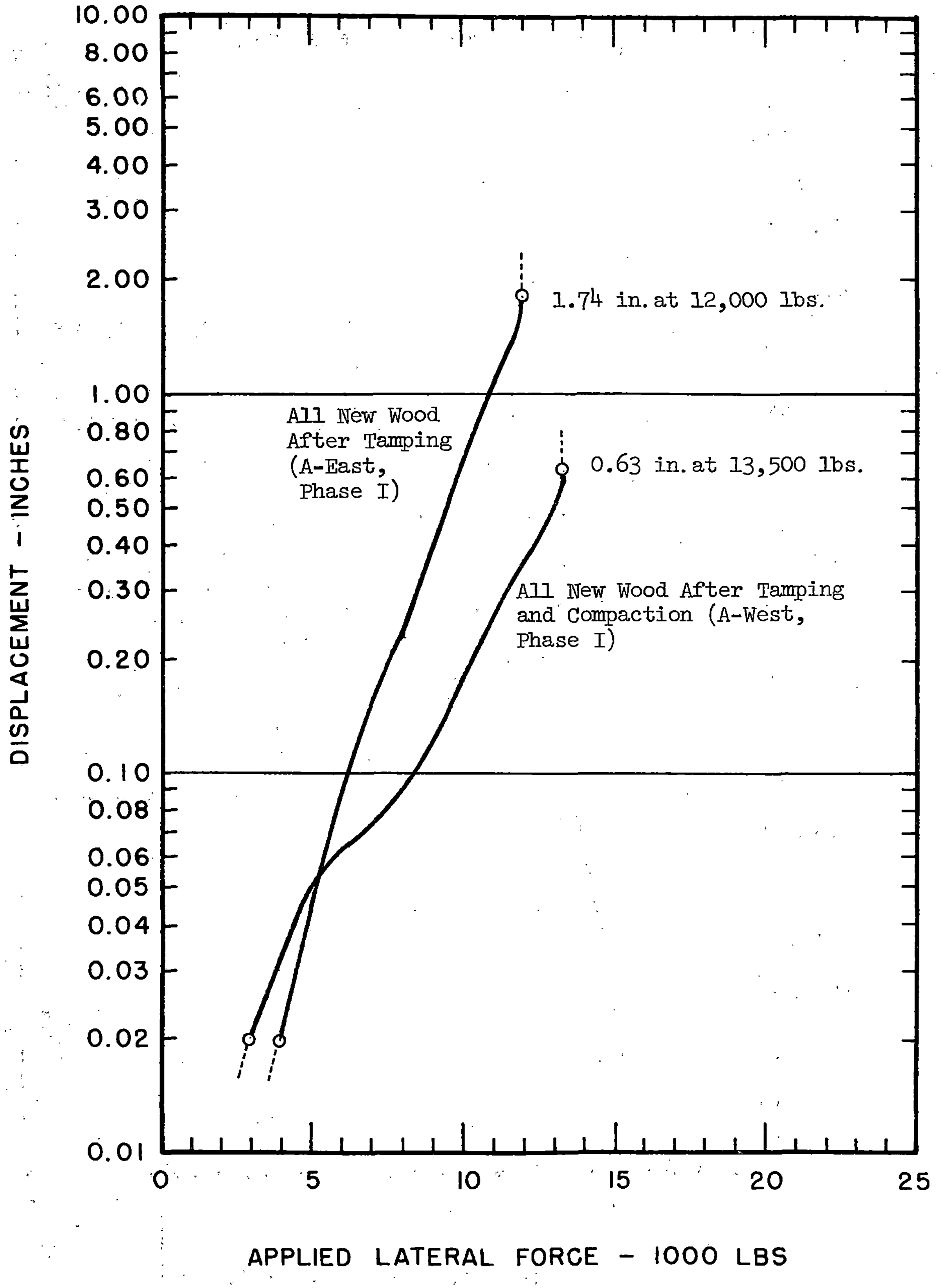


Fig. 40.2 - EFFECT OF COMPACTION
(Old and New Wood Ties)

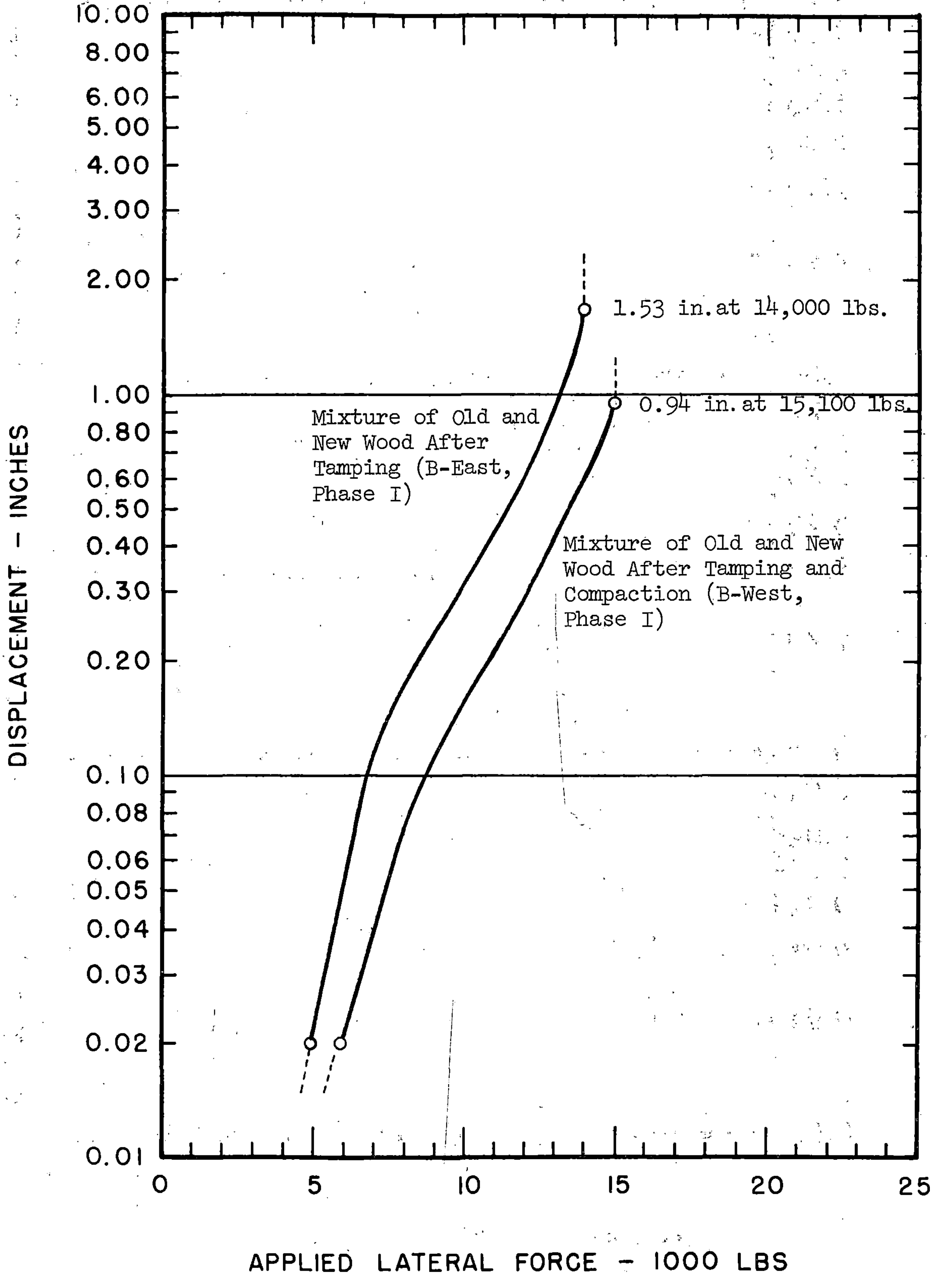


Fig. 40.3 - EFFECT OF COMPACTION
(New Concrete Ties)

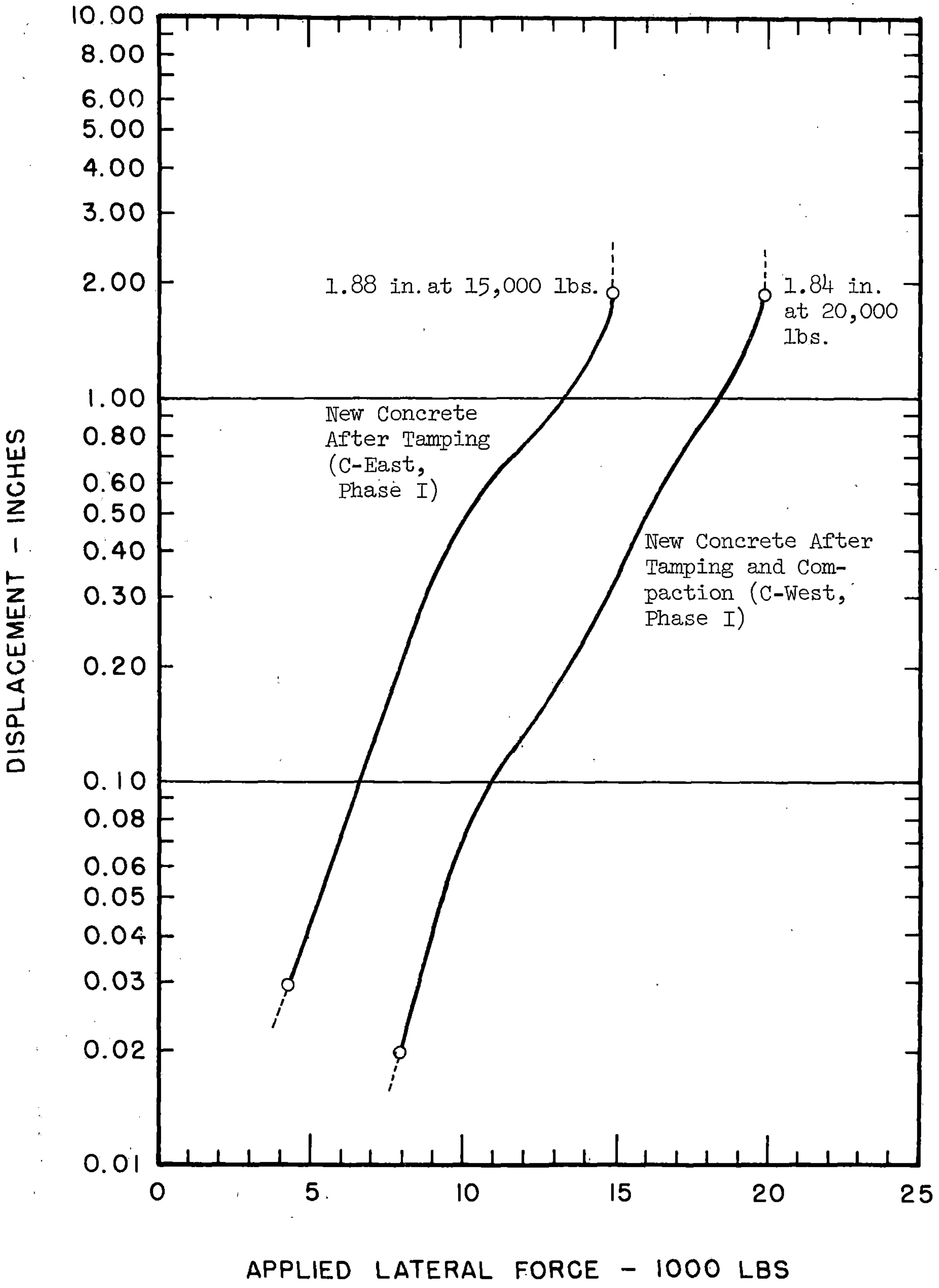


Fig. 41.1 - EFFECT OF TRAFFIC
(New Wood Ties)

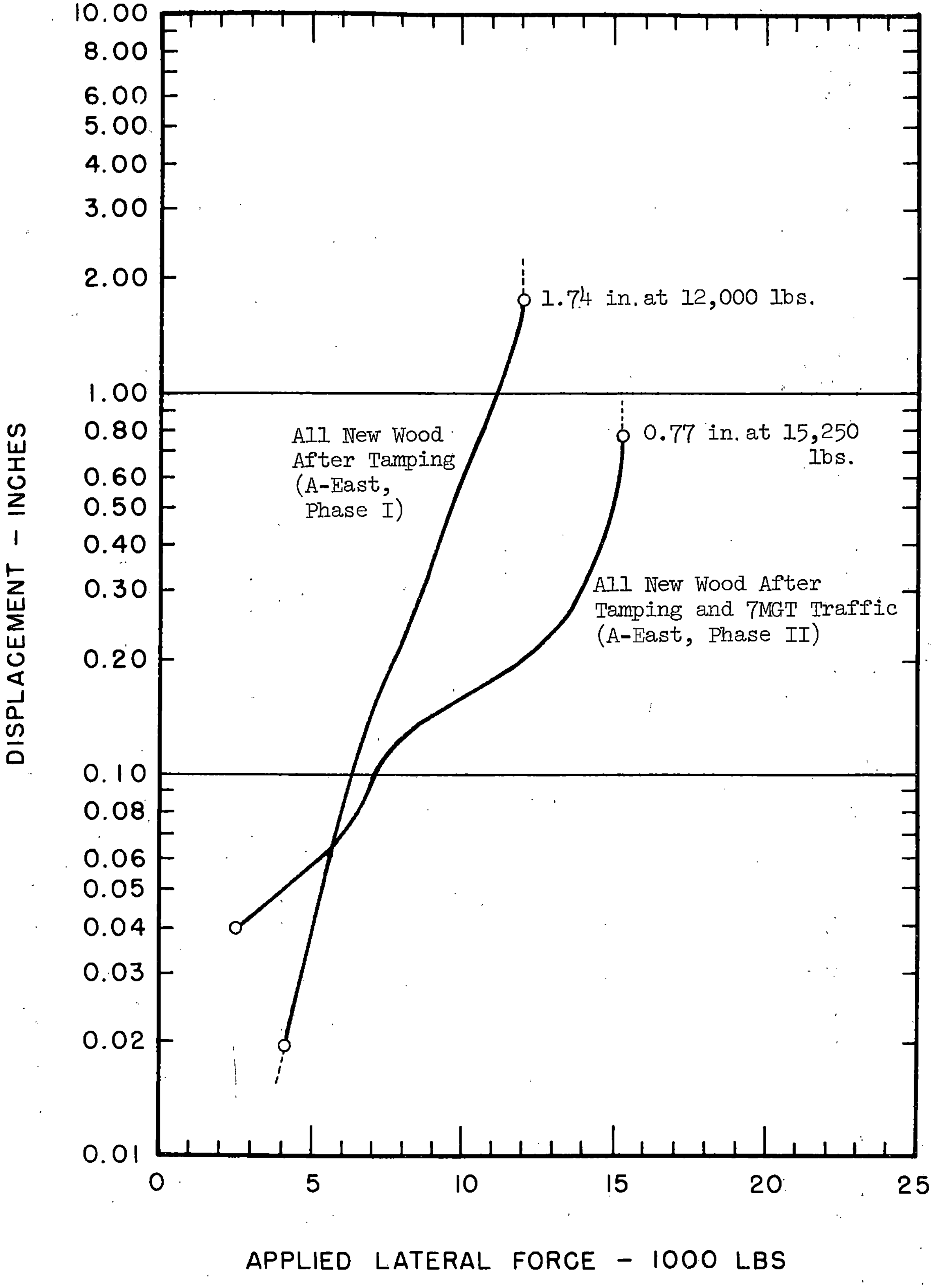


Fig. 41.2 - EFFECT OF TRAFFIC
(Old and New Wood Ties)

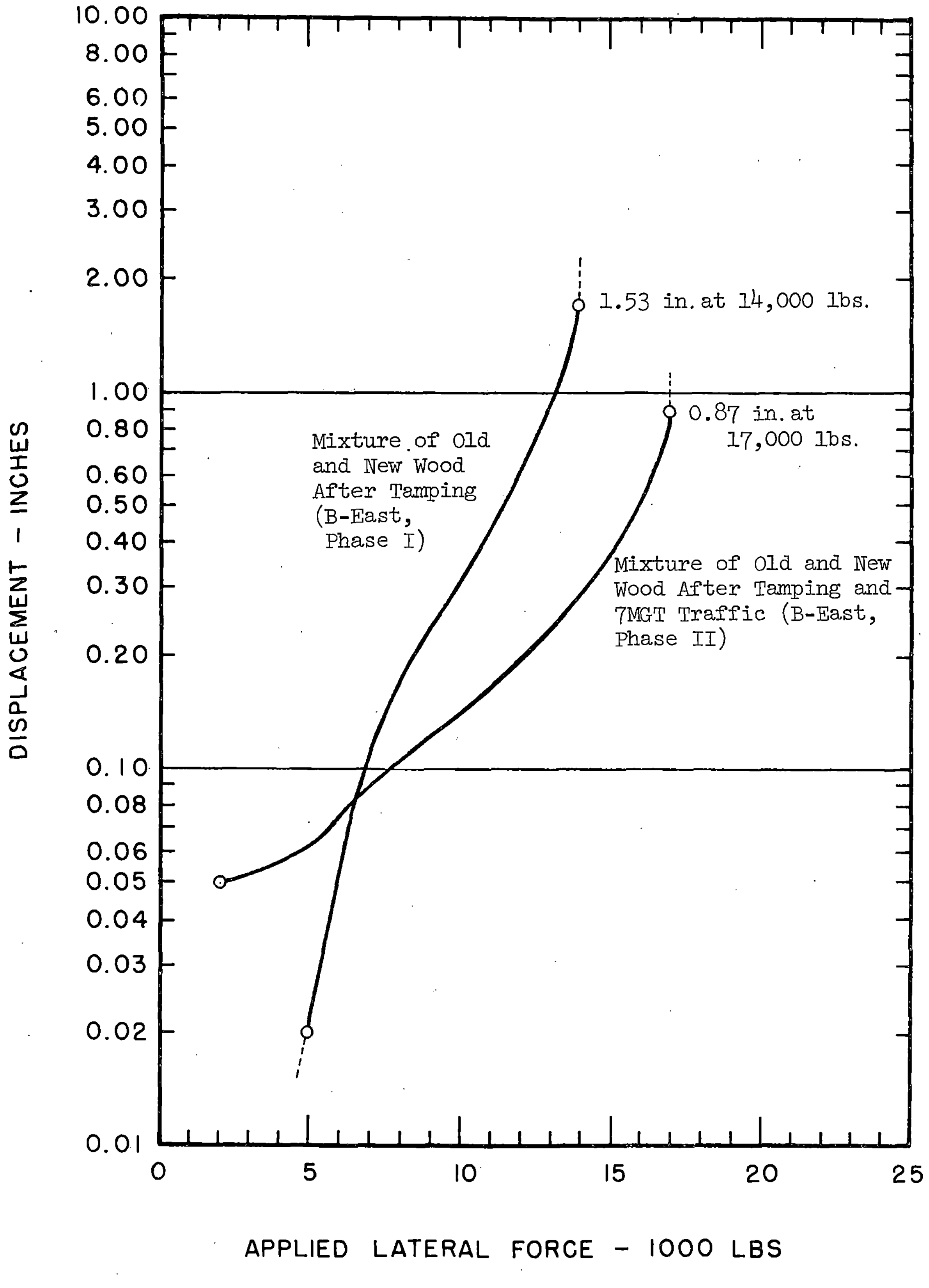


Fig. 41.3 - EFFECT OF TRAFFIC
(New Concrete Ties)

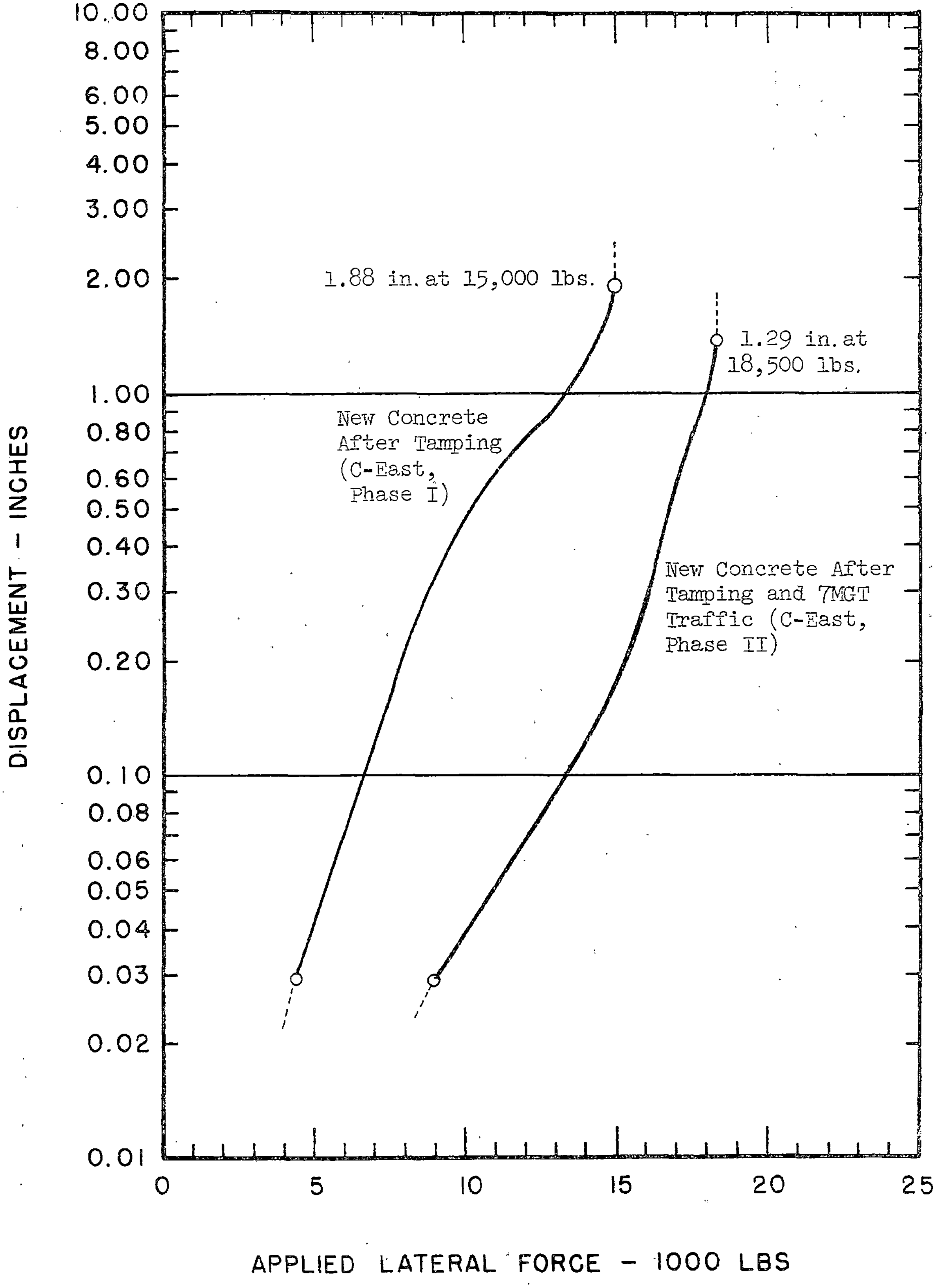


Fig. 42.1 - EFFECT OF TRAFFIC AFTER BALLAST COMPACTION
(New Wood Ties)

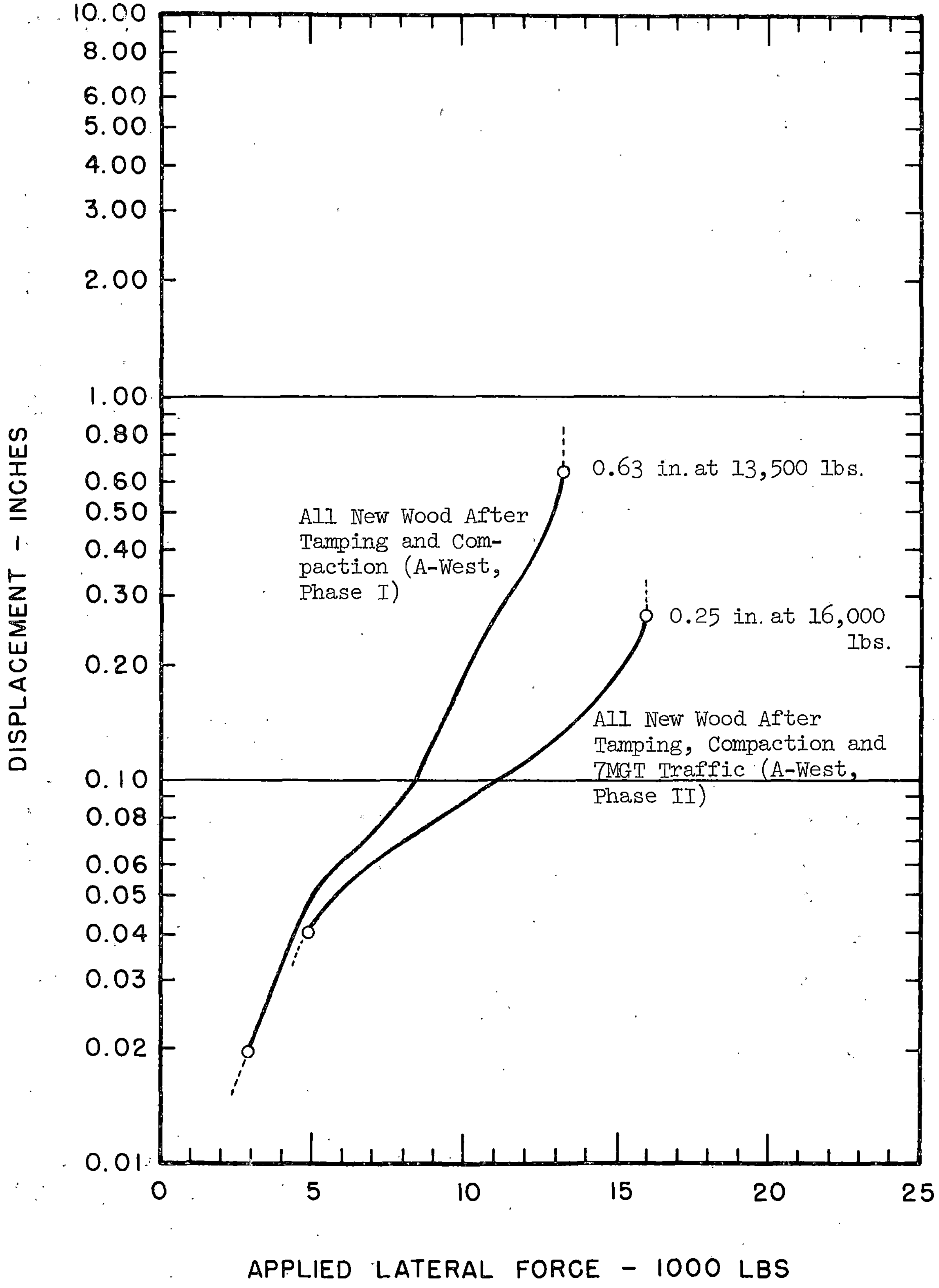


Fig. 42.2 - EFFECT OF TRAFFIC AFTER BALLAST COMPACTION
(Old and New Wood Ties)

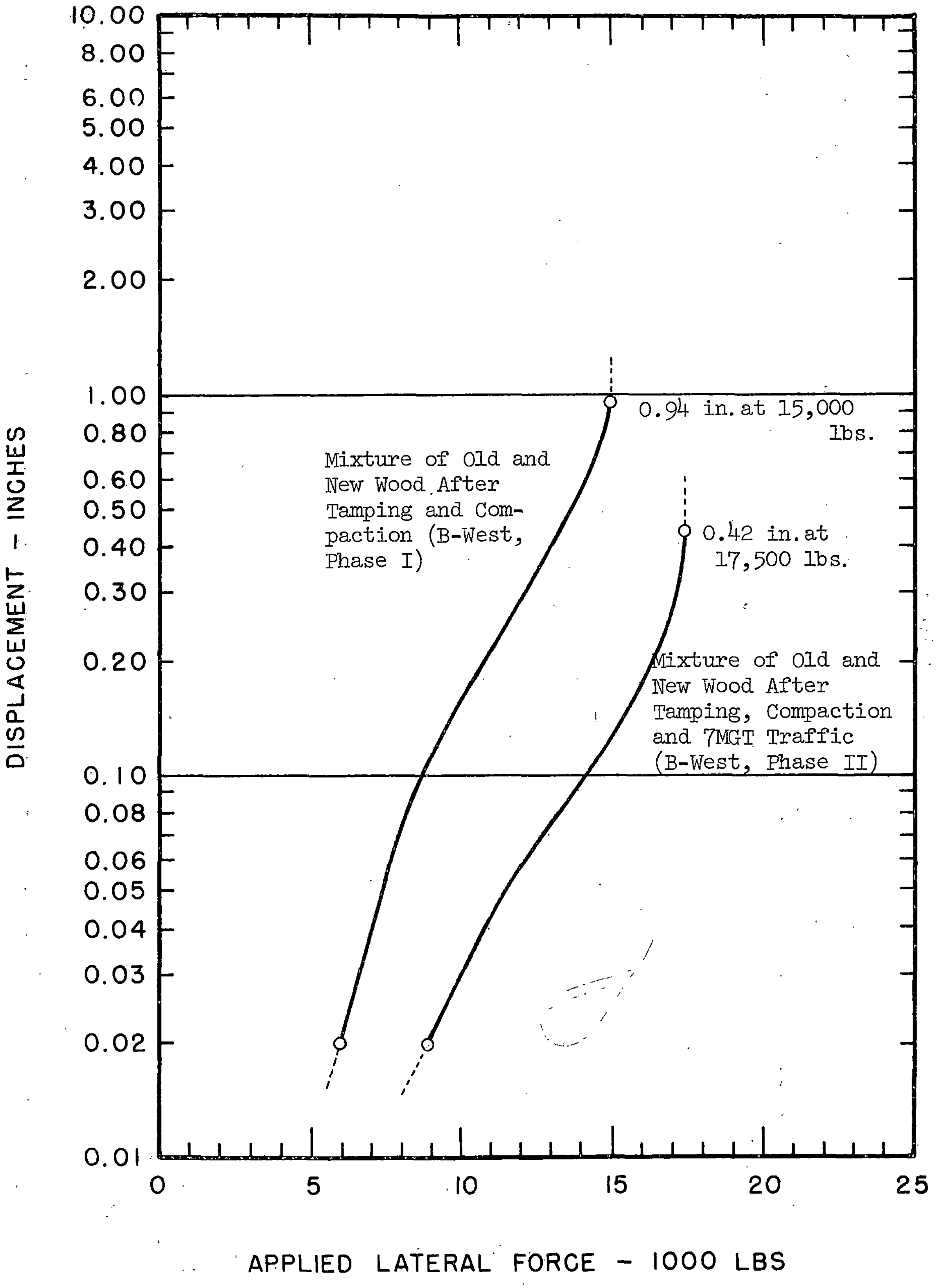
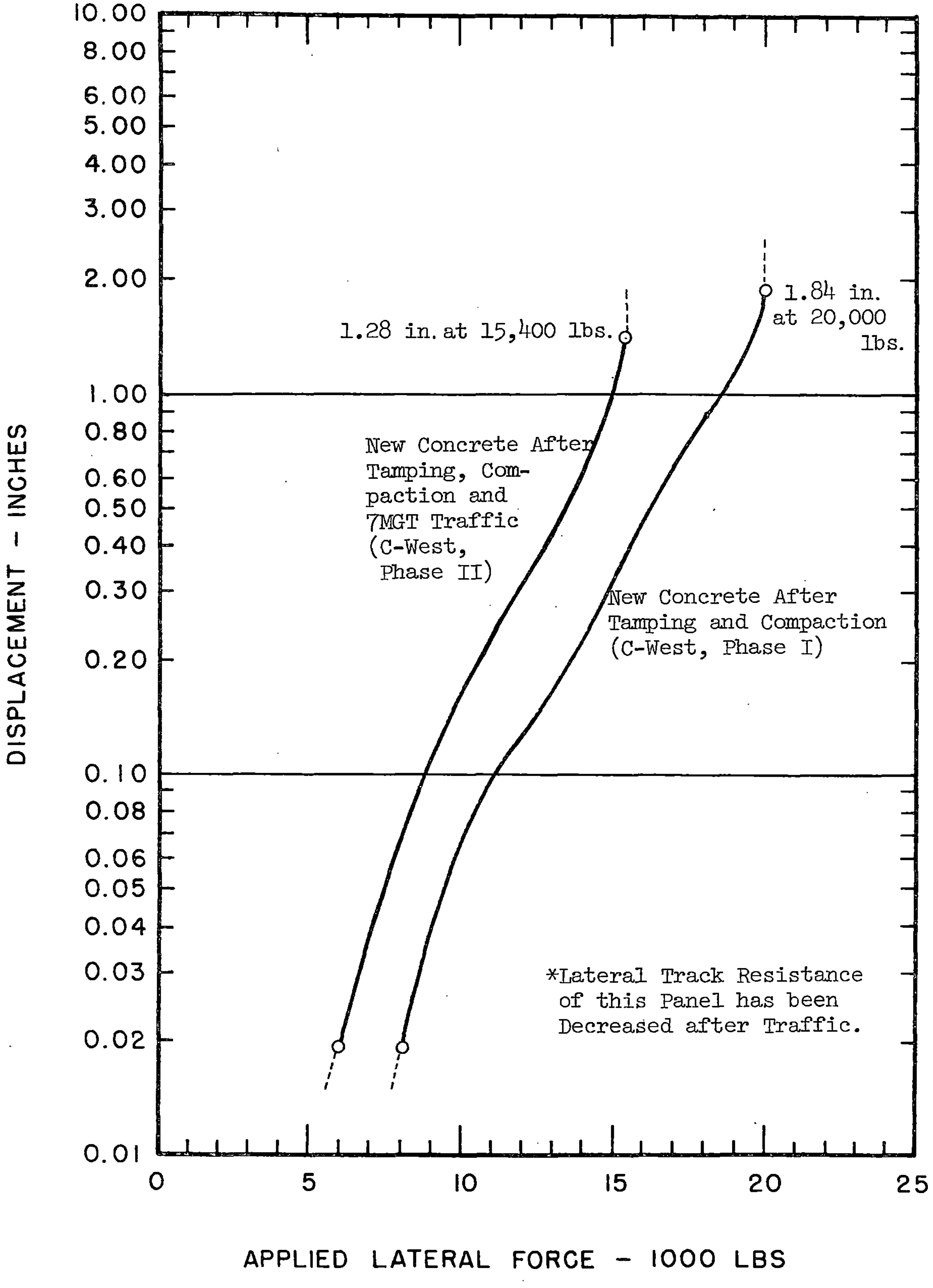


Fig. 42.3 - EFFECT OF TRAFFIC* AFTER BALLAST COMPACTION
(New Concrete Ties)



APPENDIX D

DIGITIZED DATA OF MEASURED FORCES AND DISPLACEMENTS BY PANEL

(1) PHASE I, EASTERN GROUP

(2) PHASE I, WESTERN GROUP

(3) PHASE II, EASTERN GROUP

(4) PHASE II, WESTERN GROUP

(5) CONTROL PANEL GROUP

(1) DATA OF PHASE I, EASTERN GROUP

FIG. 43.1

LATERAL TRACK STABILITY DATA

PHASE NO. I DATE Apr. 7, 1975 TRACK PANEL NO. A. EAST MAXIMUM FORCE 12,250 lbs.

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
2.5	.001	0	.0005	.010	0	0	0	0	-.005	0	.001
3.0	.001	0	.0005	.025	0	.01	0	0	-.005	0	.002
4.0	.001	0	.0005	.03	.005	.02	0	.01	-.005	0	.003
5.0	.001	0	.003	.05	.02	.05	0	.02	0	0	.005
5.5	.001	0	.009	.07	.03	.06	.001	.03	0	0	.007
6.0	.001	0	.014	.08	.06	.09	.03	.05	0	0	.009
6.5	.001	0	.026	.12	.08	.11	.05	.07	0	0	.011
7.0	.001	0	.031	.14	.11	.14	.07	.09	0	0	.014
7.5	.001	0	.033	.18	.15	.18	.11	.12	.01	0	.018
8.0	.001	0	.043	.23	.21	.23	.16	.16	.05	0	.023
8.5	.001	0	.088	.31	.29	.33	.24	.24	.11	0	.031
9.0	.001	0	.166	.38	.36	.39	.31	.30	.16	0	.038
9.5	.001	.007	.175	.42	.43	.47	.38	.36	.21	0	(4)
10.0	.001	.055	.280	.58	.59	.63	(4)	(4)	.32	0	.60
10.5	.001	.144	.475	.78	.795	.82	(4)	.68	.46	.01	.79
11.0	.001	.225	.568	.93	.97	1.01	.88	.84	.60	.03	.96
11.5	.001	.349	.870	1.18	1.23	1.25	1.13	1.06	.80	.09	1.19
12.0	.002	.584	1.137	1.63	1.74	1.74	1.61	1.52	1.20	.022	1.65
(1)	0	1.070	(3)	2.52	2.44	2.29	2.52	2.81	2.42	.57	(5)
(2)	.002	-.041	-	-.38	-.41	-.46	-.39	-.74	-.64	+.01	-

(1) Max. Displacement
(2) Force Removed
(3) Transducer Limit
(4) Off-Scale of Strip Chart
(5) Transducer Disconnected

FIG. 43.2

LATERAL TRACK STABILITY DATA

PHASE NO. I DATE Apr. 7, 1975 TRACK PANEL NO. B. EAST MAXIMUM FORCE 14,400 lbs.

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
4.55	0	0	0	.02	.02	0	0	0	0	0	0
5.0	0	0	0	.03	.03	.02	0	.01	0	0	0
5.5	0	0	0	.04	.04	.03	0	.02	.01	0	0
6.0	0	0	0	.06	.06	.05	.01	.03	.02	0	0
6.5	0	0	0	.08	.08	.07	.02	.05	.03	0	0
7.0	0	0	0	.11	.12	.11	.04	.07	.05	0	0
7.5	0	0	0	.13	.14	.13	.06	.09	.07	0	0
8.0	0	0	0	.16	.16	.16	.08	.11	.08	0	0
8.5	0	0	0	.19	.19	.19	.11	.13	.10	0	0
9.0	0	0	.012	.21	.22	.22	.13	.16	.12	0	0
9.5	0	0	.031	.25	.27	.27	.17	.19	.15	0	0
10.0	0	0	.049	.29	.31	.30	.20	.22	.17	0	0
10.5	0	0	.071	.33	.35	.35	.23	.26	.20	0	0
11.0	0	.009	.100	.38	.40	.40	.28	.29	.23	0	0
11.5	0	.040	.200	.44	.49	.48	.31	.37	.30	0	0
12.0	0	.085	.277	.55	.60	.59	.45	.47	.38	.010	0
12.5	0	.128	.323	.69	.75	.74	.60	.61	.49	.040	0
13.0	0	.170	.411	.81	.90	.88	.74	.75	.62	.082	0
13.5	0	.265	.628	1.06	1.17	1.15	1.00	1.00	.84	.156	0
14.0	-.005	.420	.900	1.43	1.55	1.53	1.17	1.37	1.18	.275	0
(1)	-	(4)	(4)	(4)	(4)	(4)	2.66	2.51	2.25	(4)	(5)
(2)	(4)	.881	.247	1.91	2.06	1.99	-.60	-.96	-.43	.341	0

(1) Max. Displacement
(2) Force Removed
(4) Off-Scale of Strip Chart
(5) Transducer Disconnected

LATERAL TRACK STABILITY DATA

PHASE NO. I **DATE** Apr. 8, 1975 **TRACK PANEL NO.** C. EAST **MAXIMUM FORCE** 15,000 lbs.

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
2.5	0	0	0	0	0	0	0	0	0	0	0
3.0	0	0	0	.015	.015	.005	0	0	0	0	0
3.5	0	0	0	.02	.02	.005	.005	0	0	0	0
4.0	0	0	.005	.03	.03	.015	.01	0	0	0	0
4.5	0	0	.005	.04	.04	.03	.02	0	0	0	0
5.0	0	0	.025	.05	.05	.04	.03	0	0	0	0
5.5	0	0	.030	.06	.070	.050	.035	0	0	0	0
6.0	0	0	.040	.08	.080	.06	.04	.01	0	0	0
6.5	0	0	.047	.09	.095	.07	.05	.012	0	0	0
8.0	-.004	-	-	-	-	-	.58	.46	.31	.084	.057
9.5	-.004	-	-	-	-	-	.58	.46	.31	.084	.057
10.0	-.004	-	-	-	-	-	.58	.46	.31	.084	.057
11.0	-.004	-	-	-	.73	-	.59	.46	.31	.084	.057
11.5	-.004	-	-	.67	.75	.68	.60	.46	.32	.084	.057
12.0	-.004	.238	.502	.69	.76	.70	.62	.47	.33	.084	.057
12.5	-.004	.249	.585	.75	.84	.76	.68	.52	.36	.093	.057
13.0	-.004	.267	.624	.80	.89	.92	.73	.56	.40	.105	.057
13.5	-.004	.460	.756	.95	1.07	.99	.89	.70	.51	.161	.056
14.0	-.004	.527	.875	1.09	1.24	1.15	1.05	.85	.62	.217	.056
14.5	-.004	.617	1.031	1.27	1.43	1.35	1.24	1.02	.78	.30	.057
15.0	-.005	.877	1.243	1.96	1.96	1.88	1.75	1.50	1.18	.553	.106
(1)	-.005	.887	1.619	2.00	2.20	2.12	1.99	1.73	1.38	.68	.134
(2)	.007	.868	1.384	1.65	2.05	-	1.68	1.55	1.30	.718	.164

(1) Max. Displacement

(2) Force Removed

FIG. 43.3

(2) DATA OF PHASE I, WESTERN GROUP

FIG. 44.1

LATERAL TRACK STABILITY DATA

PHASE NO. I DATE Apr. 8, 1975 TRACK PANEL NO. A. WEST MAXIMUM FORCE 14,300 lbs.

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
2.0	0	0	0	0	0	.01	0	0	0	0	0
3.0	0	0	0	0	0	.02	.01	.01	0	0	0
4.0	0	0	0	0	0	.03	.02	.03	0	0	0
5.0	0	0	0	.01	.02	.05	.03	.04	.02	0	0
6.0	0	0	0	.01	.03	.06	.04	.06	.02	0	0
7.0	0	0	0	.02	.04	.07	.05	.07	.02	0	0
7.5	0	0	.04	.02	.05	.08	.07	.08	.03	0	0
8.0	0	0	.010	.03	.07	.10	.08	.10	.04	0	0
9.0	0	.003	.024	.06	.10	.12	.11	.14	.06	0	0
9.5	0	.006	.036	.08	.13	.16	.13	.15	.07	0	0
10.0	0	.011	.051	.11	.15	.19	.16	.16	.09	0	0
10.5	0	.018	.070	.14	.19	.22	.20	.20	.12	0	0
11.0	0	.030	.098	.19	.25	.28	.25	.22	.16	0	0
11.5	0	.037	.114	.22	.28	.32	.28	.24	.17	0	0
12.0	0	.051	.141	.26	.33	.36	.33	.26	.21	0	0
12.5	-.002	.078	.189	.33	.41	.44	.40	.32	.27	0	0
13.0	-.007	.103	(4)	.43	.53	.56	.52	.43	.36	0	0
13.5	-.010	.149	(4)	.50	.60	.63	.58	.50	.41	0	0
(1)	.061	1.115	(3)	2.20	2.37	2.37	2.30	1.92	1.89	.529	.01
(2)	.061	1.060	.456	1.77	1.95	1.83	1.83	1.55	1.56	.529	.01

(1) Max. Displacement
(2) Force Removed
(3) Transducer Limit
(4) Off-Scale of Strip Chart

FIG. 44.2

LATERAL TRACK STABILITY DATA

PHASE NO. I DATE Apr. 9, 1975 TRACK PANEL NO. B. WEST-FIRST PULL MAXIMUM FORCE 15,200 lbs.

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
2.0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	.01	0	0	0	0
3.0	0	0	0	0	0	0	.02	0	0	0	0
3.5	0	0	0	0	0	0	.02	0	0	0	0
4.0	0	0	0	0	0	0	.02	0	0	0	0
4.5	0	-.001	0	0	0	.01	.02	0	0	0	0
5.0	0	-.001	0	0	.01	.01	.03	0	0	0	0
5.5	0	-.001	0	0	.01	.02	.04	.01	.01	0	0
6.0	0	-.001	0	0	.01	.02	.04	.01	.01	0	0
6.5	0	-.002	0	0	.02	.03	.05	.02	.01	0	0
7.0	0	-.001	0	0	.03	.04	.06	.03	.02	0	0
7.5	0	-.001	0	0	.04	.05	.07	.04	.03	0	0
8.0	0	-.001	0	.01	.05	.07	.08	.05	.04	0	0
8.5	0	-.001	0	.02	.07	.08	.10	.06	.05	0	0
9.0	0	-.001	0	.03	.08	.10	.12	.09	.07	0	0
9.5	0	-.001	.002	.06	.12	.14	.17	.13	.10	0	0
10.0	0	-.001	.003	.07	.13	.15	.18	.14	.11	0	0
10.5	0	-.001	.004	.08	.15	.17	.20	.16	.13	0	0
11.0	0	-.001	.007	.10	.18	.20	.24	.19	.16	0	-.001
11.5	-.001	-.002	.013	.13	.22	.25	.28	.23	.19	.003	-.001
12.0	-.001	-.002	.023	.17	.26	.29	.33	.28	.24	.011	-.001
12.5	-.001	0	.040	.22	.32	.36	.40	.34	.30	.022	-.001
13.0	-.002	.007	.067	.27	.38	.42	.46	.43	.36	.037	-.001
13.5	-.003	.017	.097	.33	.45	.49	.54	.49	.41	.054	-.002
14.0	-.004	.034	.132	.39	.52	.56	.60	.56	.47	.071	-.002
14.5	-.004	.082	.233	.54	.71	.77	.81	.75	.67	.142	-.003
15.0	-.007	.119	.309	.69	.87	.94	.99	.94	.83	.203	-.007
(1)	-.009	.160	.377	.78	1.0	1.07	1.14	1.08	.96	.262	-.013
(2)	-.024	-	.390	.73	.82	.88	-	-	.84	.340	-.080
(1)	Max. Displacement										
(2)	Force Removed										

FIG. 44.3

LATERAL TRACK STABILITY DATA

PHASE NO. I DATE Apr. 9, 1975 TRACK PANEL NO. B.WEST - 2ND PULL MAXIMUM FORCE 15,600 lbs.

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
2.0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	.02	0	0	0	0
3.0	0	0	0	0	0	0	.03	0	0	0	0
3.5	0	0	0	0	.01	-.01	.04	0	0	0	0
4.0	0	0	0	0	.02	+.01	.05	.01	.01	0	0
4.5	0	0	0	0	.03	.02	.06	.02	.01	0	0
5.0	0	0	0	0	.04	.03	.07	.03	.02	0	0
5.5	0	0	.004	0	.05	.04	.09	.04	.03	0	0
6.0	0	0	.005	.01	.06	.05	.10	.05	.03	0	0
6.5	0	0	.008	.02	.08	.06	.12	.06	.05	0	0
7.0	0	0	.011	.02	.09	.07	.13	.07	.06	0	0
7.5	0	0	.013	.04	.11	.09	.15	.08	.07	0	0
8.0	0	0	.018	.05	.13	.10	.17	.10	.09	0	0
8.5	0	0	.022	.07	.13	.12	.19	.12	.10	0	0
9.0	0	0	.026	.07	.14	.14	.21	.13	.12	0	0
9.5	0	0	.030	.07	.16	.16	.23	.15	.13	0	0
10.0	0	0	.039	.09	.18	.18	.25	.17	.15	.002	0
10.5	0	0	.042	.10	.20	.20	.27	.18	.16	.003	0
11.0	0	0	.048	.12	.21	.22	.28	.20	.18	.005	0
11.5	0	0	.056	.13	.23	.24	.31	.22	.20	.007	0
12.0	0	0	.063	.15	.25	.26	.33	.24	.22	.011	0
12.5	0	.002	.074	.17	.28	.29	.36	.27	.24	.015	0
13.0	0	.004	.080	.20	.30	.31	.38	.30	.26	.016	-.01
14.0	0	.012	.111	.25	.37	.39	.45	.37	.32	.025	-.02
14.5	0	.019	.129	.29	.41	.43	.49	.41	.36	.036	-.02
15.0	0	.033	.164	.33	.47	.49	.56	.48	.41	.056	-.03
(1)	-	.184	1.165	1.62	1.91	1.82	1.96	1.75	1.73	.745	-.165
(2)	-	-.008	-.190	-.42	-.26	-.69	-.60	-.56	-.50	-.061	+.04

(1) Max. Displacement

(2) Force Removed

Page 1 of 2

FIG. 44.4

LATERAL TRACK STABILITY DATA											
APPLIED LOAD 1000 LBS	PHASE NO. I DATE Apr.9, 1975 TRACK PANEL NO. C. WEST MAXIMUM FORCE 20,250 lbs.										
	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
3.5	0	0	0	0	0	0	0	0	0	0	0
4.0	0	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0
5.0	0	0	0	0	.01	0	.01	0	0	0	0
5.5	0	0	0	.01	.01	0	.01	0	0	0	0
6.0	0	0	0	.01	.01	0	.01	.01	0	0	0
6.5	0	0	0	.01	.01	.01	.01	.01	0	0	0
7.0	0	0	0	.01	.02	.01	.02	.01	0	0	0
7.5	0	0	0	.01	.03	.02	.03	.01	0	0	0
8.0	0	0	0	.02	.03	.02	.03	.02	0	0	0
8.5	0	0	.001	.02	.04	.02	.04	.02	0	0	-.001
9.0	0	-.001	.004	.03	.05	.03	.05	.03	.01	0	-.002
9.5	0	-.001	.008	.04	.06	.04	.06	.04	.02	0	-.002
10.0	0	-.001	.011	.05	.07	.07	.07	.05	.02	0	-.002
10.5	0	-.001	.014	.05	.08	.08	.09	.06	.02	0	-.002
11.0	0	-.001	.018	.06	.10	.09	.10	.07	.02	0	-.002
11.5	0	-.001	.024	.07	.11	.11	.12	.08	.04	0	-.002
12.0	0	-.001	.030	.09	.13	.12	.13	.09	.04	0	-.002
12.5	0	-.001	.041	.10	.15	.15	.15	.11	.05	0	-.002
13.0	0	-.001	.052	.12	.17	.17	.17	.12	.06	0	-.002
13.5	0	-.001	.068	.15	.21	.20	.20	.15	.07	0	-.002
14.0	0	-.001	.083	.17	.24	.23	.24	.17	.10	.002	-.002
14.5	.001	0	.103	.20	.24	.27	.27	.20	.12	.007	-.002
15.0	.001	+.005	.134	.25	.28	.33	.32	.25	.16	.014	-.002
15.5	.001	.010	.158	.29	.33	.37	.36	.28	.18	.019	-.002
16.0	.001	.024	.207	.36	.38	.46	.43	.34	.22	.030	-.003
16.5	-.001	.035	.250	.41	.45	.53	.51	.40	.27	.042	-.003
17.0	0	.064	.344	.54	.52	.69	.66	.53	.36	.070	-.005
17.5	0	.077	.384	.59	.63	.74	.71	.58	.40	.079	-.005
18.0	-.001	.109	.466	.70	.86	.86	.82	.67	.46	.105	-.006
18.5	-.002	.157	.579	.84	1.03	1.02	.97	.80	.57	.145	-.009
19.0	-.002	.253	.776	1.09	1.29	1.29	1.22	1.04	.75	.228	-.014

FIG. 44.5

LATERAL TRACK STABILITY DATA

PHASE NO. I **DATE** Apr.9, 1975 **TRACK PANEL NO.** C. WEST **MAXIMUM FORCE** 20,250 lbs.

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
19.5	-.002	.350	.965	1.32	1.55	1.55	1.47	1.27	.92	.310	-.017
20.0	-.002	.477	1.187	1.58	1.83	1.84	1.74	1.52	1.14	.424	-.020
(1)	+.005	.575	1.50	1.77	-	2.05	1.95	1.72	1.30	.52	-.026
(2)	+.031	.659	1.22	1.53	2.08	1.69	1.60	1.46	1.20	.56	-.027

(1) Max. Displacement

(2) Force Removed

(3) DATA OF PHASE II, EASTERN GROUP

FIG. 45.1

LATERAL TRACK STABILITY DATA											
APPLIED LOAD 1000 LBS	PHASE NO. II DATE Aug.11, 1975 TRACK PANEL NO. A. EAST							MAXIMUM FORCE			
	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
						Rail					
2.5	0	0	0	0	0	0.040	0	0.010	0	0	0
3.75	0	0	0	0.020	0	0.050	0	0.010	0	0	0
5.0	0	0	0	0.040	0	0.060	0	0.010	0	0	0
6.25	0	0	0	0.050	0	0.070	0.010	0.020	0	0	0
7.50	0	0	0	0.070	0.020	0.110	0.030	0.030	0	0	0
8.75	0	0	0	0.090	0.030	0.130	0.050	0.040	0	0	0
10.0	0	0	0	0.090	0.040	0.140	0.060	0.040	0	0	0
11.25	0	0	0.011	0.110	0.070	0.170	0.090	0.050	0	0	0
12.5	0	0	0.030	0.150	0.110	0.220	0.130	0.070	0	0	0
15.0	0	0	0.220	0.360	0.350	0.470	0.370	0.150	0.090	0.015	0
15.25	0	0.004	0.415	0.640	0.650	0.770	0.640	0.250	0.230	0.058	0

Track Continued to Move W/No Increase in Load

FIG. 45.2

APPLIED LOAD 1000 LBS	LATERAL TRACK STABILITY DATA PHASE NO. II DATE Aug. 11, 1975 TRACK PANEL NO. B. EAST MAXIMUM FORCE TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
						(Rail)					
2.0	0	0	0	0	0	0.020	0	0	0	0	0
4.0	0	0	0	0.020	0.010	0.050	0	0	0	0	0
5.0	0	0	0	0.030	0.020	0.060	0	0	0	0	0
5.5	0	0	0	0.040	0.030	0.070	0	0	0	0	0
6.0	0	0	0	0.040	0.030	0.070	0	0	0	0	0
6.5	0	0	0	0.040	0.030	0.080	0	0	0	0	0
7.0	0	0	0	0.050	0.040	0.090	0.010	0	0	0	0
7.5	0	0	0	0.050	0.050	0.100	0.010	0	0	0	0
8.0	0	0	0	0.060	0.050	0.100	0.010	0	0	0	0
8.5	0	0	0	0.080	0.060	0.110	0.020	0	0	0	0
9.0	0	0	0	0.090	0.070	0.120	0.020	0.025	0	0	0
9.5	0	0	0	0.090	0.080	0.140	0.030	0.025	0.010	0	0
10.0	0	0	0	0.100	0.090	0.140	0.040	0.025	0.010	0	0
10.5	0	0	0	0.110	0.100	0.150	0.040	0.025	0.010	0	0
11.0	0	0	0	0.120	0.110	0.160	0.050	0.050	0.020	0	0
11.5	0	0	0	0.130	0.120	0.170	0.050	0.050	0.030	0	0
12.0	0	0	0	0.150	0.140	0.190	0.060	0.050	0.030	0	0
12.5	0	0	0	0.150	0.150	0.200	0.070	0.075	0.040	0	0
13.0	0	0	0	0.170	0.170	0.220	0.090	0.075	0.050	0	0
13.5	0	0	0.008	0.200	0.190	0.250	0.10	0.010	0.060	0	0
14.0	0	0	0.017	0.220	0.220	0.280	0.12	0.100	0.070	0	0
14.5	0	0	0.025	0.240	0.250	0.310	0.15	0.125	0.090	0	0
15.0	0	0	0.040	0.280	0.280	0.350	0.170	0.150	0.11	0	0
15.5	0	0	0.075	0.350	0.360	0.420	0.240	0.225	0.150	0	0
16.0	0	0.016	0.130	0.460	0.500	0.550	0.32	0.275	0.21	0	0
16.5	0	0.075	0.225	0.650	0.740	0.750	0.52	0.475	0.34	0	0
17.0	-0.005	0.116	0.322	0.770	0.840	0.870	0.67	0.600	0.44	0	0
Track Continues to Move With Decreasing Load.											

LATERAL TRACK STABILITY DATA

PHASE NO. II **DATE** Aug.12, 1975 **TRACK PANEL NO.** C. EAST **MAXIMUM FORCE**

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6 *	7	8	9	10	11
2.0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0
3.0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0	0
4.0	0	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0.020	0	0	0	0	0	0
6.0	0	0	0	0	0.020	0.010	0	0	0	0	0
7.0	0	0	0	0	0.030	0.010	0	0	0	0	0
8.0	0	0	0	0.020	0.030	0.010	0	0	0	0	0
9.0	0	0	0	0.040	0.050	0.030	0.01	0	0	0	0
9.5	0	0	0	0.050	0.060	0.030	0.01	0	0	0	0
10.0	0	0	0.005	0.050	0.060	0.040	0.01	0	0	0	0
10.5	0	0	0.010	0.060	0.070	0.040	0.015	0.005	0	0	0
11.0	0	0	0.016	0.070	0.080	0.050	0.020	0.005	0	0	0
11.5	0	0	0.021	0.070	0.080	0.050	0.020	0.01	0	0	0
12.0	0	0	0.029	0.080	0.090	0.060	0.025	0.01	0.01	0	0
12.5	0	0	0.040	0.100	0.110	0.080	0.03	0.01	0.01	0	0
13.0	0	0	0.055	0.120	0.130	0.090	0.035	0.015	0.01	0	0
13.5	0	0	0.073	0.150	0.150	0.120	0.045	0.02	0.02	0	0
14.0	0	0	0.085	0.160	0.170	0.140	0.050	0.02	0.02	0	0
14.5	0	0.005	0.115	0.210	0.230	0.180	0.060	0.04	0.03	0	0
15.0	0	0.010	0.130	0.220	0.240	0.200	0.080	0.04	0.05	-0.001	-0.001
15.5	0	0.015	0.154	0.250	0.270	0.240	0.09	0.045	0.06	-0.001	-0.002
16.0	0	0.026	0.186	0.300	0.330	0.290	0.12	0.06	0.09	-0.001	-0.002
16.5	0	0.045	0.240	0.370	0.410	0.380	0.145	0.09	0.14	0.013	-0.004
17.0	0	0.095	0.358	0.530	0.590	0.580	0.25	0.16	0.27	0.053	-0.006
17.5	0	0.165	0.512	0.730	0.830	0.820	0.37	0.25	0.46	0.130	-0.005
18.0	0	0.240	0.672	0.950	1.080	1.090	0.68	0.38	0.61	0.205	-0.010
18.5	0	0.310	0.810	1.120	1.270	1.290	1.01	0.67	0.88	0.325	-0.019
19.0	0	0.642	1.331	1.710	1.880	1.900	1.55	1.13	1.27	0.568	--
19.6	0	0.720	1.425	1.900	2.100	2.130	1.81	1.45	1.45	0.692	--
Panel Continued to Move with Decreasing Load											*Rail

FIG. 45.3

(4) DATA OF PHASE II, WESTERN GROUP

LATERAL TRACK STABILITY DATA

PHASE NO. II DATE Aug.13, 1975 TRACK PANEL NO. A. WEST MAXIMUM FORCE

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT 1	2	3	4	5	6	7	8	9	10	11
						(Rail)					
4.0	0	0	0	0	0	0.045	0.010	0	0	0	0
4.5	0	0	0	0	0	0.050	0.010	0.010	0	0	0
5.0	0	0	0	0	0	0.050	0.010	0.010	0	0	0
5.5	0	0	0	0	0	0.055	0.010	0.010	0	0	0
6.0	0	0	0	0.010	0.010	0.060	0.010	0.010	0	0	0
6.5	0	0	0	0.010	0.010	0.060	0.010	0.010	0	0	0
7.0	0	0	0	0.010	0.010	0.070	0.010	0.010	0	0	0
7.5	0	0	0	0.015	0.015	0.070	0.010	0.010	0	0	0
8.0	0	0	0	0.015	0.020	0.075	0.010	0.010	0	0	0
8.5	0	0	0	0.020	0.020	0.080	0.020	0.010	0	0	0
9.0	0	0	0	0.020	0.025	0.085	0.020	0.010	0	0	0
9.5	0	0	0	0.025	0.030	0.090	0.020	0.010	0.010	0	0
10.0	0	0	0	0.030	0.030	0.090	0.020	0.020	0.010	0	0
11.0	0	0	0	0.035	0.040	0.100	0.020	0.020	0.010	0	0
11.5	0	0	0	0.040	0.050	0.110	0.030	0.020	0.010	0	0
12.0	0	0	0	0.040	0.050	0.110	0.030	0.020	0.020	0	0
12.5	0	0	0	0.050	0.060	0.125	0.030	0.030	0.020	0	0
13.0	0	0	0	0.050	0.060	0.130	0.030	0.030	0.020	0	0
13.5	0	0	0	0.060	0.070	0.140	0.040	0.030	0.030	0	0
14.0	0	0	0.001	0.070	0.080	0.150	0.040	0.040	0.040	0	0
14.5	0	0	0.006	0.080	0.090	0.170	0.050	0.040	0.050	0	0
15.0*	0	0	.013	.090	.11	.19	.060	.050	.060	0	0
15.5	0	0	0.020	0.110	0.140	0.220	0.070	0.060	0.080	0	0
16.0	0	0	0.026	0.130	0.160	0.250	0.090	0.070	0.090	0	0
16.3							0.200	0.15	0.250	0	0

Tracks Continued to Deform with Decreasing Load.

(* Data for 15.0 Load Interpolated as Actual Displacement Figures not Available)

FIG. 46.1

FIG. 46.2

LATERAL TRACK STABILITY DATA

PHASE NO. II DATE Aug.13, 1975 TRACK PANEL NO. B.WEST MAXIMUM FORCE

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7	8	9	10	11
							(Rail)				
2.0	0	0	0	0	0	0	0	0	0	0	0
4.0	0	0	0	0	0	0	0	0	0	0	0
5.0	0	0	0	0	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0	0	0	0	0
6.0	0	0	0	0	0.010	0.010	0.010	0	0	0	0
6.5	0	0	0	0	0.010	0.010	0.010	0	0	0	0
7.0	0	0	0	0	0.010	0.010	0.010	0	0	0	0
7.5	0	0	0	0	0.010	0.010	0.010	0	0	0	0
8.0	0	0	0	0	0.010	0.020	0.010	0	0	0	0
8.5	0	0	0	0.010	0.020	0.020	0.010	0	0	0	0
9.0	0	0	0	0.010	0.020	0.020	0.020	0.025	0.010	0	0
9.5	0	0	0	0.010	0.020	0.030	0.020	0.025	0.010	0	0
10.0	0	0	0	0.010	0.030	0.030	0.020	0.025	0.010	0	0
10.5	0	0	0	0.010	0.030	0.040	0.020	0.025	0.020	0	0
11.0	0	0	0	0.020	0.040	0.040	0.030	0.025	0.020	0	0
11.5	0	0	0	0.020	0.040	0.050	0.030	0.025	0.030	0	0
12.0	0	0	0	0.020	0.050	0.060	0.040	0.050	0.030	0	0
13.0	0	0	0	0.030	0.060	0.070	0.040	0.050	0.040	0	0
13.5	0	0	0	0.030	0.060	0.080	0.050	0.050	0.050	0	0
14.0	0	0	0	0.040	0.080	0.090	0.050	0.075	0.060	0	0
14.5	0	0	0	0.040	0.080	0.100	0.060	0.075	0.070	0	0
15.0	0	0	0	0.050	0.090	0.110	0.060	0.100	0.080	0	0
15.5	0	0	0	0.060	0.110	0.140	0.070	0.125	0.100	0	-0.00
16.0	0	0	0	0.070	0.130	0.160	0.090	0.150	0.110	0	-0.00
17.0	0	0	0	0.120	0.200	0.250	0.140	0.225	0.200	0	-0.00
17.5	-0.001	0	0.023	0.240	0.350	0.42	0.220	0.400	0.350	0.004	-0.003
17.0							1.920				
Panel Continued to Move with Decreasing Load.											

FIG. 46.3

LATERAL TRACK STABILITY DATA

PHASE NO. II DATE Aug.12, 1975 TRACK PANEL NO. C. WEST MAXIMUM FORCE

TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT

APPLIED LOAD 1000 LBS	1	2	3	4	5	6 (Rail)	7	8	9	10	11
1.5	0	0	0	0	0	0	0	0	0	0	0
2.0	0	0	0	0	0	0	0	0	0	0	0
3.0	0	0	0	0	0	0	0	0	0	0	0
4.0	0	0	0	0	0	0	0	0	0	0	0
5.0	0	0	0	0.010	0.010	0.010	0.010	0	0	0	0
6.0	0	0	0	0.020	0.020	0.020	0.020	0.025	0.010	0	0
7.0	0	0	0	0.020	0.040	0.050	0.030	0.050	0.020	0	0
8.0	0	0	0	0.040	0.060	0.060	0.040	0.050	0.020	0	0
10.0	0	0	0.016	0.070	0.100	0.110	0.060	0.100	0.060	0	0
11.0	0	0	0.080	0.170	0.240	0.260	0.090	0.125	0.080	0	0
12.0	0	0	0.089	0.190	0.260	0.290	0.140	0.225	0.150	0.009	0
12.5	0	0	0.107	0.220	0.300	0.340	0.160	0.250	0.170	0.015	0
13.0	0	0	0.155	0.290	0.390	0.420	0.200	0.350	0.220	0.030	-0.001
13.5	0	0.006	0.170	0.310	0.420	0.450	0.220	0.375	0.240	0.035	-0.002
14.0	0	0.029	0.254	0.420	0.570	0.610	0.300	0.500	0.350	0.069	-0.004
14.5	-0.001	0.072	0.424	0.590	0.770	0.810	0.400	0.700	0.500	0.125	-0.007
15.0	-0.009	0.167	(4)	0.820	1.040	1.100	0.740	0.950	0.700	0.209	-0.011
15.4	-0.010	0.180	0.675	0.980	1.220	1.280	1.240	1.725	0.840	0.274	-0.016

Panel Continues to Move with Decreasing Load.

(4) Off-Scale of Strip Chart

(5) DATA OF CONTROL PANEL GROUP

FIG. 47.1

LATERAL TRACK STABILITY DATA

PHASE NO. II **DATE** Aug.14, 1975 **TRACK PANEL NO.** D. EAST **MAXIMUM FORCE**

TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT

APPLIED LOAD 1000 LBS	1	2	3	4	5	6	7	8	9	10	11
							(Rail)				
2.0	0	0	0	0	0	0	0.010	0	0	0	0
3.0	0	0	0	0	0	0	0.010	0	0	0	0
4.0	0	0	0	0	0	0	0.010	0	0	0	0
5.0	0	0	0	0	0	0	0.010	0	0	0	0
6.0	0	0	0	0	0	0	0.010	0	0	0	0
7.0	0	0	0	0	0	0	0.020	0	0	0	0
8.0	0	0	0	0	0	0.010	0.020	0	0.010	0	0
9.0	0	0	0	0.010	0.010	0.010	0.020	0	0.010	0	0
10.0	0	0	0	0.010	0.010	0.020	0.030	0	0.020	0	0
11.0	0	0	0	0.010	0.020	0.030	0.030	0	0.020	0	0
12.0	0	0	0	0.010	0.020	0.030	0.030	0	0.030	0	0
13.0	0	0	0	0.010	0.030	0.040	0.040	0.025	0.040	0	0
14.0	0	0	0	0.020	0.030	0.050	0.040	0.025	0.040	0	0
15.0	0	0	0	0.020	0.040	0.050	0.040	0.025	0.050	0	0
16.0	0	0	0	0.030	0.040	0.060	0.050	0.025	0.060	0	0
17.0	0	0	0	0.030	0.050	0.070	0.050	0.025	0.070	0	0
18.0	0	0	0.001	0.040	0.060	0.080	0.060	0.050	0.070	0	0
19.0	0	0	0.006	0.050	0.070	0.100	0.070	0.050	0.090	0	0
20.0	0	0	0.009	0.060	0.090	0.120	0.080	0.075	0.100	0	0
21.0	0	0	0.013	0.060	0.100	0.140	0.070	0.075	0.120	0	0
22.0	0	0	0.017	0.080	0.120	0.150	0.080	0.100	0.140	0	-.001
23.0	0	0	0.019	0.080	0.130	0.170	0.090	0.125	0.150	0	-.001
24.0	0	0	0.032	0.110	0.170	0.220	0.110	0.175	0.190	0	-.001
25.0	0	0	0.041	0.140	0.200	0.250	0.140	0.175	0.220	0	-.002
26.0	0	0	0.059	0.170	0.250	0.320	0.160	0.250	0.270	0	-.002
26.5	0	0	0.080	0.220	0.320	0.390	0.200	0.325	0.330	0.006	-.004
27.0	0	0	0.111	0.300	0.400	0.480	0.240	0.325	0.410	0.020	-.006
Test Terminated at 26K# to Protect Cable.											

FIG. 47.2

LATERAL TRACK STABILITY DATA

PHASE NO. II DATE Aug.14, 1975 TRACK PANEL NO. E. EAST MAXIMUM FORCE

TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT

APPLIED LOAD 1000 LBS	1	2	3	4	5	6	7	8	9	10	11
							(Rail)				
4.0	0	0	0	0	0	0	0.010	0	0	0	0
5.0	0	0	0	0	0	0	0.010	0	0	0	0
6.0	0	0	0	0	0	0	0.010	0	0.010	0	0
7.0	0	0	0	0	0	0	0.020	0	0.010	0	0
8.0	0	0	0	0	0.010	0	0.020	0	0.020	0	0
9.0	0	0	0	0	0.010	0.010	0.030	0	0.020	0	0
10.0	0	0	0	0	0.020	0.010	0.030	0	0.030	0	0
11.0	0	0	0	0	0.020	0.010	0.030	0	0.030	0	0
12.0	0	0	0	0.010	0.020	0.020	0.030	0.025	0.030	0	0
13.0	0	0	0	0.010	0.030	0.020	0.030	0.025	0.040	0	0
14.0	0	0	0	0.010	0.030	0.020	0.040	0.025	0.040	0	0
15.0	0	0	0	0.010	0.040	0.030	0.040	0.025	0.050	0	0
16.0	0	0	0	0.010	0.040	0.030	0.040	0.025	0.050	0	0
17.0	0	0	0	0.010	0.050	0.040	0.050	0.025	0.060	0	0
18.0	0	0	0	0.010	0.050	0.040	0.050	0.025	0.060	0	0
19.0	0	0	0	0.010	0.060	0.050	0.050	0.050	0.070	0	0
20.0	0	0	0	0.010	0.060	0.050	0.060	0.050	0.070	0	0
21.0	0	0	0	0.010	0.070	0.060	0.060	0.050	0.080	0	0
22.0	0	0	0	0.010	0.070	0.060	0.060	0.050	0.080	0	0
23.0	0	0	0	0.020	0.080	0.070	0.060	0.050	0.090	0	0
24.0	0	0	0	0.020	0.090	0.080	0.070	0.075	0.100	0	0
25.0	0	0	0	0.020	0.090	0.090	0.070	0.075	0.100	0	0
26.0	0	0	0	0.020	0.100	0.100	0.080	0.100	0.110	0	0

FIG. 47.3

LATERAL TRACK STABILITY DATA

PHASE NO. II **DATE** Aug.14, 1975 **TRACK PANEL NO.** D. WEST **MAXIMUM FORCE**

TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT

APPLIED LOAD 1000 LBS	1	2	3	4	5	6	7	8	9	10	11
						(Rail)					
2.7	0	0	0	0.010	0.010	0.040	0.010	0	0	0	0
4.0	0	0	0	0.020	0.010	0.040	0.010	0	0	0	0
5.0	0	0	0	0.020	0.020	0.040	0.010	0	0	0	0
6.0	0	0	0	0.020	0.020	0.040	0.010	0.025	0	0	0
7.0	0	0	0	0.030	0.030	0.060	0.010	0.025	0	0	0
8.0	0	0	0	0.030	0.030	0.060	0.010	0.025	0	0	0
9.0	0	0	0	0.040	0.040	0.070	0.020	0.025	0	0	0
10.0	0	0	0	0.040	0.040	0.080	0.020	0.025	0	0	0
11.0	0	0	0.003	0.050	0.050	0.080	0.020	0.050	0	0	0
12.0	0	0	0.005	0.050	0.050	0.090	0.020	0.050	0	0	0
13.0	0	0	0.006	0.060	0.060	0.100	0.030	0.050	0	0	0
14.0	0	0	0.008	0.060	0.070	0.100	0.030	0.050	0	0	0
15.0	0	0	0.010	0.070	0.070	0.110	0.030	0.050	0	0	0
16.0	0	0	0.011	0.070	0.080	0.110	0.030	0.050	0	0	0
17.0	0	0	0.014	0.080	0.090	0.120	0.040	0.075	0.010	0	0
18.0	0	0	0.016	0.090	0.090	0.130	0.040	0.075	0.010	0	0
19.0	0	0	0.017	0.090	0.100	0.150	0.050	0.100	0.010	0	0
20.0	0	0	0.019	0.100	0.110	0.150	0.050	0.100	0.0020	0	0
21.0	0	0	0.022	0.110	0.110	0.160	0.050	0.100	0.020	0	0
22.0	0	0	0.023	0.110	0.120	0.170	0.060	0.125	0.020	0	0
23.0	0	0	0.027	0.130	0.140	0.190	0.070	0.125	0.020	0	0
24.0	0	0	0.029	0.130	0.140	0.199	0.070	0.125	0.030	0	0
25.0	0	0	0.031	0.140	0.150	0.200	0.070	0.150	0.030	0	0
26.0	0	0	0.035	0.150	0.170	0.220	0.080	0.150	0.030	0	0

Test Terminated at 26K# to Protect Cable.

FIG. 47.4

LATERAL TRACK STABILITY DATA

PHASE NO. II DATE Aug.13, 1975 TRACK PANEL NO. E. WEST MAXIMUM FORCE

APPLIED LOAD 1000 LBS	TRANSDUCER NUMBER AND INCHES OF DISPLACEMENT										
	1	2	3	4	5	6	7 (Rail)	8	9	10	11
4.0	0	0	0	0	0.010	0.030	0	0	0	0	0
5.0	0	0	0	0	0.020	0.030	0	0	0	0	0
6.0	0	0	0	0.010	0.020	0.040	0	0	0	0	0
7.0	0	0	0	0.010	0.030	0.050	0.010	0	0	0	0
8.0	0	0	0	0.020	0.030	0.050	0.010	0.010	0	0	0
9.0	0	0	0	0.020	0.040	0.060	0.010	0.010	0.010	0	0
10.0	0	0	0	0.020	0.050	0.070	0.010	0.010	0.010	0	0
11.0	0	0	0	0.030	0.050	0.070	0.020	0.010	0.020	0	0
12.0	0	0	0	0.040	0.060	0.080	0.020	0.020	0.020	0	0
13.0	0	0	0	0.040	0.060	0.090	0.020	0.020	0.020	0	0
14.0	0	0	0	0.060	0.070	0.100	0.030	0.020	0.030	0	0
15.0	0	0	0	0.060	0.080	0.110	0.030	0.020	0.030	0	0
16.0	0	0	0	0.060	0.090	0.110	0.030	0.030	0.040	0	-0.001
17.0	0	0	0	0.070	0.090	0.120	0.040	0.030	0.040	0	-0.002
18.0	0	0	0	0.070	0.110	0.140	0.040	0.030	0.040	0	-0.002
19.0	0	0	0	0.080	0.110	0.150	0.050	0.050	0.050	0	-0.002
20.0	0	0	0	0.090	0.120	0.150	0.050	0.040	0.050	0	-0.003
21.0	0	0	0	0.090	0.130	0.160	0.060	0.040	0.050	0	-0.003
22.0	0	0	0	0.100	0.150	0.180	0.060	0.050	0.060	0	-0.003
23.0	0	0	0	0.110	0.150	0.200	0.070	0.050	0.070	0	-0.004
24.0	0	0	0	0.120	0.170	0.210	0.080	0.060	0.080	0	-0.004
25.0	0	0	0	0.140	0.190	0.230	0.080	0.060	0.080	0	-0.004
26.0	0	0	0	0.150	0.200	0.240	0.090	0.070	0.090	0	-0.004
27.0	0	0	0	0.160	0.220	0.260	0.100	0.070	0.100	0	-0.005
28.0	0	0	0	0.180	0.240	0.290	0.110	0.080	0.110	0	-0.005
28.5	0	0	0	0.190	0.260	0.310	0.120	0.090	0.120	0	-0.005
Cable Broke.											

APPENDIX E

TEST LOG SHEETS

TEST LOG SHEET

Run Series: Lateral Track Stability Date: 7 April 1975

Test Director: I. A. Reiner

Recorded by: A. E. Krenzel

10:30 Arrived at Sabot Test Site. Persons present:

I. A. Reiner, Test Director, Chessie Systems

J. T. May, Test Engineer, Reaction Instruments

A. E. Krenzel, Support Engineer, Reaction Instruments

C. C. Dean, Support, Reaction Instruments

B. R. Lemaster, Support, Reaction Instruments

C. W. Mason, Support, Reaction Instruments

Mr. Henley, Chessie Systems

Location of test is approx. 150 yds. East & West of Sabot Station.

The track is 132 pound rail with limestone ballast. The ties in the test area consist of:

A. East - New ties

B. East - New and old ties mixed

C. East - Concrete ties

A. West - New ties

B. West - New and old ties mixed

C. West - Concrete ties

Weather is clear with temperature estimated at 50^{o}, 5-10 MPH winds.

10:45 Advised by Mr. Henley that the track has been closed for testing through 16:00 hours, Thursday, 10 April, 1975. Testing could continue past 16:00 each day if necessary.

Track crew has raised and tamped the track on East End. 2" lift, alternate tie tamp.

11:45 Moved test equipment into test area and began preparation for pulling Panel A. East. Joint end clearance obtained by removing adjoining rail.

12:15 Dozer and hydraulics in place. Break for lunch.

13:15 Began set-up of Signal Conditioning and hooking of Transducers. Decision made to move #11 Transducer to measure center of rail movement over 4" range. Set-up wire across track to measure change in rail height, both sides.

Load cell amplifier sensitivities, Brush chart channel assignments and scaling as follows:

	Exitation	Gain	Brush Chart Channel	B C Scale
Load Cell	10.000V	2.485	12	10 $\frac{MV}{div}$
Tranducer #1	9.539V	-	1	2.5 $\frac{MV}{div}$
#2	9.605V	-	2	2.5 $\frac{MV}{div}$
#3	9.585V	-	3	2.5 $\frac{MV}{div}$
#4	15.342V	-	4	25 $\frac{MV}{div}$
#5	15.409V	-	5	25 $\frac{MV}{div}$
#6	15.387V	-	6	25 $\frac{MV}{div}$
#7	15.348V	-	7	25 $\frac{MV}{div}$
#8	15.383V	-	8	25 $\frac{MV}{div}$

	Exitation	Gain	Brush Chart Channel	B C Scale
#9	15.467V	-	9	$25\ \frac{MV}{div}$
#10	9.760V	-	10	$2.5\ \frac{MV}{div}$
#11	9.567V	-	11	$2.5\ \frac{MV}{div}$

14:40 Set-Up completed. Began taking up slack of cable on dozer.

14:41 Began Test.

14:45 Pump Cavitation, Applied load of 1750#

14:47 Resume Test.

15:06 Complete Test.

15:15 Removed equipment from Panel A East onto Panel B. East.

15:45 Started setting up equipment on B East.

16:35 Set-up completed all equipment zeroed. Ready for test.

16:40 Applied 1100# with dozer. Channel 6 is measuring rail distance. Returned transducer #11 to original position.

16:45 Waiting for traffic to pass.

17:05 Began testing.

17:26 Testing of Panel B East completed.

17:30 Removed test equipment from test site into truck for storage.

18:15 Left test area.

06:15 Crew call. Date: 8 April 1975

08:00 Arrived at Sabot Station. Persons present:

I. A. Reiner - Test Director, Chessie Systems.

Mr. Henley, Chessie Systems.

A. E. Krenzel, Test Engineer, Reaction Instruments.

C. C. Dean, Support, Reaction Instruments.

B. R. Lemaster, Support, Reaction Instruments.

C. W. Mason, Support, Reaction Instruments

Weather is approx. 50°F, clear with winds of 5-10 MPH.

08:15 Removed equipment from truck onto hand car.

08:45 Cleared siding and moved to test area, panel C East.

10:15 Set-up completed. Reading for testing.

10:25 Test Started.

10:35 Pressure to 6400#. Cable on dozer spool slipping. Tightened to 7000#.

10:40 Resume testing.

10:55 Test completed.

11:00 Began removal of equipment.

11:30 Area C East cleared. Moved back to Sabot station to wait for Consolidator to complete work on West end.

11:45 Took photos of Consolidator at work. Confirmed 5 sec. consolidation time with FRA.

13:15 Arrived at panel A West with equipment. Reversed dozer and dug in the blade with cable running under the dozer and over the blade.

14:05 Finished driving posts needed for todays test. Hooked up transducers and waiting for train to pass.

15:00 All transducers connected. Zeroes drifting due to workmen moving adjoining rail to gain slack for rail gap. Workmen completed work and all transducers rezeroed.

15:20 Starting test.

16:13 Test Completed.

16:45 All equipment removed from Panel A West. Left test area to store all equipment in truck.

17:15 Loading completed. All personnel left for motel.

06:15 Crew Call Date: 9 April 1975

08:00 Arrived at Sabot Station. Persons present.
I. A. Reiner, Test Director, Chessie System.
A. E. Krenzel, Test Engineer, Reaction Instruments.
C. C. Dean, Support, Reaction Instruments.
B. R. Lemaster, Support, Reaction Instruments.
C. W. Mason, Support, Reaction Instruments.
Mr. Henley, Chessie Systems.

Location of todays test will be approximately 150 yds. West of Sabot Station.

Weather is clear. Slight wind, temperature approx. 50°F.

08:20 Completed loading equipment onto hand car.

08:30 Arrived at test site, Panel B. West. Waiting for train to pass.

09:20 All transducers in place and leveled. Hydraulics hooked-up. Waiting for track men to move rail for gap.

09:45 Crew completed work. Now transducers and load cell can be hooked up and zeroed.

10:07 Coal train will be on siding during test. Stopped only 3 car lengths from passing the entire test area. Asked dispatcher if the train could move down 3 car lengths. There was room to move 2 lengths but the slack absorbed 2 car lengths with no movement on West end at test site.

10:47 Began test.

11:32 Test Completed.

Had problem with cable on the spool. It was necessary to re-hook after 14,000# and 1.6" of displacement. Approximately 15' of cable had been rewound on spool prior to test to prevent slippage but the problem still existed.

No spikes in tie #23, last tie, on West end of Panel.

11:40 Removed equipment from Panel B West onto Panel C West.

12:15 Stopped for lunch.

12:45 Started hooking up equipment. Transducers zeroed, load cell zeroed, hydraulics hooked-up.

13:00 Dr. John Gerig, President, Reaction Instruments, and Joe T. May, Reaction Instrument, arrived to observe testing.

13:45 Ready for test. Waiting for train to pass.

14:00 Test beginning. Second train holding until test completed.

14:10 Posts come out of spreader. Stopped test. Dug out ballast and re-hooked spreader.

14:16 Re-started test.

14:22 Passing 12,500# with no problem.

14:32 Test completed.

14:35 Removed all equipment from Panel back onto hand car, cleaned up area, and returned to Sabot Station.

15:45 Completed loading all equipment back into truck.

16:00 Crane arrived for loading consolidator back onto flat car.

16:15 Loading completed.

17:30 Completed tightening all cables and clamps on consolidator.

17:45 Crew cleared area for home.

TEST LOG SHEET

Date 11 August 1975

Run Series: Lateral Track Stability after seven million gross tons.

Test Director: I. A. Reiner

Recorded by: A. B. Gordon

08:30 Arrived at Sabot, Va. Test Site. Personnel present:

J. T. May, Test Engineer, Reaction Instruments

A. E. Krenzel, Support Engineer, Raction Instruments

A. B. Gordon, Support Engineer, Reaction Instruments

B. R. LeMaster, Support, Reaction Instruments

C. W. Mason, Support, Reaction Instruments

Mr. Henley, Chessie Systems.

Location of test is approximately 150 yds. East & West of Sabot Station.

The track is 132 pound rail with limestone ballast. The ties in the test area consist of:

A. East - New ties)
B. East - New and old ties mixed) Unconsolidated
C. East - Concrete ties)

A. West - New ties)
B. West - New and old ties mixed) Consolidated
C. West - Concrete ties)

Weather is hot and humid with temperatures ranging daily from 85^{o} in morning to 95^{o} in afternoon.

Advised by Mr. Henley that the tracks have been closed for testing through 16:00 hrs., Friday, 15 August, 1975.

August 11 1975

09:30 Equipment loaded on hand car and moved to test site.

11: 30 Visitors' arrive: Levitt Peterson, FRA: Joe Wandrisco, FRA

11:45 Test Panel A - East Channel #6 is rail deflection

Initial sensitivity and offset valves:

		Sensitivity		Offset
Transducer	# 1	2.5	mv/div	0.04 inchs
	# 2	2.5	"	0.04 "
	# 3	2.5	"	0.04 "
	# 4	25.0	"	0.4 "
	# 5	25.0	"	0.4 "
	# 6	25.0	"	0.4 "
	# 7	25.0	"	0.4 "
	# 8	62.5	"	0.8 "
	# 9	25.0	"	0.0 "
	#10	2.5	"	0.04 "
	#11	2.5	"	0.04 "

Load cell data:
Excitation: 10.003 volts
Calibration: 2.48 volts
Zero: 0.03 volts
25 mv/div. sensitivity 0.0 lbs. offset

12:38 Test begins

12:55 Adjust cable on winch because of slippage

13:00 All Channels zeroed

13:15 Channel #6 tested for cresting

13:16 Test complete.

13.45 Lunch

11 August 1975

14:15 Test Panel B. East

	Sensitivity		Offset
Transducer # 1	2.5	mv/div.	0.04 inches
# 2	2.5	"	0.04 "
# 3	2.5	"	0.04 "
# 4	25.0	"	0.4 "
# 5	25.0	"	0.4 "
# 6	25.0	"	0.4 "
# 7	25.0	"	0.4 "
# 8	62.5	"	0.8 "
# 9	25.0	"	0.0 "
#10	2.5	"	0.04 "
#11	2.5	"	0.04 "

Load cell data. Excitation :
(Channel # 12) Calibration:
Zero :
10 mv/ div. sensitivity 0.0 lbs. offset
9.997 volts

15:21 Test complete 2.48 volts

15:00 J. T. May returns to Washington D. C. 0.038 volts

12 August 1975

08:30 **Mr. I.A.** Reiner arrives at test site

08:30 **Test Panel** C East   Channel # 6 is rail deflection

08:45 Reorder Channels electrically zeroed. Dividers checked. Power Supplies

Trimmed to 15.000 volts

16.000 volts

		Sensitivity		Offset	
09:05	Transducer # 1	2.5	mv/div.	0.04	inches
	# 2	2.5	"	0.44	"
	# 3	2.5	"	0.44	"
	# 4	25.0	"	0.4	"
	# 5	25.0	"	0.4	"
	# 6	25.0	"	0.4	"
	# 7	25.0	"	0.4	"
	# 8	62.5	"	0.4	"
	# 9	25.0	"	0.4	"
	#10	2.5	"	0.04	"
	#11	2.5	"	0.04	"

Test Personnel:

I.A. Reiner
A. E. Krenzel
A. B. Gordon
B. R. Lemaster
C. W. Mason

Loadcell data: Excitation: 9.997 volts
(Channel # 12) Calibration: 2.48 volts
Zero: 0.038 volts

10 mv/div. sensitivity   0.0 lbs offset

09:38 Stop test at 5 klbs. to re-arrange yoke timbers

09:43 Re-start test at 3.9 klbs.

10:07 Stop test at 19 klbs.

10:10 Take-up slack and pull panel until channel #6 shows cresting.

10:15 Test Completed.

12 August 1975

11:00 Test Panel C West Channel # 6 is rail deflection

11:55 Power Supplies trimmed to ±15.000 volts
+16.000 volts
11:55 Dividers Trimmed

11:58

	Sensitivity		Offset
Transducer # 1	2.5	mv/div	0.16 inches
# 2	2.5	"	0.04 "
# 3	2.5	"	0.04 "
# 4	25.0	"	0.4 "
# 5	25.0	"	0.4 "
# 6	25.0	"	0.4 "
# 7	25.0	"	0.4 "
# 8	62.5	"	0.4 "
# 9	25.0	"	0.4 "
#10	2.5	"	0.04 "
#11	2.5	"	0.36 "

Test Personnel:
I. A. Reiner
A. E. Krenzel
A. B. Gordon
B. R. Lemaster
C. W. Mason

01:00 Load cell data:
10.0 mv/div.
sensitivity
0.0 lbs. offset

Excitation: 9.997 volts
Calibration: 2.48 volts
Zero: 0.035 volts

12:00 Stop for lunch

12:50 Power Supplies Trimmed. Dividers Trimmed.

12:59 West bound train passes on parallel track

13:21 Test begins (5 mm/sec. chart speed)

13:37 Test stopped at 15 klbs. All transducers disconnected except channel #6.

13:40 Test resumed until channel #6 showed cresting.

13:41 Test completed

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☆U.S. GOVERNMENT PRINTING OFFICE: 1977-261-264/514

Lateral Resistance of Railroad Track (Final Report), 1977
US DOT, FRA

DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION
Washington, D.C. 20590

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