USER'S MANUAL

2, 3, & 4 AXLE RIGID TRUCK CURVE NEGOTIATION MODEL

K. R. Smith
R. D. MacMillan
G. C. Martin

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An International Government-Industry Research Program on Track-Train Dynamics

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BACKGROUND INFORMATION
on the
TRACK-TRAIN DYNAMICS PROGRAM

The Track-Train Dynamics Program encompasses studies fo the dynamic interaction of a train consist with track as affected by operating practices, terrain, and climatic conditions.

Trains cannot move without these dynamic interactions. Such interactions, however, frequently manifest themselves in ways climaxing in undesirable and costly results. While often differing and sometimes necessarily so, previous efforts to reasonably control these dynamic interactions have been reflected in the operating practices of each railroad and in the design and maintenance specifications for track and equipment.

Although the matter of track-train dynamics is by no means a new phenomena, the increase in train lengths, car sizes and loadings has emphasized the need to reduce wherever possible excessive dynamic train action. This, in turn, requires a greater effort to achieve more control over the stability of the train as speeds have increased and railroad operations become more systemized.

The Track-Train Dynamics Program is representative of many new programs in which the railroad industry is pooling its resources for joint study and action.

A major planning effort on track-train dynamics was initiated in July 1971 by the Southern Pacific Transportation Company under contract to the AAR and carried out with AAR staff support. Completed in early 1972, this plan clearly indicated that no individual railroad has both the resouces and the incentive to undertake the entire program. Therefore, the AAR was authorized by its Board to proceed with the Track-Train Dynamics Program.

In the same general period, the FRA signaled its interest in vehicle dynamics by development of plans for a major test facility. The design of a track loop for train dynamic testing and the support of related research programs were also pursued by the FRA.

In organizing the effort, it was recognized that a substantial body of information and competence on this problem resided in the railroad supply industry and that significant technical and financial resources were available in government.

Through the Railway Progress Institute, the supply industry coordinated its support for this program and has made available men, equipment, data from earlier proprietary studies, and monetary contributions.

Through the FRA, contractor personnel and direct financial resources have been made available.

Through the Transportation Development Agency, the Canadian Government has made a major commitment to work on this problem and to coordinate that work with the United States' effort.

Through the Office de Recherches et D'Essais, the research arm of the Union Internationale des Chemins de Fer, the basis for a full exchange of information with European groups active in this field had been arranged.

The Track-Train Dynamics Program is managed by the Research and Test Department of the Association of American Railroads under the direction of an industry-government steering committee. Railroad members are designated by elected members of the AAR's Operation-Transportation General Committee, supply industry members by the Railway Progress Institute, U. S. Government members by the Federal Railroad Administration, and Canadian Government members by the Transportation Development Agency. Appropriate task forces and advisory groups are established by the steering committee on an ad hoc basis, as necessary to pursue and resolve elements of the program.

The staff of the program comprises AAR employees, personnel contributed on a full- or part-time basis by railroads or members of the supply industry, and personnel under contract to the Federal Railroad Administration or the Transportation Development Agency.

The program plan as presented in 1972 comprised:

1) Phase I -- 1972-1974

   Analysis of and interim action regarding the present dynamic aspects of track, equipment, and operations to reduce excessive train action.

2) Phase II -- 1974-1977

   Development of improved track and equipment specifications and operating practices to increase dynamic stability.

3) Phase III -- 1977-1982

   Application of more advanced scientific principles to railroad track, equipment, and operations to improve dynamic stability.

Phase I officially ended in December of 1974. The major technical elements of Phase I included:

a) The establishment of the dynamic characteristics of track and equipment.

b) The development and validation of mathematical models to permit the rapid analysis of the effects on dynamic stability of modifications in design, maintenance, and use of equipment and track structures.

c) The development of interim guidelines for train handling, makeup, track structures, and engineer training to reduce excessive train action.

The attached report represents the user's manual documentation for the 2,3,and 4 Axle Rigid Truck Curve Negotiation Model, which was developed as an element of item b) above.

ACKNOWLEDGEMENT

The contents of the manual are largely based upon a program developed by Mr. Karl R. Smith of Electro Motive Division, General Motors Corporation. Further development and enhancements have been made by Mr. R. MacMillan, Research Engineer, Dr. G. C. Martin, Deputy Project Director of Track-Train Dynamics, and Director-Dynamics Research of the AAR Research and Test Department.

Also, the authors wish to acknowledge Mr. Edward F. Lind, Director, Phase I of the Track-Train Dynamics Research Program. Mr. Lind's leadership has been a major contributing factor to the entire success of the Track-Train Dynamics Research Program—A program which has and will continue to produce significant contributions to the railroad industry for years to come.

Finally, the contribution by Electro Motive Division, General Motors Corporation in the model development is deeply appreciated.

This program was developed as part of an effort in Task #7, Mathematical modelling of Phase I of the Track-Train Dynamics Research Program.

TABLE OF CONTENTS

I. INTRODUCTION

The rigid truck curve negotiation model calculates the lateral wheel-rail forces associated with the negotiation of a section of curved track by a rigid framed locomotive truck for a variety of normal operating conditions. The model itself is of a quasi-static nature modeling the truck in static equilibrium for each set of input data. Each truck of the locomotive is modeled individually and is assumed to have a conventional center bearing connection from the bolster to the locomotive, which does not impart any rotational stiffness. (this is a valid assumption under the static context of the model.) The model simulates two, three and four axle trucks. The model will also compute the curving forces under various external conditions that exist which include:

1. Operation at over or under balance speed.
2. Train operation forces which may result in buff force components acting at the truck center bearing.
3. Any combination of individual axle loads.
4. Any combination of individual wheel loads consistent with axle loads.
5. Development of a tractive or braking effort.
6. Any combination of individual wheel radii.

II. COMPUTER ENVIRONMENT

The truck curve negotiation model is written in Fortran IV. Execution of the program on an IBM 370/158 required 520 bytes of core. As can be seen on the SAMPLE EXECUTION (APPENDIX A), the net CPU time required for the twelve simulations was approximately one minute.

III. CONTROL CARDS (JCL)

A very simple PROC has been written to simplify execution of the program on the Association of American Railroads 370/158 system. A listing of this procedure (TKVEXEC) is provided on the next page. Input (usually in card form) is read into the system via unit 5. It is then copied onto a temporary file (unit 7) so that a listing of card input (by column) can be printed before actual processing of the data by the system begins.

IV. INPUT DATA

A. DATA DESCRIPTION - The following data is required for operation of the program:

1. The tractive effort being developed by the locomotive and acting along the locomotive centerline.

2. The braking effort being developed by the locomotive and acting along the locomotive centerline.

3. The net buff force acting along the locomotive centerline. (The buff force at the No. 2 or trailing coupler, minus the buff force at the No. 1 or leading coupler.)

```
//****************************** MACMILLAN ******************************
//*                                                                      *
//*    THIS PROC EXECUTES THE TRUCK CURVING MODEL MAINLINE PROGRAM       *
//*                                                                      *
//****************************** MACMILLAN ******************************
//*
//TKVEXEC  PROC    DSNPROG='P08TRDM.TKV.EXECPROG'
//*
//TRUCK    EXEC    PGM=TKVMAINL,REGION=576K
//STEPLIB  DD      DSN=&DSNPROG,DISP=SHR
//FT05F001 DD      DDNAME=INPUT
//FT06F001 DD      SYSOUT=A
//FT07F001 DD      DSN=&&TMPCARD,
//             DISP=(NEW,DELETE),SPACE=(80,(1000,500),RLSE),
//             DCB=(BLKSIZE=80,LRECL=80,RECFM=FB),UNIT=SYSDA
```

4. An indication of which truck (leading or trailing) is to be modeled.

5. The magnitude of the centerplate "breakaway" moment.

6. The truck longitudinal speed.

7. The track radius at the point of study.

8. A description of the total free lateral axle to truck frame clearances in the truck and their locations.

9. A description of the total wheel-to-rail clearance at each axle.

10. The vertical load acting on each wheel.

11. The diameter of each wheel.

12. The lateral load acting perpendicular to the locomotive centerline at the center bearing.

13. The gauge of the track.

14. A description of the truck indicating its wheelbase, and centerplate location.

15. The distance between bolster centers on the locomotive.

16. A description of any lateral axle-to-truck frame suspension. This requires the knowledge of the total available travel and the system stiffness. (This is to apply to rubber thrust blocks, etc.)

17. A description of the friction-creep relationship to be used. The program is designed to handle relationships of the type depicted in Figure 1, where the curved portion of the graph may be represented by an equation of form:

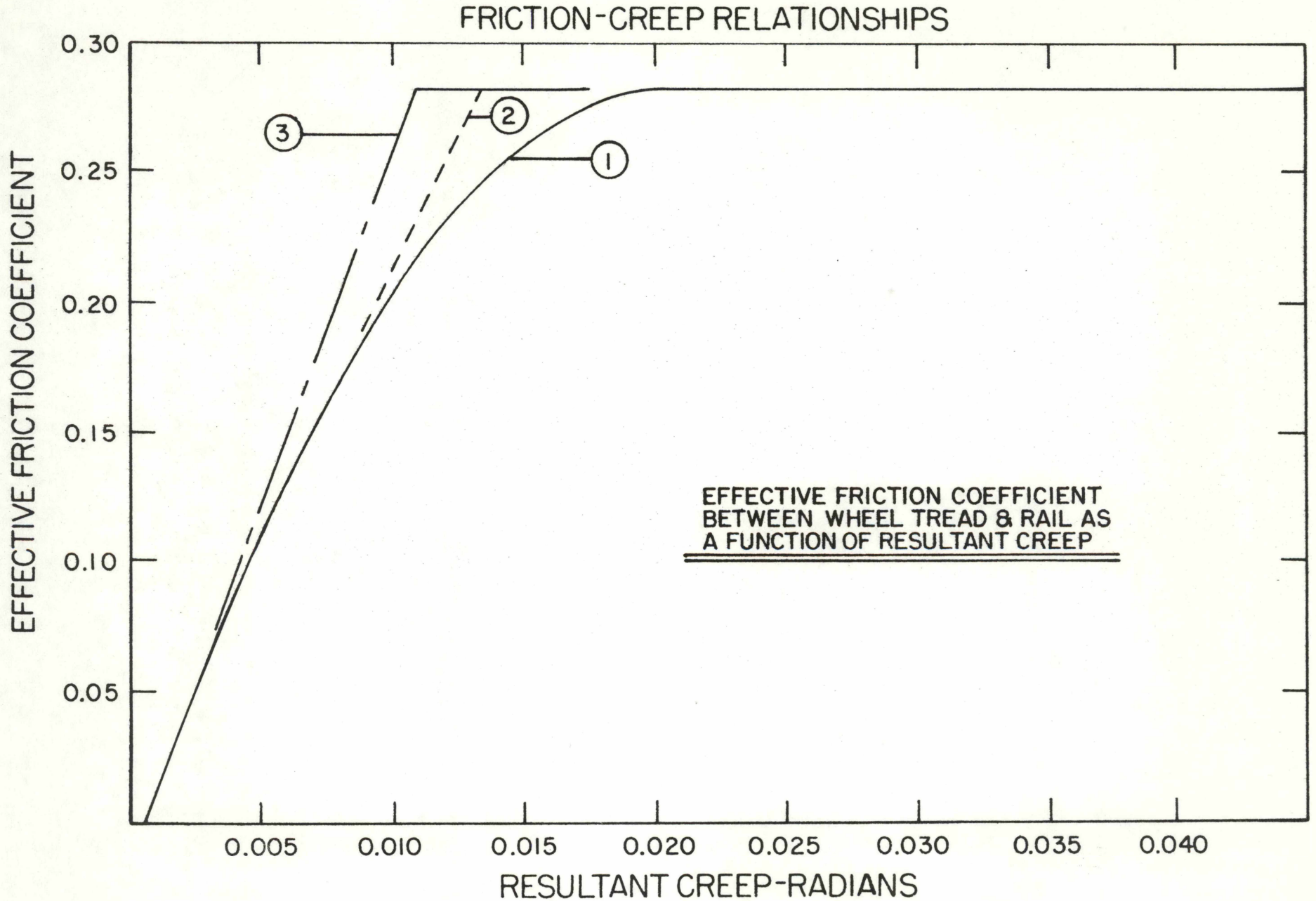
$$A_4X^4 + A_3X^3 + A_2X^2 + A_1X + A_0 = F$$

Where X = Resultant Creep expressed in radians

F = Coefficient of Friction

This equation if valid up to a cutoff creep value after which a constant peak coefficient is used by the system. The coefficients for the curves shown if Figure 1 are as follows:

a. Curve 1 $A_0 = -0.00059402$


FRICTION-CREEP RELATIONSHIPS
EFFECTIVE FRICTION COEFFICIENT
0.30
0.25
0.20
0.15
0.10
0.05
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
RESULTANT CREEP-RADIANS
3
2
1
EFFECTIVE FRICTION COEFFICIENT
BETWEEN WHEEL TREAD & RAIL AS
A FUNCTION OF RESULTANT CREEP

A_1 = +23.1745758

A_2 = -191.89145

A_3 = -14123.605

A_4 = +98954.0

Cutoff = 0.020

Peak = 0.289

b. Curve 2 $A_0 = A_2 = A_3 = A_4 = 0.0$

A_1 = 21.5062

Cutoff = 0.01344

Peak = 0.289

18. Explanation of truck option. For some types of locomotive trucks, the truck is not symmetrical in that the bolster is not centrally located. For these trucks a difference will exist between the leading truck and trailing truck in their alignment with the locomotive centerline, causing a difference in the lateral and longitudinal components of the center bearing load transmitted from the locomotive to each truck. The variable "truck" specifies whether the truck under consideration is the leading or trailing truck on the locomotive.

B. CARD LAYOUT - The data for execution of the program must be entered on cards according to the specifications indicated below. Note that under the TYPE heading, FX refers to integer format (must be right justified in columns indicated), and FL refers to real format (numbers must contain decimal point and can be placed anywhere within the specified columns). Note also that certain data is required only if a three or four axle truck is being simulated. Each variable description indicates whether that variable is for all cases (ALL), 3 and 4 axle trucks only (3 and 4 AXLE), or for 4 axle only (4 AXLE). FORMAT specifications are included, and

in the case where some data is needed only for three and four axle truck, the FORMAT refers to the four axle case.

Input Card 1 - Format (I1)

Column	Variable	Type	Units	Description
1	NAX	FX	-	Number of axles on truck being simulated. Must be 2, 3, or 4. (ALL)

Input Card 2 - Format (20A4)

Column	Variable	Type	Units	Description
1-80	-	-	-	A verbal description of the truck type or distinctive program inputs. The choice of words are at the option of the operator. (ALL)

Input Card 3 - Format (I10, 6F10.0)

Column	Variable	Type	Units	Description
1-10	NCPL	FX	-	The number of lateral centerplate loads inputed to the program. (ALL)
11-20	TE	FL	Lbs.	The tractive effort to be considered. (ALL)
21-30	BE	FL	Lbs.	The braking effort to be considered. (ALL)
31-40	BUFF	FL	Lbs.	The buff force to be considered. (ALL)
41-50	TRUCK	FL	-	Truck position option. TRUCK = 1.0 for leading truck, & TRUCK = 2.0 for trailing truck. (ALL)
51-60	CPBMOM	FL	Inch-lbs.	The centerplate breakaway moment. (ALL)
61-70	SPEED	FL	MPH	The longitudinal truck speed. (ALL)

Input Card 4 - Format (F10.0)

Column	Variable	Type	Units	Description
1-10	RF	FL	Feet	The radius of the section of track being transversed by the locomotive. (ALL)

Input Card 5 - Format (8F10.5)

Column	Variable	Type	Units	Description
1-10	AFCL1	FL	Inches	The nominal free clearance per side between the axle & truck frame at axle No. 1. (ALL)
11-20	RWCL1	FL	Inches	The nominal free clearance per side between the rail & wheel flange at axle No. 1. (ALL)
21-30	AFCL2	FL	Inches	The nominal free clearance per side between the axle & truck frame at axle No. 1. (ALL)
31-40	RWCL2	FL	Inches	The nominal free clearance per side between the rail & wheel flange at axle No. 2. (ALL)
41-50	AFCL3	FL	Inches	The nominal free clearance per side between the axle & truck frame at axle No. 3. (3 and 4 AXLE)
51-60	RWCL3	FL	Inches	The nominal free clearance per side between the rail & wheel flange at axle No. 3.(3 and 4 AXLE)
61-70	AFCL4	FL	Inches	The nominal free clearance per side between the axle & truck frame at axle No. 4.(4 AXLE)
71-80	RWCL4	FL	Inches	The nominal free clearance per side between the rail & wheel flange at axle No. 4. (4 AXLE)

Input Card 6 - Format (8F10.0)

Column	Variable	Type	Units	Description
1-10	WL11	FL	Lbs.	The vertical wheel load at axle No. 1, innerside of the curve. (ALL)

Column	Variable	Type	Units	Description
11-20	WL12	FL	Lbs.	The verticl wheel load at axle No. 1, inner side of the curve. (ALL)
21-30	WL21	FL	Lbs.	The vertical wheel load at axle No. 2, innerside of the curve. (ALL)
31-40	WL22	FL	Lbs.	The vertical wheel load at axle No. 2, outer side of the curve. (ALL)
41-50	WL31	FL	Lbs.	The vertical wheel load at axle No. 3, inner side of the curve. (3 and 4 AXLE)
51-60	WL32	FL	Lbs.	The vertical wheel load at axle No. 3, outer side of the curve. (3 and 4 AXLE)
61-70	Wl41	FL	Lbs.	The vertical wheel load axle No. 4, Inner side of the curve. (4 AXLE)
71-80	WL42	FL	Lbs.	The vertical wheel load at axle No. 4, Outer side of the curve. (4 AXLE)

Input Card 7 - Format (8F10.4)

Column	Variable	Type	Units	Description
1-10	WD11	FL	Inches	The wheel diameter at axle No. 1, inner side of the curve. (ALL)
11-20	WD12	FL	Inches	The wheel diameter at axle No. 1, outer side of curve. (ALL)
21-30	WD21	FL	Inches	The wheel diameter at axle No. 2, inner side of the curve. (ALL)
31-40	WD22	FL	Inches	The wheel diamter at axle No. 2, outer isde of the curve. (ALL)
41-50	WD31	FL	Inches	The wheel diameter at axle No. 3, inner side of curve. (3 and 4 AXLE)

Column	Variable	Type	Units	Description
51-60	WD32	FL	Inches	The wheel diameter at axle No. 3, outer side of the curve. (3 and 4 AXLE)
61-70	WD41	FL	Inches	The wheel diameter at axle No. 4, inner side of the curve. (4 AXLE)
71-80	WD42	FL	Inches	The wheel diameter at axle No. 4, outer side of the curve. (4 AXLE)

Input Card 8 - Format (7F10.3)

Column	Variable	Type	Units	Description
1-10	G	FL	Inches	The track gauge. (ALL)
11-20	BC	FL	Inches	The distance between the locomotive bolster centers. (ALL)
21-30	WBASE	FL	Inches	The truck wheelbase; distance between lead & trailing axle centerlines. (ALL)
31-40	CPD	FL	Inches	The distance between the lead axle centerline and bolster centerline. (ALL)
41-50	A	FL	Inches	The distance between the lead axle centerline and second axle centerline. (3 and 4 AXLE)
51-60	B	FL	Inches	The distance between the second axle centerline and third axle centerline. (3 and 4 AXLE)
61-70	C	FL	Inches	The distance between the third axle centerline and trailing axle centerline. (4 AXLE)

Input Card 9 - Format (F10.5, F10.0)

Column	Variable	Type	Units	Description
1-10	DDEFL	FL	Inches	The total additional lateral axle displacement allowed by the lateral axle suspension. This is in addition to the lateral free clearances. (ALL)

Column	Variable	Type	Units	Description
11-20	RATE	FL	Lb./ In.	The stiffness of the lateral axle suspension. (Note: This "suspension" is in reference to resilient rubber axle thrust blocks, etc.) (ALL)

Input Card 10 - Format (F10.8, F10.6, F10.4,F10.2, F10.0, F10.7, F10.5)

Column	Variable	Type	Units	Description
1-10	AO	FL	-	The coefficient AO in the friction/creep curve equation. (ALL)
11-20	A1	FL	-	The coefficient A1 in the Friction/creep curve equation. (ALL)
21-30	A2	FL	-	The coefficient A2 in the friction/creep curve equation. (ALL)
31-40	A3	FL	-	The coefficient A3 in the friction/creep curve equation. (ALL)
41-50	A4	FL	-	The coefficient A4 in the friction/creep curve equation. (ALL)
51-60	CUTOFF	FL	-	This is creep value after which the friction coefficient remains constant. (ALL)
61-70	PEAK	FL	-	The maximum coefficient of friction attained at the knee of the curve, i. e., at the cutoff value. (ALL)

Input Card(s) 11 - Format (F10.0)

Column	Variable	Type	Units	Description
1-10	CPL (I)	FL	Lbs.	The lateral load acting at the locomotive center bearing and perpendicular to the locomotive centerline. The number of loads inputed must be equal to NCPL; use a new card for each different load. (ALL)

V. PROGRAM OUTPUT

A. DATA DESCRIPTION - The output page will list the computed curving forces along with the input data from which they were calculated. The variables are explained below. After each variable description, an indication is given whether it applies to all cases (ALL),(2 and 3 AXLE), 3 axle only (3 AXLE), or 4 axle only (4 AXLE). Note that "outer" refers to the truck side furthest from the center of curvature. All .forces are in pounds.

1. CPL - The component of the lateral centerplate load applies at the locomotive center bearing that acts perpendicular to the truck centerline. (ALL)

2. K12 - The lateral flange force developed at the leading outer wheel. (ALL)

3. K21 - The lateral flange force developed at the second inner wheel. (ALL)

4. K22 - The lateral flange force developed at the second outer wheel. (ALL)

5. K31 - The lateral flange force developed at the third inner wheel (3 and 4 AXLE)

6. K32 - The lateral flange force developed at the third outer wheel. (3 and 4 AXLE)

7. K41 - The lateral flange force developed at the fourth inner wheel. (4 AXLE)

8. K42 - Thelateral flange force developed at the fourth outer wheel (4 AXLE)

9. FRICT11 - The lateral component of the friction force developed at the tread of the leading inner wheel. (2 and 3 AXLE)

10. FRICT12 - The lateral component of the friction force developed at the tread of the leading outer wheel. (ALL)

11. FRICT21 - The lateral component of the friction force developed at the tread of the second inner wheel. (2 and 3 AXLE)

12. FRICT22 - Thelateral component of the friction force developed at the tread of the second outer wheel. (2 and 3 AXLE)

13. FRICT31 - The lateral component of the friction force developed at the tread of the third inner wheel. (3 AXLE)

14. FRICT32 - The lateral component of the friction force developed at the tread of the third outer wheel. (3 AXLE)

15. FRICT41 - The lateral component of the friction force developed at the tread of the fourth inner wheel. (4 AXLE)

16. FRICT42 - The lateral component of the friction force developed at the tread of the fourth outer wheel. (4 AXLE)

17. D1 - The perpendicular distance (inches) from the leading axle to the instantaneous center ("frction center") of rotation. (ALL)

18. S - The perpendicular distance (inches) from the truck centerline to the instantaneous center of rotation. (ALL)

In addition to the outputs listed above, the moment about the instantaneous center of rotation due to the longitudinal components of the friction force at each wheel plus the net lateral load at the leading outer and trailing inner wheels will be displayed.

B. ERRORS AND WARNINGS - An effort has been made to keep the model flexible by allowing a wide (usually unlimited) range of values for most input parameters. Some input values are examined (e.g., speed must not be negative) for validity and if in error, the simulation will be aborted with a message issued on the output sheet. Warnings may occur when the model cannot determine an equilibrium configuration.

Specifically the messages are:

1. ERROR - INVALID SPEED. A negative value has been found on the input card.

2. ERROR - INVALID WHEEL RADIUS. A wheel radius (input is diameter) is either zero or negative.

3. ERROR - TRACTIVE OR BRAKING EFFORT MUST BE 0.0. Both TE and BE were input.

4. WARNING - TRUCK IS AT TRANSITION POINT, NUMBERS GIVEN ARE ONLY A CLOSE APPROXIMATION. The model could not determine an exact equilibrium position, but numbers from last iteration are quite reliable.

5. WARNING - FRICTION CENTER LOCATION AND FORCES ARE CLOSE APPROXIMATION IN THIS CASE. Due to the nature of the model, the iteration procedure in its attempt to balance the parameter has encountered a case where balance (unbalanced force $\leq$ 50 lbs.) is not attained.

6. SOLUTION NOT POSSIBLE IN THIS CASE - The iteration procedure to determine force balance required more than 10,000 attempts. The configuration can't be solved by this model. This is an internal check on the iteration process used in searching for the friction center. A 10,000 element array has been filled if this message occurs, simply aborting execution. This occurrence is highly improbable.

7. The message - A FRICTION COEFFICIENT OF GREATER THAN... IS REQUIRED TO BALANCE THE TRACTIVE, BRAKING, OR BUFF FORCES INPUTTED TO THE PROGRAM For equilibrium to be reached with these forces, a new friction-creep relationship which attains a greater peak coefficient of friction must be used - will appear when the available friction as specified by the inputted friction-creep curve is not sufficient to balance the tractive, braking, or buff forces specified. This indicated that a gross slipping condition would occur, unless the available friction were to increase. The coefficient of friction printed out will be the same as the peak friction constant inputted to the program to serve as a check for proper data input. The corrective action required will be to follow one of these three approaches:

A. Increase the wheel loads to increase the friction forces.

B. Increase the peak attainable coefficient of friction.

C. Decrease the specified tractive, braking, or buff forces.

8. The message - FINAL CONSTRAINT - will appear when the curve size specified is below that which can be negotiated by the truck without having flange contact at the leading outer, middle inner (third inner for 4-axle) and trailing outer wheels. The program is not designed to compute flange forces once the theoretical threshold of final constraint has been passed.
(3 and 4 AXLE TRUCKS ONLY)

9. The message - NO EQUILIBRIUM POSITION HAS BEEN DETERMINED - will appear when the truck is at the exact transition point between first degree constraint and free curving. Recommended action is to change the radius of curvature slightly.

APPENDIX A - SAMPLE EXECUTION

The following pages contain a) a listing of the card deck for a sample problem and b) the output generated (JCL included) from execution. Twelve simulations are included.

```
//TKVEXECA JOB     (P08T,RDM),'E0000 MACMILLAN',CLASS=F
//TKVEXEC  EXEC    TKVEXEC
//TRUCK.INPUT DD   *
2
TEST  NEW SYSTEM  FRONT TRUCK  2-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          1.0       9000.0       40.0
     1500.0
       0.250      0.3125       0.250      0.3125
    32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0
       56.5       484.0     163.375      78.375
      0.250     20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020       0.289
     2000.0
2
TEST  NEW SYSTEM  FRONT TRUCK  2-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          1.0       9000.0       40.0
     1500.0
       0.250      0.3125       0.250      0.3125
    32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0
       56.5       484.0     163.375      78.375
      0.250     20000.0
        0.0     21.5062          0.0          0.0          0.0     0.01344       0.289
     2000.0
2
TEST  NEW SYSTEM  REAR TRUCK  2-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          2.0       9000.0       40.0
     1000.0
       0.250      0.3125       0.250      0.3125
    32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0
       56.5       484.0     163.375      78.375
      0.250     20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020       0.289
     2000.0
2
TEST  NEW SYSTEM  REAR TRUCK  2-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          2.0       9000.0       40.0
     1000.0
       0.250      0.3125       0.250      0.3125
    32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0
       56.5       484.0     163.375      78.375
      0.250     20000.0
        0.0     21.5062          0.0          0.0          0.0     0.01344       0.289
     2000.0
3
TEST  NEW SYSTEM  FRONT TRUCK  3-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          1.0       9000.0       40.0
     1500.0
       0.250      0.3125       0.250      0.3125       0.250      0.3125
    32500.0     32500.0     32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0        36.0        36.0
       56.5       484.0     163.375      78.375      79.625      83.750
      0.250     20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020       0.289
     2000.0
3
TEST  NEW SYSTEM  FRONT TRUCK  3-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          1.0       9000.0       40.0
     1500.0
       0.250      0.3125       0.250      0.3125       0.250      0.3125
    32500.0     32500.0     32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0        36.0        36.0
       56.5       484.0     163.375      78.375      79.625      83.750
      0.250     20000.0
        0.0     21.5062          0.0          0.0          0.0     0.01344       0.289
     2000.0
```

```
3
TEST  NEW SYSTEM  REAR TRUCK  3-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0         0.0         0.0         2.0      9000.0        40.0
     1000.0
       0.250      0.3125      0.250      0.3125      0.250      0.3125
    32500.0     32500.0     32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0        36.0        36.0
       56.5       484.0     163.375      78.375      79.625      83.750
      0.250     20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020       0.289
     2000.0
3
TEST  NEW SYSTEM  REAR TRUCK  3-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0         0.0         0.0         2.0      9000.0        40.0
     1000.0
       0.250      0.3125      0.250      0.3125      0.250      0.3125
    32500.0     32500.0     32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0        36.0        36.0
       56.5       484.0     163.375      78.375      79.625      83.750
      0.250     20000.0
        0.0     21.5062         0.0         0.0         0.0     0.01344       0.289
     2000.0
4
TEST  NEW SYSTEM  FRONT TRUCK  4-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0         0.0         0.0         1.0      9000.0        40.0
     1500.0
       0.250      0.3125      0.250      0.3125      0.250      0.3125      0.250      0.3125
    32500.0     32500.0     32500.0     32500.0     32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0        36.0        36.0        36.0        36.0
       56.5       484.0     187.375      78.375      62.500      61.250      63.625
      0.250     20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020       0.289
     2000.0
4
TEST  NEW SYSTEM  FRONT TRUCK  4-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0         0.0         0.0         1.0      9000.0        40.0
     1500.0
       0.250      0.3125      0.250      0.3125      0.250      0.3125      0.250      0.3125
    32500.0     32500.0     32500.0     32500.0     32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0        36.0        36.0        36.0        36.0
       56.5       484.0     187.375      78.375      62.500      61.250      63.625
      0.250     20000.0
        0.0     21.5062         0.0         0.0         0.0     0.01344       0.289
     2000.0
4
TEST  NEW SYSTEM  REAR TRUCK  4-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0         0.0         0.0         2.0      9000.0        40.0
     1000.0
       0.250      0.3125      0.250      0.3125      0.250      0.3125      0.250      0.3125
    32500.0     32500.0     32500.0     32500.0     32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0        36.0        36.0        36.0        36.0
       56.5       484.0     187.375      78.375      62.500      61.250      63.625
      0.250     20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020       0.289
     2000.0
4
TEST  NEW SYSTEM  REAR TRUCK  4-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0         0.0         0.0         2.0      9000.0        40.0
     1000.0
       0.250      0.3125      0.250      0.3125      0.250      0.3125      0.250      0.3125
    32500.0     32500.0     32500.0     32500.0     32500.0     32500.0     32500.0     32500.0
       36.0        36.0        36.0        36.0        36.0        36.0        36.0        36.0
       56.5       484.0     187.375      78.375      62.500      61.250      63.625
      0.250     20000.0
        0.0     21.5062         0.0         0.0         0.0     0.01344       0.289
     2000.0
/*
//
```

```
//TKVEXECA JOB     (P08T,RDM),'E0000 MACMILLAN',CLASS=F                    JOB  109
//TKVEXEC  EXEC    TKVEXEC
***                                                                        13240
****************************** MACMILLAN ******************************   13250
***                                                                    *   13260
***   THIS PROC EXECUTES THE TRUCK CURVING MODEL MAINLINE PROGRAM      *   13270
***                                                                    *   13280
****************************** MACMILLAN ******************************   13290
***                                                                        13300
XXTKVEXEC  PROC    DSNPROG='P08TRDM.TKV.EXECPROG'                          13310
***                                                                        13320
XXTRUCK    EXEC    PGM=TKVMAINL,REGION=576K                                13330
XXSTEPLIB   DD     DSN=&DSNPROG,DISP=SHR                                   13340
IEF653I SUBSTITUTION JCL - DSN=P08TRDM.TKV.EXECPROG,DISP=SHR
XXFT05F001  DD     DDNAME=INPUT                                            13350
XXFT06F001  DD     SYSOUT=A                                                13360
XXFT07F001  DD     DSN=&&TMPCARD,                                          13370
XX            DISP=(NEW,DELETE),SPACE=(80,(1000,500),RLSE),                13380
XX            DCB=(BLKSIZE=80,LRECL=80,RECFM=FB),UNIT=SYSDA                13390
//TRUCK.INPUT DD   *
//
IEF236I ALLOC. FOR TKVEXECA TRUCK    TKVEXEC
IEF237I 141   ALLOCATED TO STEPLIB
IEF237I 601   ALLOCATED TO FT05F001
IEF237I 710   ALLOCATED TO FT06F001
IEF237I 141   ALLOCATED TO FT07F001
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   P08TRDM.TKV.EXECPROG                              KEPT
IEF285I   VOL SER NOS= VSDATA.
IEF285I   SYS75333.T131716.RV000.TKVEXECA.TMPCARD           DELETED
IEF285I   VOL SER NOS= VSDATA.
IEF373I STEP /TRUCK   / START 75335.1011
IEF374I STEP /TRUCK   / STOP  75335.1021 CPU   1MIN 03.25SEC STOR VIRT 520K
AEF200I I/O COUNTS FOR STEP TRUCK
AEF201I      105 EXCPS ON DA UNIT 141
AEF201I      134 EXCPS ON UR UNIT 601
AEF201I      838 EXCPS ON UR UNIT 710
AEF201I      265 EXCPS ON DA UNIT 141
AEF203I PAGING  IN-0000202  OUT-0000193
AEF204I STORAGE  ALLOC-0576K  USED-0520K

IEF375I  JOB /TKVEXECA/ START 75335.1011
IEF376I  JOB /TKVEXECA/ STOP  75335.1021 CPU   1MIN 03.25SEC
```

```
INPUT CARD DATA(BY COLUMN)                    PAGE      1

0000000001111111111222222222233333333334444444444555555555566666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890123456789
2
TEST  NEW SYSTEM  FRONT TRUCK  2-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          1.0       9000.0       40.0
     1500.0
        0.250      0.3125       0.250      0.3125
    32500.0    32500.0    32500.0    32500.0
       36.0       36.0       36.0       36.0
       56.5      484.0    163.375     78.375
      0.250    20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020      0.289
     2000.0
2
TEST  NEW SYSTEM  FRONT TRUCK  2-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          1.0       9000.0       40.0
     1500.0
        0.250      0.3125       0.250      0.3125
    32500.0    32500.0    32500.0    32500.0
       36.0       36.0       36.0       36.0
       56.5      484.0    163.375     78.375
      0.250    20000.0
        0.0    21.5062          0.0          0.0          0.0    0.01344      0.289
     2000.0
2
TEST  NEW SYSTEM  REAR TRUCK  2-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          2.0       9000.0       40.0
     1000.0
        0.250      0.3125       0.250      0.3125
    32500.0    32500.0    32500.0    32500.0
       36.0       36.0       36.0       36.0
       56.5      484.0    163.375     78.375
      0.250    20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020      0.289
     2000.0
2
TEST  NEW SYSTEM  REAR TRUCK  2-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          2.0       9000.0       40.0
     1000.0
        0.250      0.3125       0.250      0.3125
    32500.0    32500.0    32500.0    32500.0
       36.0       36.0       36.0       36.0
       56.5      484.0    163.375     78.375
      0.250    20000.0
        0.0    21.5062          0.0          0.0          0.0    0.01344      0.289
     2000.0
3
TEST  NEW SYSTEM  FRONT TRUCK  3-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          1.0       9000.0       40.0
     1500.0
        0.250      0.3125       0.250      0.3125       0.250      0.3125
    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0

0000000001111111111222222222233333333334444444444555555555566666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890123456789
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00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

      36.0       36.0       36.0       36.0       36.0       36.0
      56.5      484.0    163.375     78.375     79.625     83.750
     0.250    20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020      0.289
    2000.0
3
TEST  NEW SYSTEM  FRONT TRUCK  3-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
         1          0.0        0.0        0.0        1.0     9000.0       40.0
    1500.0
     0.250     0.3125     0.250     0.3125     0.250     0.3125
   32500.0    32500.0    32500.0    32500.0    32500.0    32500.0
      36.0       36.0       36.0       36.0       36.0       36.0
      56.5      484.0    163.375     78.375     79.625     83.750
     0.250    20000.0
       0.0    21.5062        0.0        0.0        0.0    0.01344      0.289
    2000.0
3
TEST  NEW SYSTEM  REAR TRUCK  3-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
         1          0.0        0.0        0.0        2.0     9000.0       40.0
    1000.0
     0.250     0.3125     0.250     0.3125     0.250     0.3125
   32500.0    32500.0    32500.0    32500.0    32500.0    32500.0
      36.0       36.0       36.0       36.0       36.0       36.0
      56.5      484.0    163.375     78.375     79.625     83.750
     0.250    20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020      0.289
    2000.0
3
TEST  NEW SYSTEM  REAR TRUCK  3-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
         1          0.0        0.0        0.0        2.0     9000.0       40.0
    1000.0
     0.250     0.3125     0.250     0.3125     0.250     0.3125
   32500.0    32500.0    32500.0    32500.0    32500.0    32500.0
      36.0       36.0       36.0       36.0       36.0       36.0
      56.5      484.0    163.375     78.375     79.625     83.750
     0.250    20000.0
       0.0    21.5062        0.0        0.0        0.0    0.01344      0.289
    2000.0
4
TEST  NEW SYSTEM  FRONT TRUCK  4-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
         1          0.0        0.0        0.0        1.0     9000.0       40.0
    1500.0
     0.250     0.3125     0.250     0.3125     0.250     0.3125     0.250     0.3125
   32500.0    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0
      36.0       36.0       36.0       36.0       36.0       36.0       36.0       36.0
      56.5      484.0    187.375     78.375     62.500     61.250     63.625
     0.250    20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020      0.289
    2000.0
4

00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
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0000000001111111111222222222233333333334444444444555555555566666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890123456789
TEST  NEW SYSTEM  FRONT TRUCK  4-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          1.0       9000.0         40.0
     1500.0
       0.250      0.3125       0.250      0.3125       0.250      0.3125       0.250      0.3125
    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0
       36.0       36.0       36.0       36.0       36.0       36.0       36.0       36.0
       56.5      484.0    187.375     78.375     62.500     61.250     63.625
      0.250    20000.0
        0.0    21.5062        0.0        0.0        0.0    0.01344      0.289
     2000.0
4
TEST  NEW SYSTEM  REAR TRUCK  4-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          2.0       9000.0         40.0
     1000.0
       0.250      0.3125       0.250      0.3125       0.250      0.3125       0.250      0.3125
    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0
       36.0       36.0       36.0       36.0       36.0       36.0       36.0       36.0
       56.5      484.0    187.375     78.375     62.500     61.250     63.625
      0.250    20000.0
-.00059402 23.174582-191.89146-14123.609 98954.044      0.020      0.289
     2000.0
4
TEST  NEW SYSTEM  REAR TRUCK  4-AXLE  MEDIUM MOMENT WITH CREEP FACTOR
          1          0.0          0.0          0.0          2.0       9000.0         40.0
     1000.0
       0.250      0.3125       0.250      0.3125       0.250      0.3125       0.250      0.3125
    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0    32500.0
       36.0       36.0       36.0       36.0       36.0       36.0       36.0       36.0
       56.5      484.0    187.375     78.375     62.500     61.250     63.625
      0.250    20000.0
        0.0    21.5062        0.0        0.0        0.0    0.01344      0.289
     2000.0

0000000001111111111222222222233333333334444444444555555555566666666667777777778
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2-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM FRONT TRUCK 2-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1500.0 FEET (3.8 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
TRUCK WHEEL BASE = 163.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

FRICTION-CREEP CURVE CHARACTERISTICS

A0 =	-0.000594020	CUTOFF =	0.020000
A1 =	23.1745758		
A2 =	-191.89145		
A3 =	-14123.605		
A4 =	98954.0	PEAK =	0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

********** RESULTS ********** RESULTS **********

CURVING FORCES(LBS)

CPL	K12	K21	K22	FRICT11	FRICT12	FRICT21	FRICT22
2000.	13679.	0.	0.	5915.	5915.	-68.	-68.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 161.69 S = 0.00 132116.5

		L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL = 7763.8 LBS	AXLE 1	0.182	0.239
NET LATERAL LOAD AT TRAILING INNER WHEEL = -68.4 LBS	AXLE 2	-0.002	0.0

2-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM FRONT TRUCK 2-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1500.0 FEET (3.8 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
TRUCK WHEEL BASE = 163.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

FRICTION-CREEP CURVE CHARACTERISTICS

A0 = 0.0 CUTOFF = 0.013440
A1 = 21.5061951
A2 = 0.0
A3 = 0.0
A4 = 0.0 PEAK = 0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

RESULTS RESULTS

CURVING FORCES(LBS)

CPL	K12	K21	K22	FRICT11	FRICT12	FRICT21	FRICT22
2000.	14411.	0.	0.	6278.	6278.	-66.	-66.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 161.69 S = 0.00 132956.9

		L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL = 8132.7 LBS	AXLE 1	0.193	0.250
NET LATERAL LOAD AT TRAILING INNER WHEEL = -65.5 LBS	AXLE 2	-0.002	0.0

2-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM REAR TRUCK 2-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1000.0 FEET (5.7 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
TRUCK WHEEL BASE = 163.375 INCHES
BOLSTER CENTERS = 464.000 INCHES

	AXLE 1	AXLE 2	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

FRICTION-CREEP CURVE CHARACTERISTICS

A0 =	-0.000594020	CUTOFF =	0.020000
A1 =	23.174575		
A2 =	-191.89145		
A3 =	-14123.605		
A4 =	98954.0	PEAK =	0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

********** RESULTS ********** RESULTS **********

CURVING FORCES(LBS)

CPL	K12	K21	K22	FRICT11	FRICT12	FRICT21	FRICT22
2000.	18225.	0.	0.	8031.	8031.	95.	95.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 164.94 S = 0.00 183516.6

			L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL =	10194.5 LBS	AXLE 1	0.247	0.314
NET LATERAL LOAD AT TRAILING INNER WHEEL =	94.8 LBS	AXLE 2	0.003	0.0

2-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM REAR TRUCK 2-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1000.0 FEET (5.7 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
TRUCK WHEEL BASE = 163.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

FRICTION-CREEP CURVE CHARACTERISTICS

A0 = 0.0 CUTOFF = 0.013440
A1 = 21.5061951
A2 = 0.0
A3 = 0.0
A4 = 0.0 PEAK = 0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

********** RESULTS ********** RESULTS **********

CURVING FORCES(LBS)

CPL	K12	K21	K22	FRICT11	FRICT12	FRICT21	FRICT22
2000.	20728.	0.	0.	9258.	9258.	120.	120.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 165.44 S = 0.00 191292.5

		L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL = 11469.7 LBS	AXLE 1	0.285	0.353
NET LATERAL LOAD AT TRAILING INNER WHEEL = 120.1 LBS	AXLE 2	0.004	0.0

3-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM FRONT TRUCK 3-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1500.0 FEET (3.8 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
LEAD AXLE TO SECOND AXLE DISTANCE = 79.625 INCHES
SECOND AXLE TO THIRD AXLE DISTANCE = 83.750 INCHES
TRUCK WHEEL BASE = 163.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	AXLE 3	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	0.31250	INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

FRICTION-CREEP CURVE CHARACTERISTICS

A0 =	-0.000594020	CUTOFF =	0.020000
A1 =	23.1745758		
A2 =	-191.89145		
A3 =	-14123.605		
A4 =	98954.0	PEAK =	0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

********** RESULTS ********** RESULTS **********

---WARNING---TRUCK IS AT TRANSITION POINT, NUMBERS GIVEN HERE ARE ONLY A CLOSE APPROXIMATION---WARNING---

CURVING FORCES(LBS)

CPL	K12	K21	K22	K31	K32	FRICT11	FRICT12	FRICT21	FRICT22	FRICT31	FRICT32
2000.	12977.	0.	4026.	0.	1939.	5192.	5192.	2350.	2350.	-1010.	-1010.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 138.44 S = 0.00 197281.4

			L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL =	7785.7 LBS	AXLE 1	0.160	0.240
NET LATERAL LOAD AT SECOND OUTER WHEEL =	1675.4 LBS	AXLE 2	0.072	0.052
NET LATERAL LOAD AT TRAILING INNER WHEEL =	-1009.8 LBS	AXLE 3	-0.031	0.091

CLEARANCE BETWEEN MIDDLE OUTER WHEEL AND RAIL = -0.219 INCH

3-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM FRONT TRUCK 3-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1500.0 FEET (3.8 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
LEAD AXLE TO SECOND AXLE DISTANCE = 79.625 INCHES
SECOND AXLE TO THIRD AXLE DISTANCE = 83.750 INCHES
TRUCK WHEEL BASE = 163.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	AXLE 3	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	0.31250	INCH

FRICTION-CREEP CURVE CHARACTERISTICS

A0 = 0.0 CUTOFF = 0.013440
A1 = 21.5061951
A2 = 0.0
A3 = 0.0
A4 = 0.0 PEAK = 0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

********** RESULTS ********** RESULTS **********

---WARNING---TRUCK IS AT TRANSITION POINT, NUMBERS GIVEN HERE ARE ONLY A CLOSE APPROXIMATION---WARNING---

CURVING FORCES(LBS)

CPL	K12	K21	K22	K31	K32	FRICT11	FRICT12	FRICT21	FRICT22	FRICT31	FRICT32
2000.	13311.	0.	3873.	0.	1861.	5366.	5366.	2274.	2274.	-978.	-978.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 138.19 S = 0.00 194935.3

		L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL = 7945.5 LBS	AXLE 1	0.165	0.244
NET LATERAL LOAD AT SECOND OUTER WHEEL = 1599.0 LBS	AXLE 2	0.070	0.049
NET LATERAL LOAD AT TRAILING INNER WHEEL = -978.0 LBS	AXLE 3	-0.030	0.087

CLEARANCE BETWEEN MIDDLE OUTER WHEEL AND RAIL = -0.219 INCH

3-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM REAR TRUCK 3-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1000.0 FEET (5.7 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
LEAD AXLE TO SECOND AXLE DISTANCE = 79.625 INCHES
SECOND AXLE TO THIRD AXLE DISTANCE = 83.750 INCHES
TRUCK WHEEL BASE = 163.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	AXLE 3	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	0.31250	INCH

FRICTION-CREEP CURVE CHARACTERISTICS

A0 =	-0.000594020	CUTOFF =	0.020000
A1 =	23.1745758		
A2 =	-191.89145		
A3 =	-14123.605		
A4 =	98954.0	PEAK =	0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

********** RESULTS ********** RESULTS **********

CURVING FORCES(LBS)

CPL	K12	K21	K22	K31	K32	FRICT11	FRICT12	FRICT21	FRICT22	FRICT31	FRICT32
2000.	20906.	0.	0.	0.	0.	7240.	7240.	3579.	3579.	-1355.	-1355.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 140.91 S = 0.00 280502.8

			L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL =	13666.1 LBS	AXLE 1	0.223	0.420
NET LATERAL LOAD AT SECOND OUTER WHEEL =	-3578.6 LBS	AXLE 2	0.110	-0.110
NET LATERAL LOAD AT TRAILING INNER WHEEL =	-1355.3 LBS	AXLE 3	-0.042	0.0

TRUCK IS IN A TRANSITION BETWEEN FREE CURVING AND FIRST DEGREE CONSTRAINT

3-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM REAR TRUCK 3-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1000.0 FEET (5.7 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
LEAD AXLE TO SECOND AXLE DISTANCE = 79.625 INCHES
SECOND AXLE TO THIRD AXLE DISTANCE = 83.750 INCHES
TRUCK WHEEL BASE = 163.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	AXLE 3	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	0.31250	INCH

FRICTION-CREEP CURVE CHARACTERISTICS

A0 = 0.0 CUTOFF = 0.013440
A1 = 21.5061951
A2 = 0.0
A3 = 0.0
A4 = 0.0 PEAK = 0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

********** RESULTS **********

CURVING FORCES(LBS)

CPL	K12	K21	K22	K31	K32	FRICT11	FRICT12	FRICT21	FRICT22	FRICT31	FRICT32
2000.	22818.	0.	0.	0.	0.	8188.	8188.	3550.	3550.	-1328.	-1328.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 140.58 S = 0.00 287902.9

		L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL =	14630.2 LBS	AXLE 1	0.252	0.450
NET LATERAL LOAD AT SECOND OUTER WHEEL =	-3550.1 LBS	AXLE 2	0.109	-0.109
NET LATERAL LOAD AT TRAILING INNER WHEEL =	-1328.0 LBS	AXLE 3	-0.041	0.0

TRUCK IS IN A TRANSITION BETWEEN FREE CURVING AND FIRST DEGREE CONSTRAINT

4-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM FRONT TRUCK 4-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1500.0 FEET (3.8 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
LEAD AXLE TO SECOND AXLE DISTANCE = 62.500 INCHES
SECOND AXLE TO THIRD AXLE DISTANCE = 61.250 INCHES
THIRD AXLE TO FOURTH AXLE DISTANCE = 63.625 INCHES
TRUCK WHEEL BASE = 187.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	AXLE 3	AXLE 4	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	0.31250	0.31250	INCH

FRICTION-CREEP CURVE CHARACTERISTICS

A0 = -0.000594020 CUTOFF = 0.020000
A1 = 23.1745758
A2 = -191.89145
A3 = -14123.605
A4 = 98954.0 PEAK = 0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

********** RESULTS ********** RESULTS **********

CURVING FORCES(LBS)

CPL	K12	K21	K22	K31	K32	K41	K42	FRICT11	FRICT12	FRICT41	FRICT42
2000.	15856.	0.	7405.	0.	0.	0.	0.	6048.	6048.	-859.	-859.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 166.19 S = 0.00 257867.3

			L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL	= 9807.8 LBS	AXLE 1	0.186	0.302
NET LATERAL LOAD AT SECOND OUTER WHEEL	= 3390.2 LBS	AXLE 2	0.124	0.104
NET LATERAL LOAD AT THIRD OUTER WHEEL	= -1709.5 LBS	AXLE 3	0.053	-0.053
NET LATERAL LOAD AT TRAILING INNER WHEEL	= -858.5 LBS	AXLE 4	-0.026	0.0

CLEARANCE BETWEEN THIRD OUTER WHEEL AND RAIL = -0.102 INCH

4-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM FRONT TRUCK 4-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1500.0 FEET (3.8 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
LEAD AXLE TO SECOND AXLE DISTANCE = 62.500 INCHES
SECOND AXLE TO THIRD AXLE DISTANCE = 61.250 INCHES
THIRD AXLE TO FOURTH AXLE DISTANCE = 63.625 INCHES
TRUCK WHEEL BASE = 187.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	AXLE 3	AXLE 4	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	0.31250	0.31250	INCH

FRICTION-CREEP CURVE CHARACTERISTICS

A0 = 0.0 CUTOFF = 0.013440
A1 = 21.5061951
A2 = 0.0
A3 = 0.0
A4 = 0.0 PEAK = 0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

********** RESULTS ********** RESULTS **********

CURVING FORCES(LBS)

CPL	K12	K21	K22	K31	K32	K41	K42	FRICT11	FRICT12	FRICT41	FRICT42
2000.	16625.	0.	7427.	0.	0.	0.	0.	6453.	6453.	-823.	-823.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 166.19 S = 0.00 256913.8

			L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL =	10171.5 LBS	AXLE 1	0.199	0.313
NET LATERAL LOAD AT SECOND OUTER WHEEL =	3401.2 LBS	AXLE 2	0.124	0.105
NET LATERAL LOAD AT THIRD OUTER WHEEL =	-1647.9 LBS	AXLE 3	0.051	-0.051
NET LATERAL LOAD AT TRAILING INNER WHEEL =	-822.7 LBS	AXLE 4	-0.025	0.0

CLEARANCE BETWEEN THIRD OUTER WHEEL AND RAIL = -0.102 INCH

4-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM REAR TRUCK 4-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1000.0 FEET (5.7 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
LEAD AXLE TO SECOND AXLE DISTANCE = 62.500 INCHES
SECOND AXLE TO THIRD AXLE DISTANCE = 61.250 INCHES
THIRD AXLE TO FOURTH AXLE DISTANCE = 63.625 INCHES
TRUCK WHEEL BASE = 187.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	AXLE 3	AXLE 4	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	0.31250	0.31250	INCH

FRICTION-CREEP CURVE CHARACTERISTICS

A0 = -0.000594020 CUTOFF = 0.020000
A1 = 23.1745758
A2 = -191.89145
A3 = -14123.605
A4 = 98954.0 PEAK = 0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

********** RESULTS ********** RESULTS **********

CURVING FORCES(LBS)

CPL	K12	K21	K22	K31	K32	K41	K42	FRICT11	FRICT12	FRICT41	FRICT42
2000.	23113.	0.	7061.	0.	0.	0.	0.	7926.	7926.	-1563.	-1563.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

D1 = 161.42 S = 0.00 367387.5

			L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL	= 15187.8 LBS	AXLE 1	0.244	0.467
NET LATERAL LOAD AT SECOND OUTER WHEEL	= 1572.6 LBS	AXLE 2	0.169	0.048
NET LATERAL LOAD AT THIRD OUTER WHEEL	= -2250.8 LBS	AXLE 3	0.069	-0.069
NET LATERAL LOAD AT TRAILING INNER WHEEL	= -1562.7 LBS	AXLE 4	-0.048	0.0

TRUCK IS IN A TRANSITION BETWEEN FREE CURVING AND FIRST DEGREE CONSTRAINT

4-AXLE TRUCK CURVE NEGOTIATION MODEL 24 NOV 1975

CURVE NEGOTIATION FORCES UNDER THE INFLUENCE OF LATERAL CENTER PLATE LOADS

TEST NEW SYSTEM REAR TRUCK 4-AXLE MEDIUM MOMENT WITH CREEP FACTOR

RADIUS OF CURVATURE = 1000.0 FEET (5.7 DEGREES)
TRUCK SPEED = 40.0 MPH (704.0 INCHES/SEC)
TRACK GAUGE = 56.50 INCHES

LEAD AXLE TO BOLSTER CENTER DISTANCE = 78.375 INCHES
LEAD AXLE TO SECOND AXLE DISTANCE = 62.500 INCHES
SECOND AXLE TO THIRD AXLE DISTANCE = 61.250 INCHES
THIRD AXLE TO FOURTH AXLE DISTANCE = 63.625 INCHES
TRUCK WHEEL BASE = 187.375 INCHES
BOLSTER CENTERS = 484.000 INCHES

	AXLE 1	AXLE 2	AXLE 3	AXLE 4	
WHEEL LOADS-INNER RAIL	32500.0	32500.0	32500.0	32500.0	LBS
WHEEL LOADS-OUTER RAIL	32500.0	32500.0	32500.0	32500.0	LBS
WHEEL RADII-INNER RAIL	18.0000	18.0000	18.0000	18.0000	INCHES
WHEEL RADII-OUTER RAIL	18.0000	18.0000	18.0000	18.0000	INCHES
AXLE--FRAME CLEARANCES	0.25000	0.25000	0.25000	0.25000	INCH
RAIL--WHEEL CLEARANCES	0.31250	0.31250	0.31250	0.31250	INCH

FRICTION-CREEP CURVE CHARACTERISTICS

A0 = 0.0 CUTOFF = 0.013440
A1 = 21.5061951
A2 = 0.0
A3 = 0.0
A4 = 0.0 PEAK = 0.28900

LATERAL SUSPENSION STIFFNESS VALUES

DDEFL = 0.250000 INCH
RATE = 20000.0 LB/INCH

NO TRACTIVE OR BRAKING EFFORT
BUFF FORCE = 0.0 LBS
CENTER PLATE BREAKAWAY MOMENT = 9000.0 INCH-LBS

********** RESULTS ********** RESULTS **********

CURVING FORCES(LBS)

CPL	K12	K21	K22	K31	K32	K41	K42	FRICT11	FRICT12	FRICT41	FRICT42
2000.	25801.	0.	7629.	0.	0.	0.	0.	9252.	9252.	-1500.	-1500.

FRICTION CENTER LOCATION(INCHES) FRICTIONAL MOMENT(INCH-LBS)

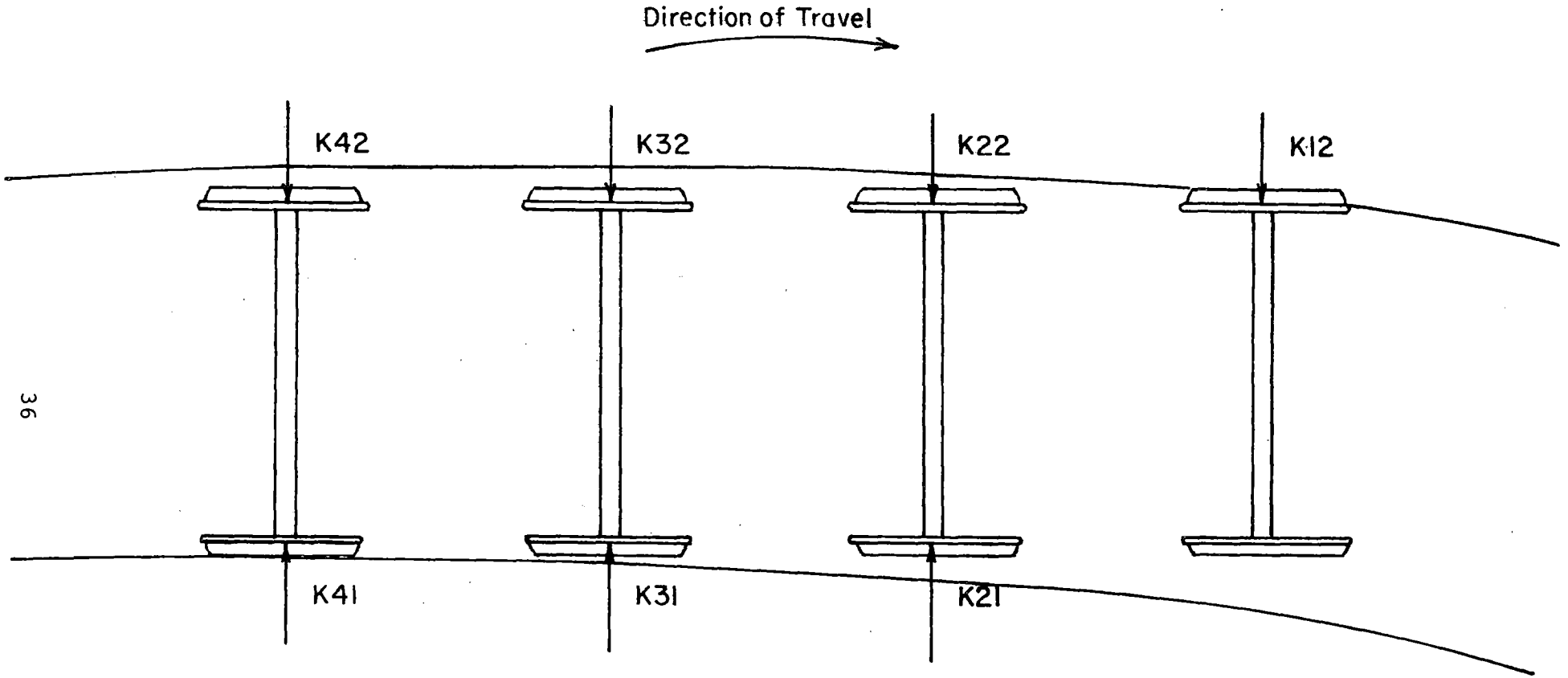
D1 = 161.62 S = 0.00 379273.0

			L/V RATIOS INNER RAIL	L/V RATIOS OUTER RAIL
NET LATERAL LOAD AT LEADING OUTER WHEEL	= 16548.9 LBS	AXLE 1	0.285	0.509
NET LATERAL LOAD AT SECOND OUTER WHEEL	= 1855.7 LBS	AXLE 2	0.178	0.057
NET LATERAL LOAD AT THIRD OUTER WHEEL	= -2206.1 LBS	AXLE 3	0.068	-0.068
NET LATERAL LOAD AT TRAILING INNER WHEEL	= -1499.8 LBS	AXLE 4	-0.046	0.0

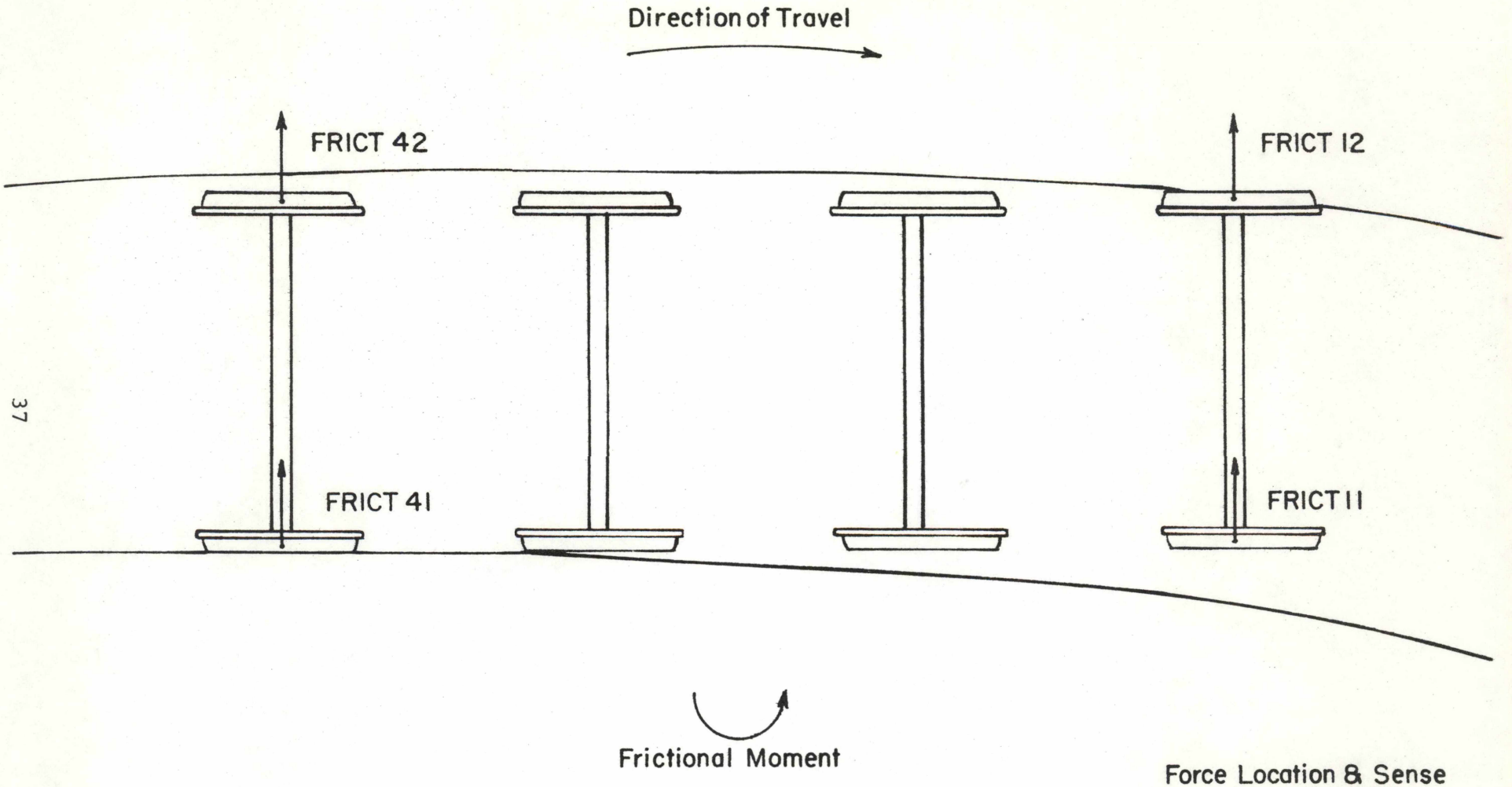
TRUCK IS IN A TRANSITION BETWEEN FREE CURVING AND FIRST DEGREE CONSTRAINT

APPENDIX B - LOCOMOTIVE AND TRUCK NOMENCLATURE

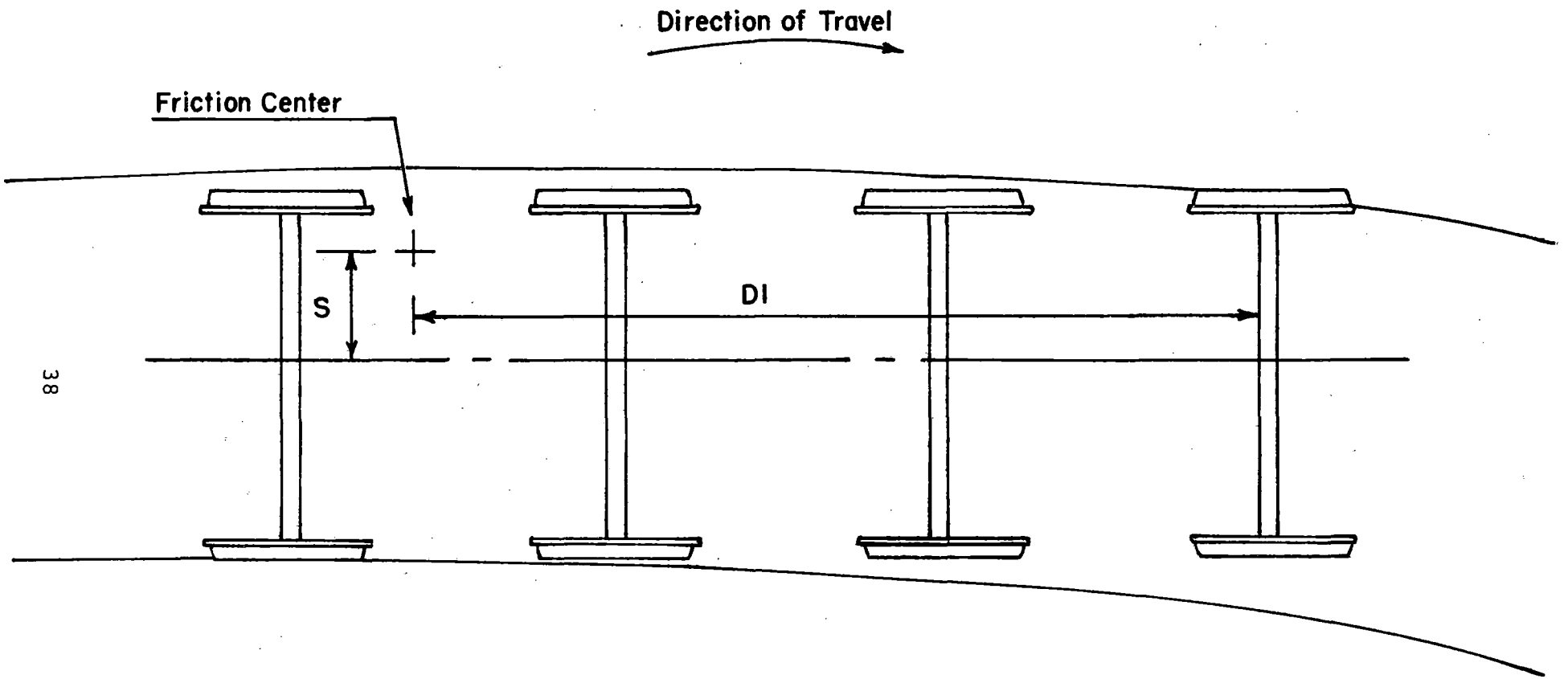
The pages following provide a representation of the orientation of the trucks, the forces and friction center location, and general system geometry. The 4-axle truck is shown since it is most complex.



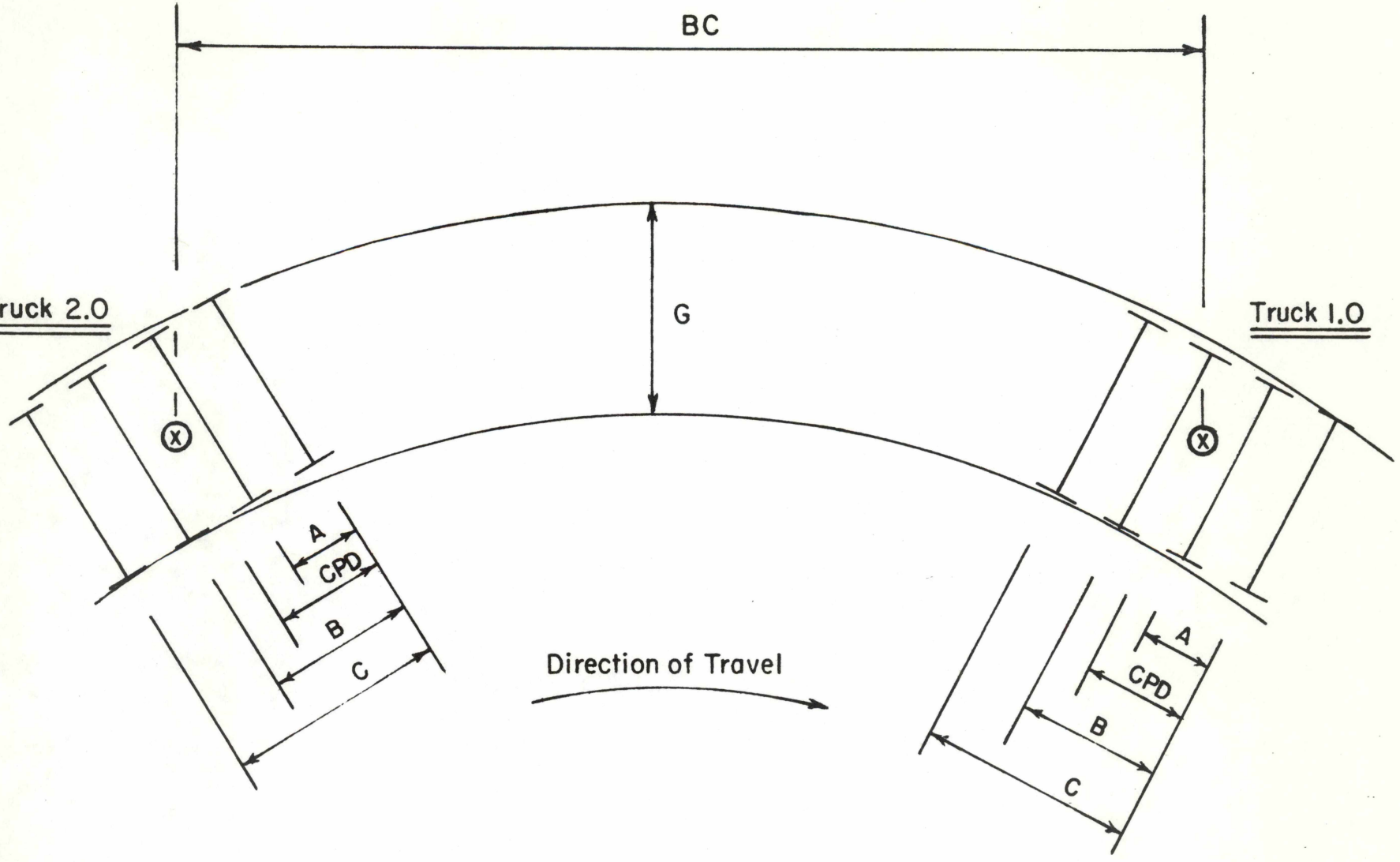
FLANGE FORCES



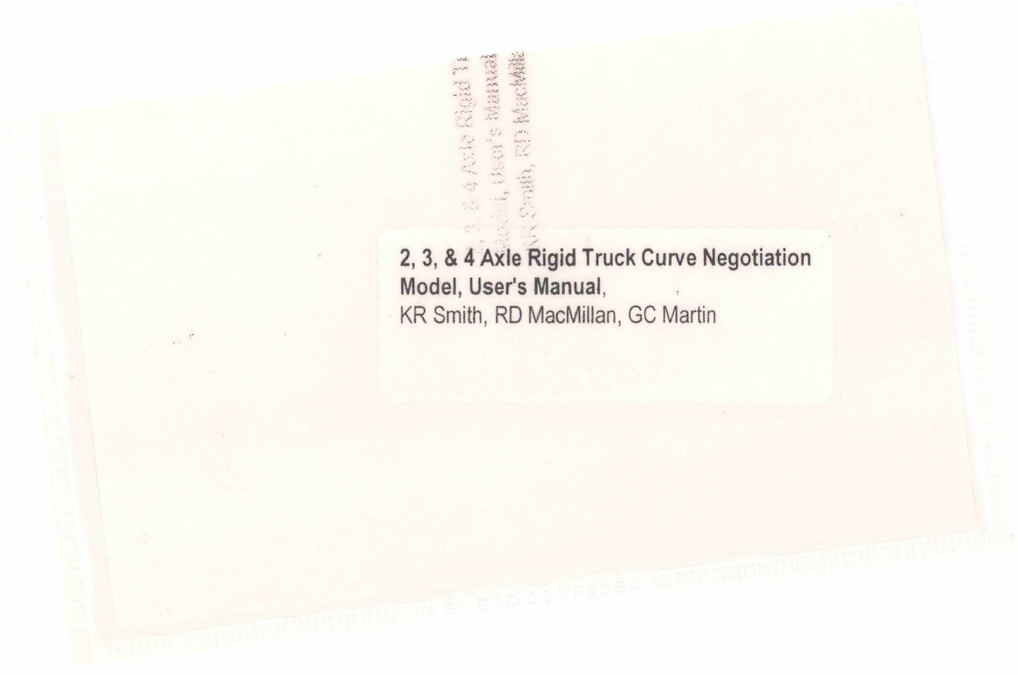
FRICTION FORCES



FRICTION CENTER LOCATION



LOCOMOTIVE & TRUCK NOMENCLATURE



2, 3, & 4 Axle Rigid Truck Curve Negotiation Model, User's Manual,
KR Smith, RD MacMillan, GC Martin