COMPUTER SIMULATION

OF

HIGHWAY TRAFFIC

A Thesis submitted in the
Faculty of Applied Science, University of Newcastle upon Tyne,
for the degree of Doctor of Philosophy.

STEWART SUMNER BSc.

April, 1970

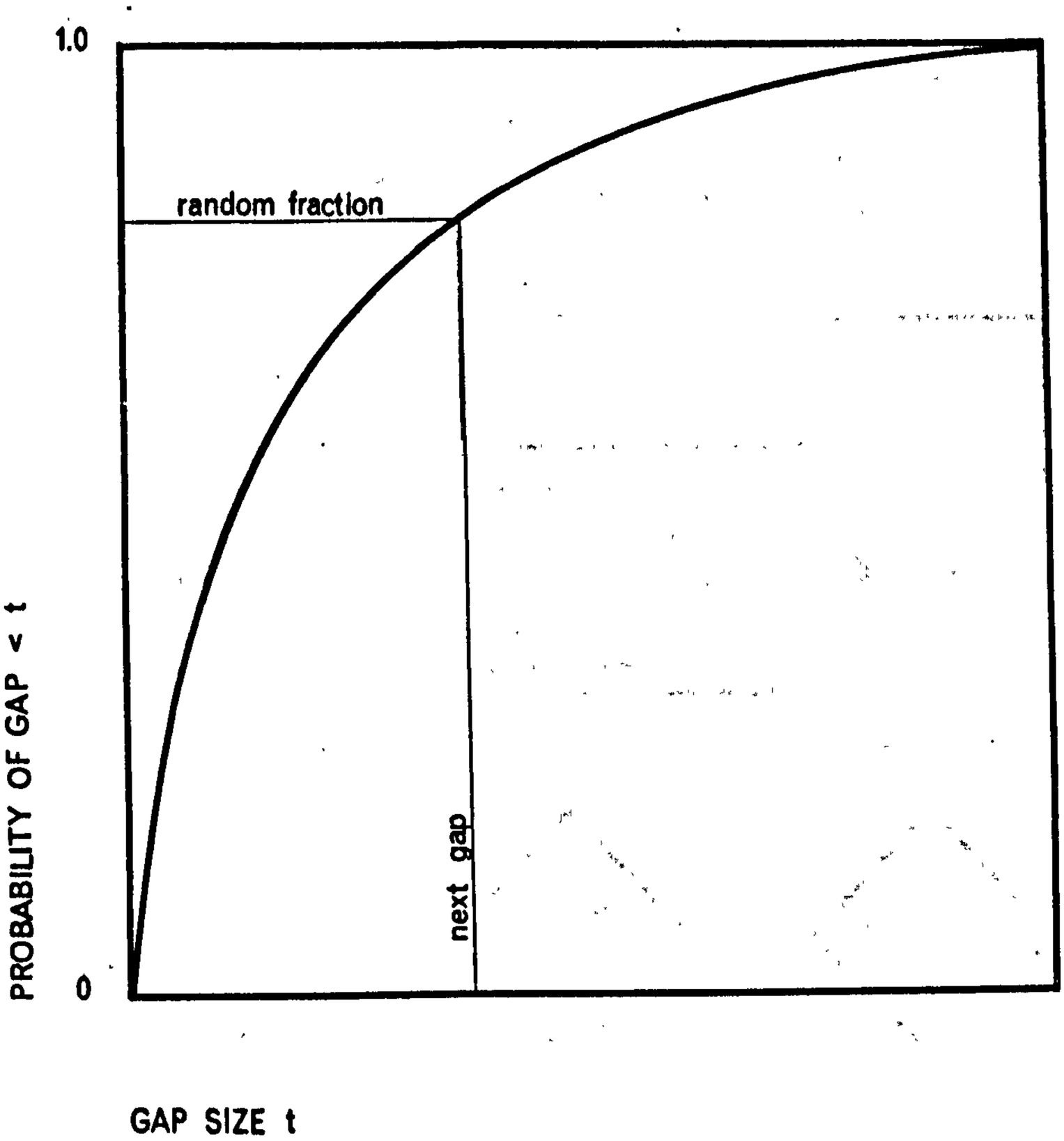


Fig. 1.1 Random sampling from a gap distribution

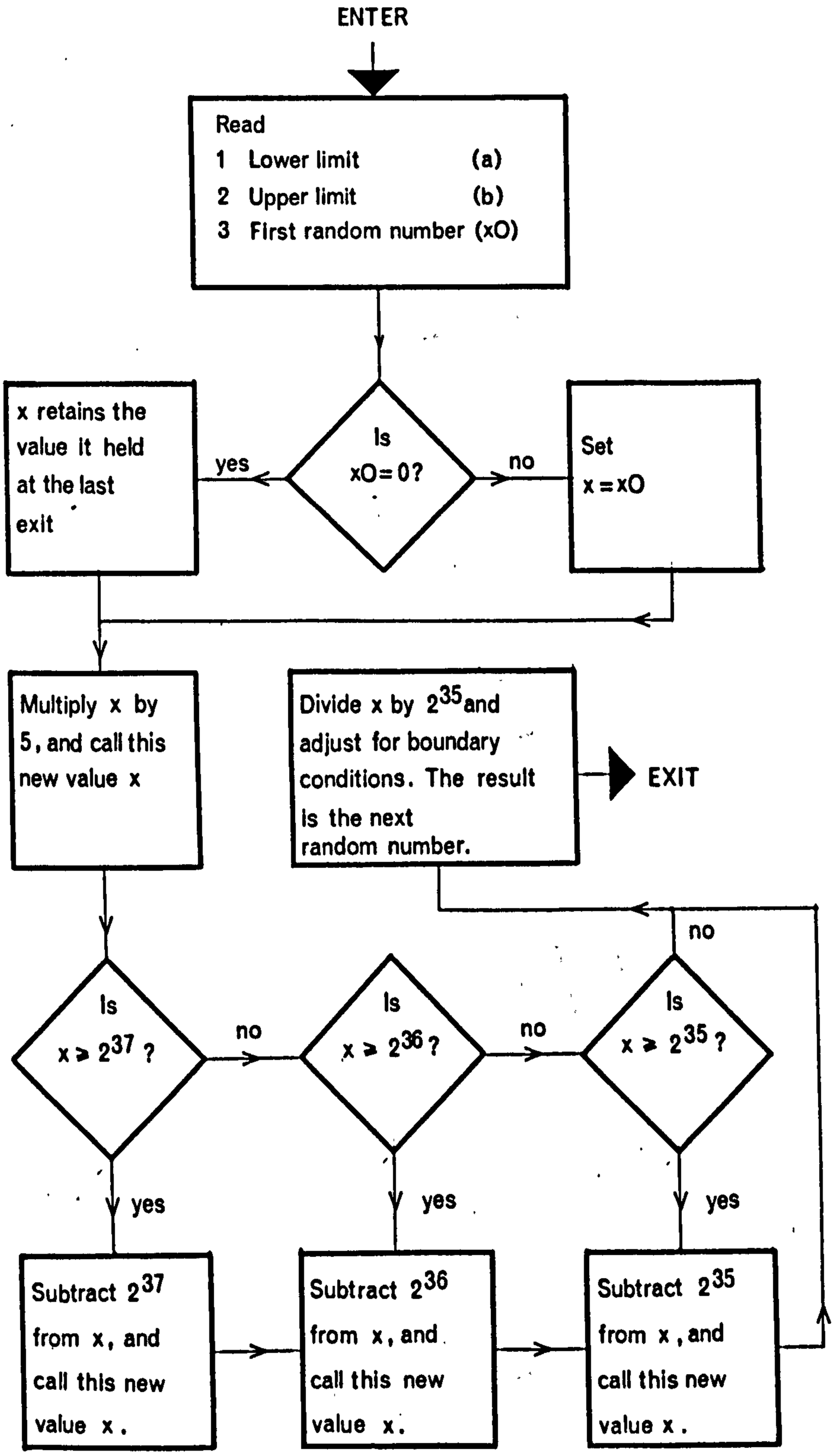


Fig. 1.2 Pseudo - random number generator flow diagram

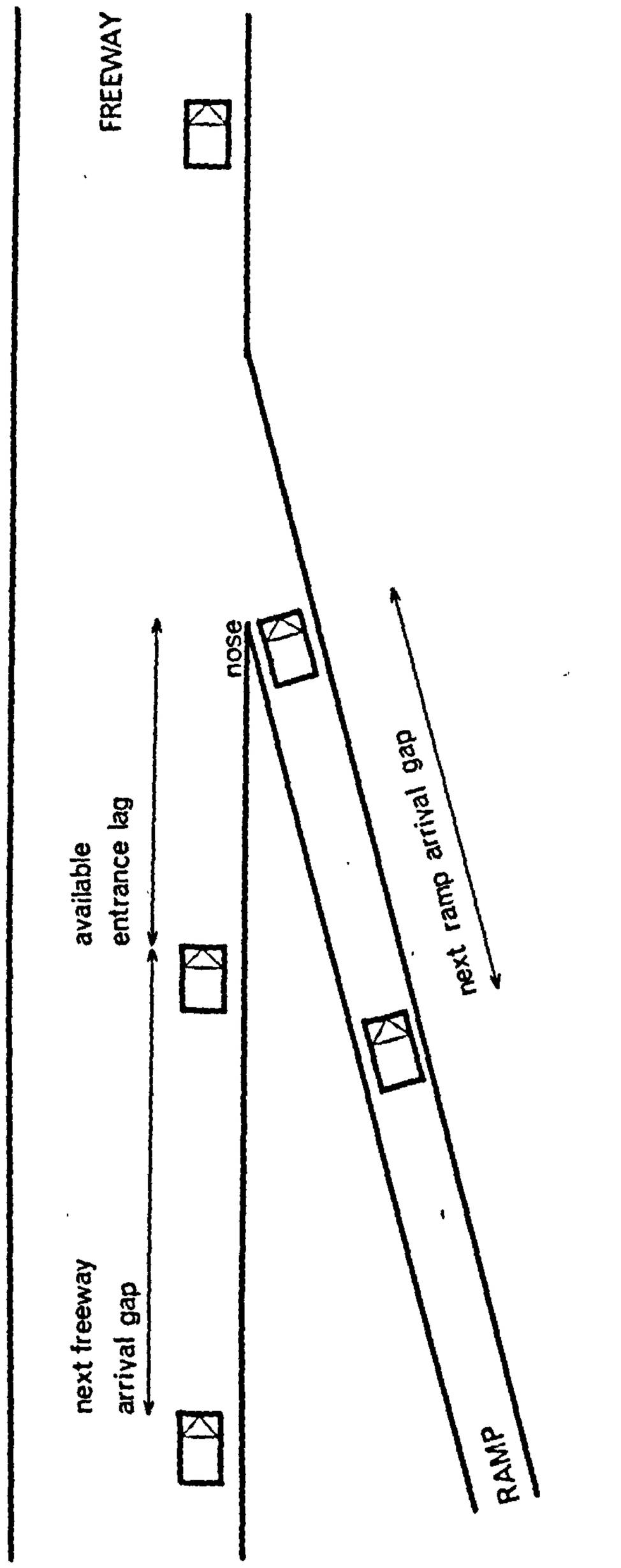


Fig. 1.3 Arrangement of WOHL's model

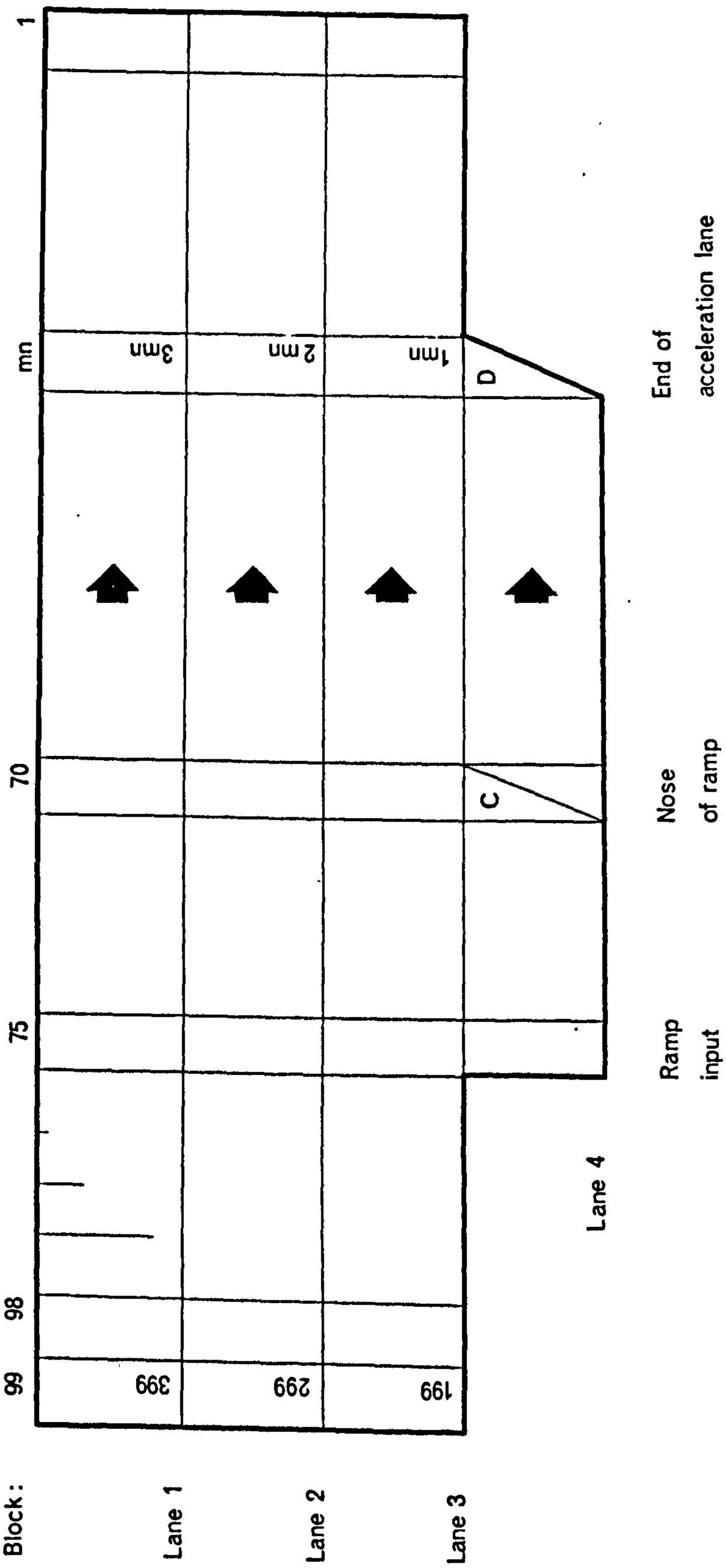


Fig. 1.4 Arrangement of PERCHONOK's model

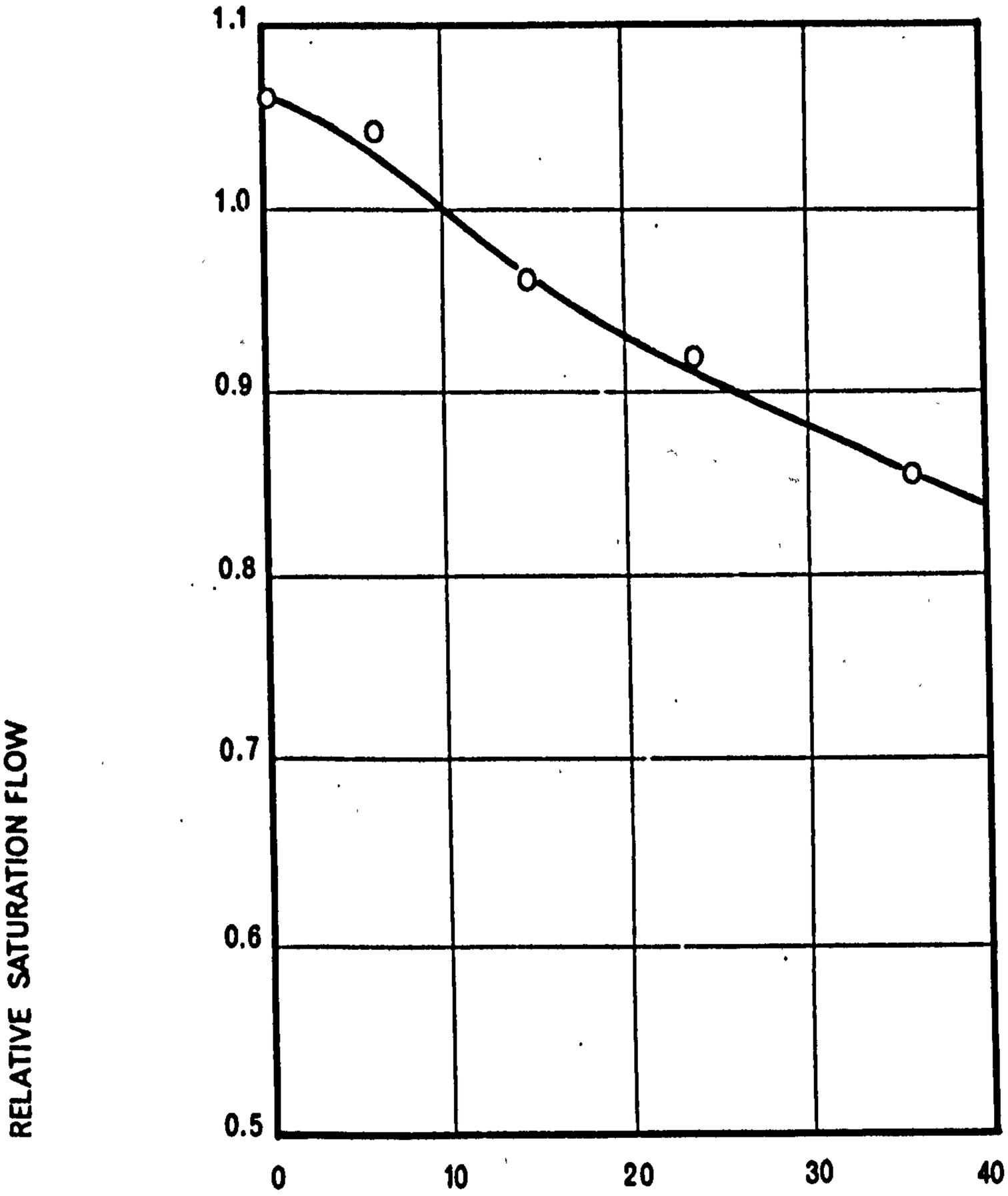


Fig. 2.1 Variation in saturation flow with turning traffic

(Source : Fig. 5, ref. 2.2)

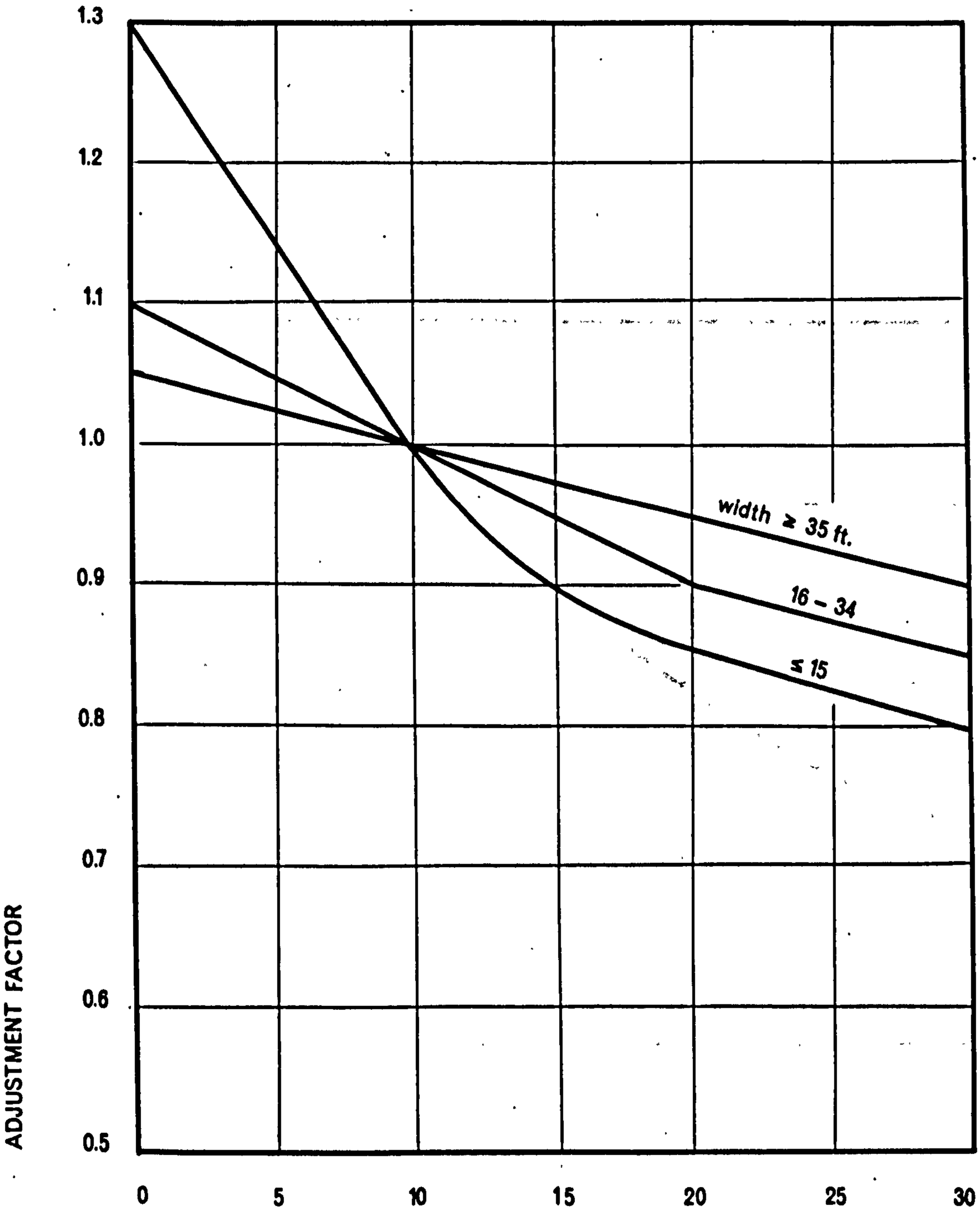


Fig. 2.2 Adjustment factors for right turns on two way streets

(Source : Table 6.5, ref. 2.13)

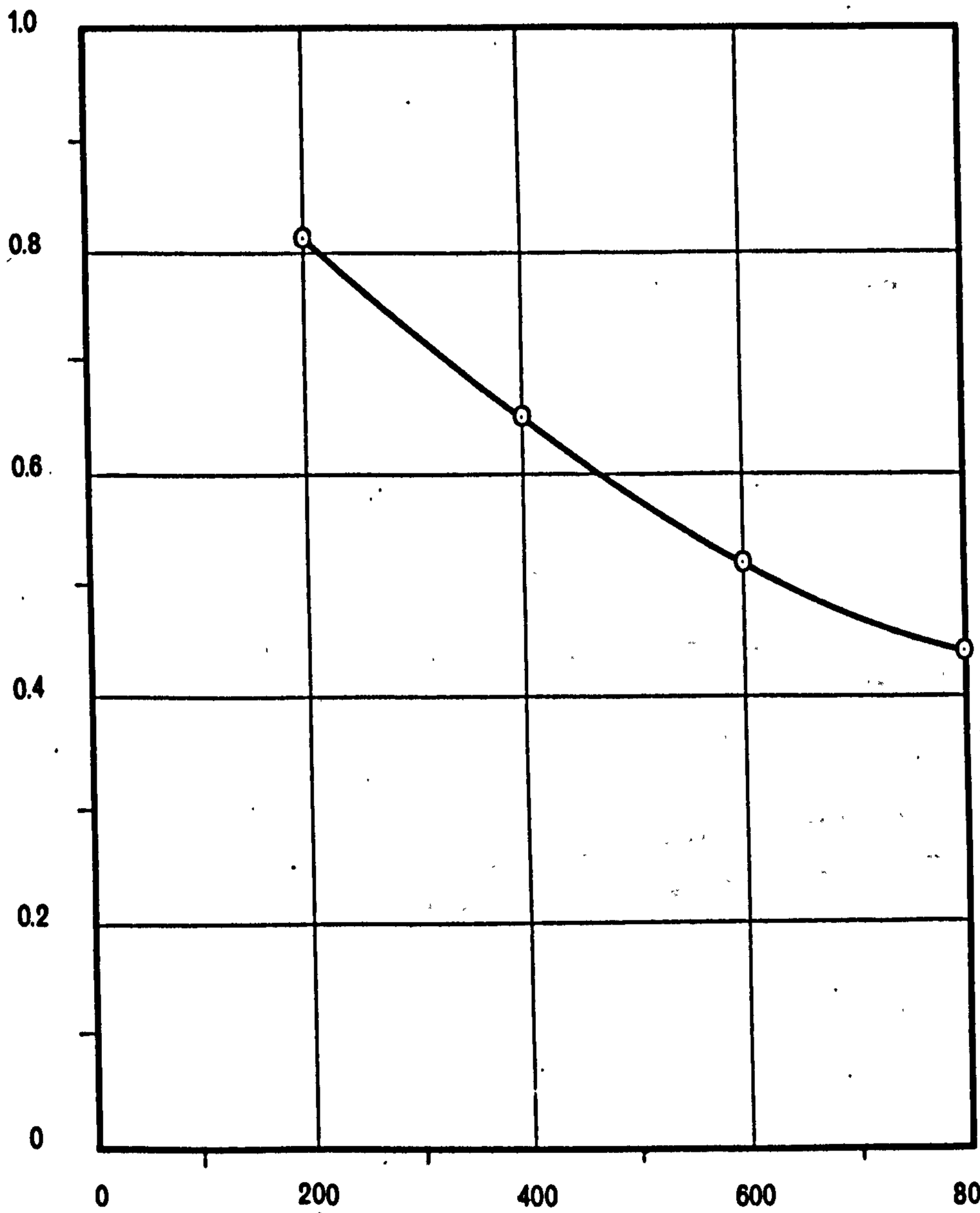


Fig. 2.3

(Source : Fig. 7, ref. 2.16)

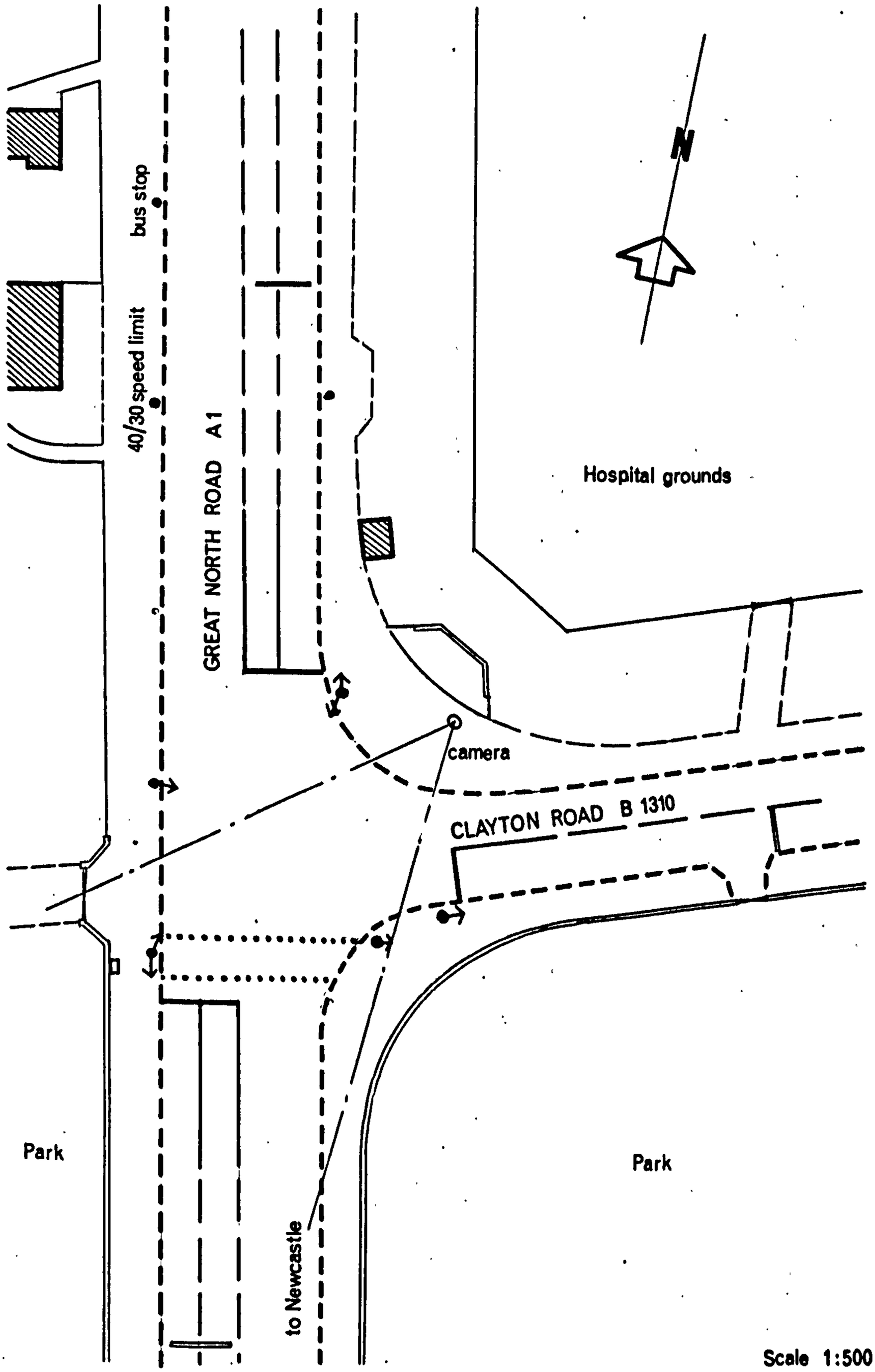


Fig. 2.4 The test site

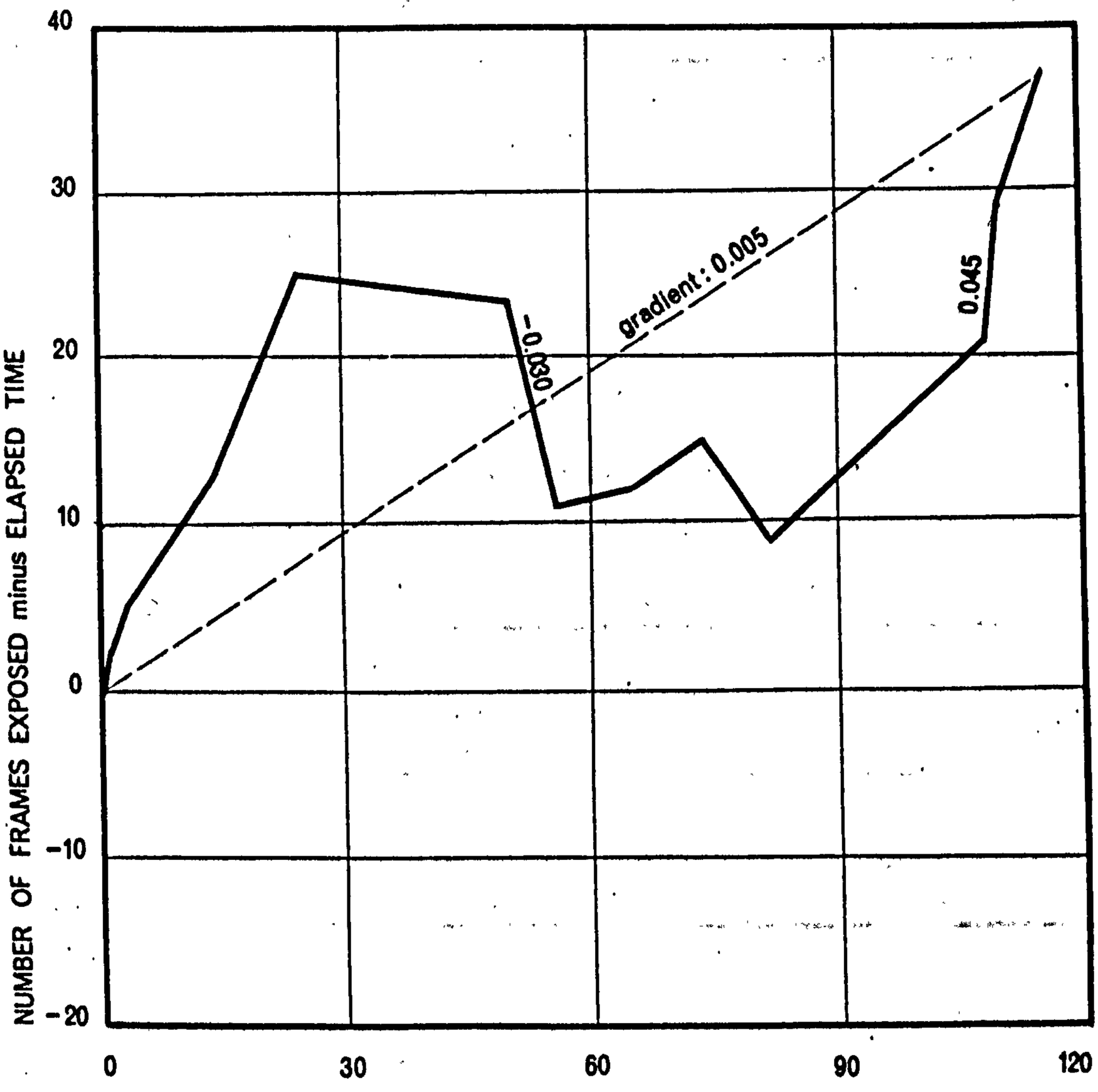


Fig. 2.5 Errors in mechanical timer based upon film A1/CR II

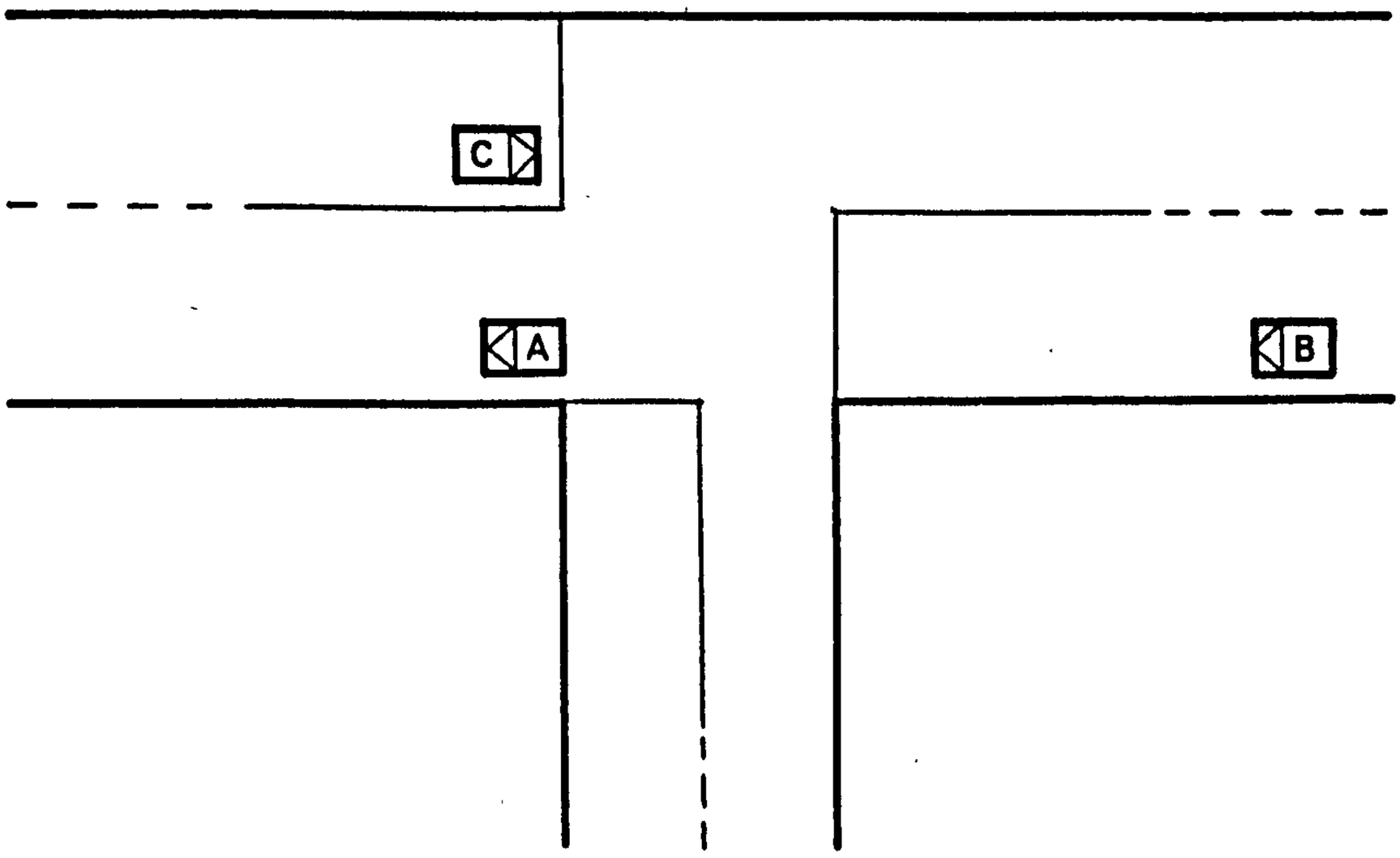


Fig. 2.6 Gap Acceptance

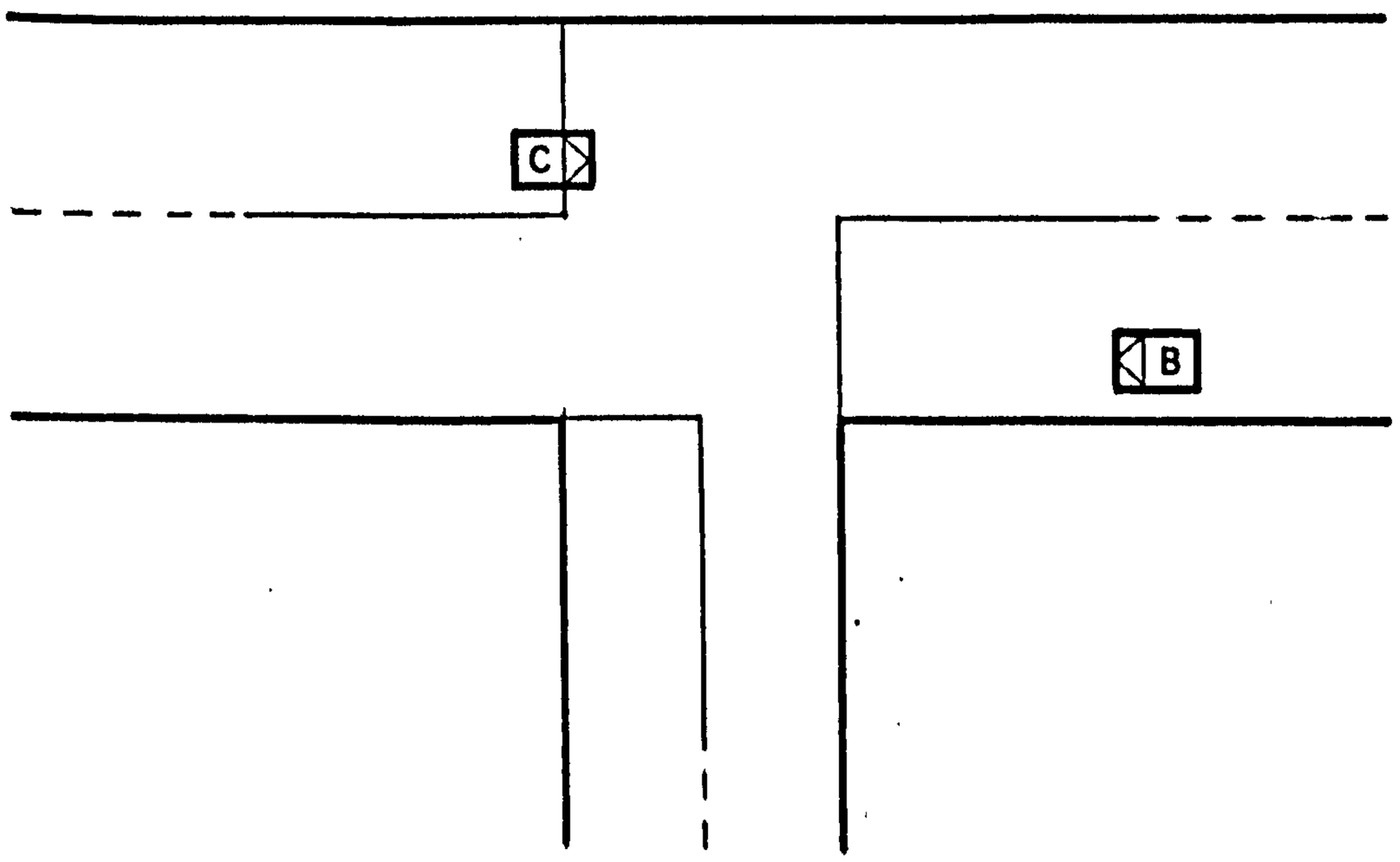


Fig. 2.7 Lag Acceptance

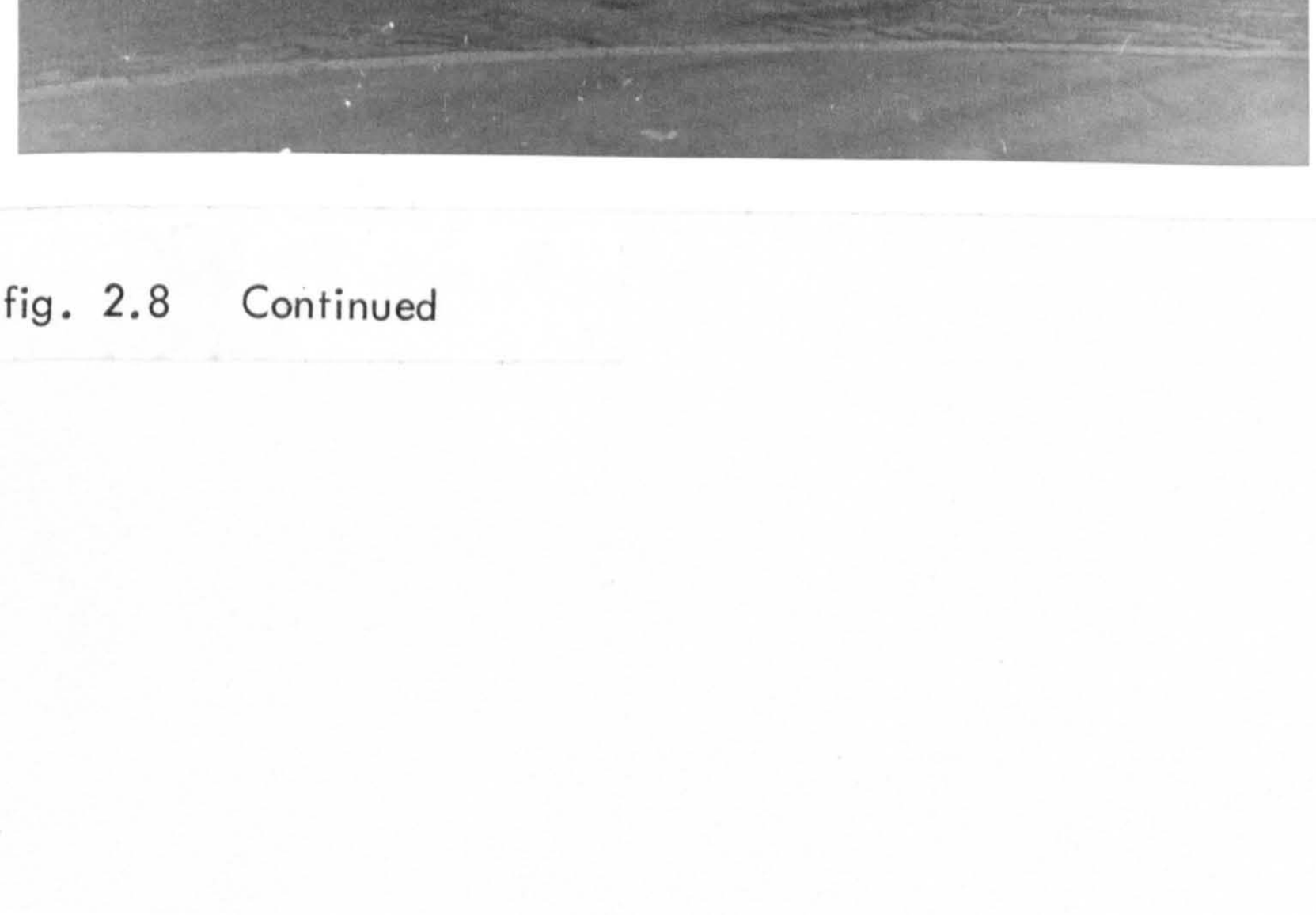
1

2

3

fig. 2.8 Gap measurement using time lapse cinematography

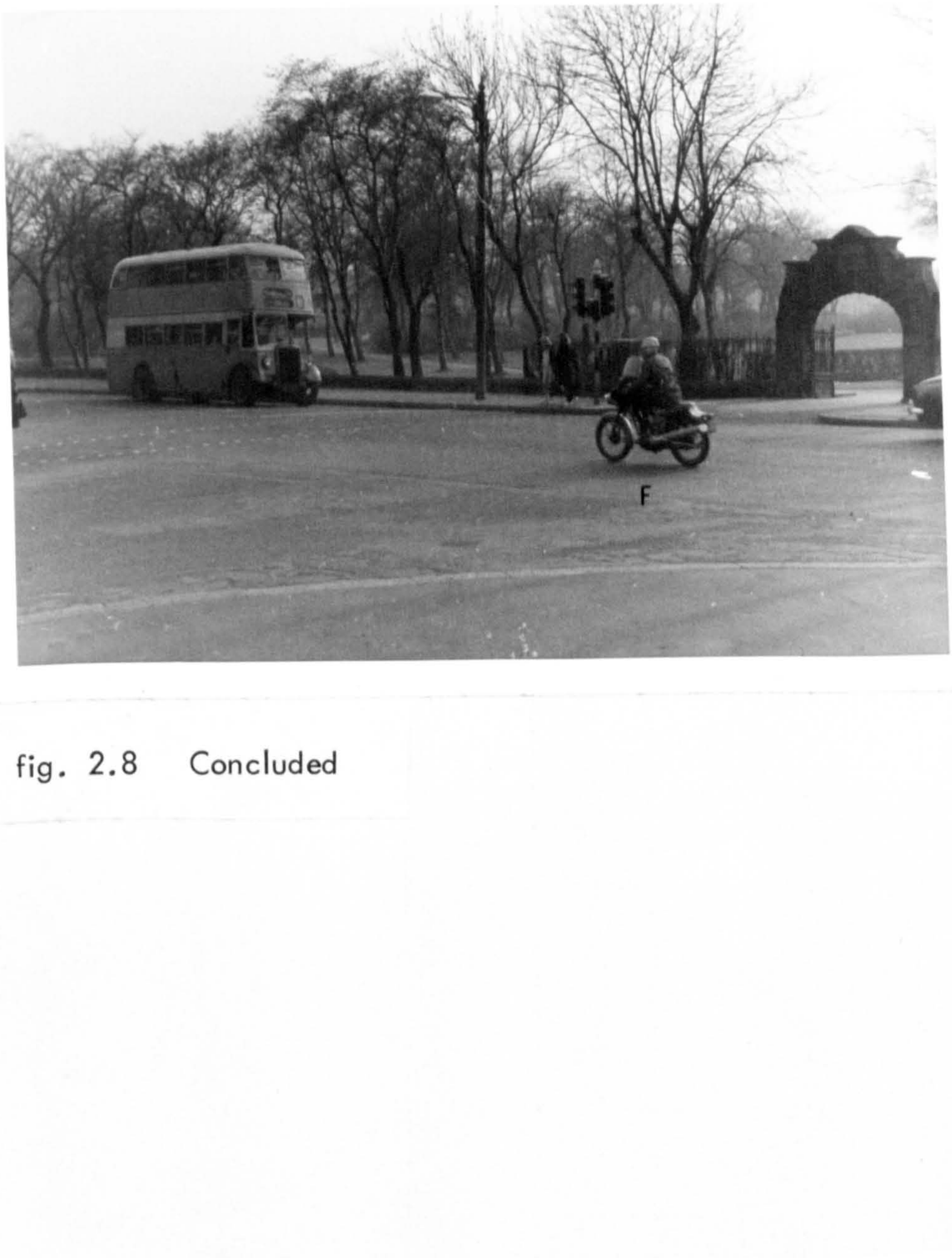
4



5

fig. 2.8 Continued

6



7

fig. 2.8 Concluded

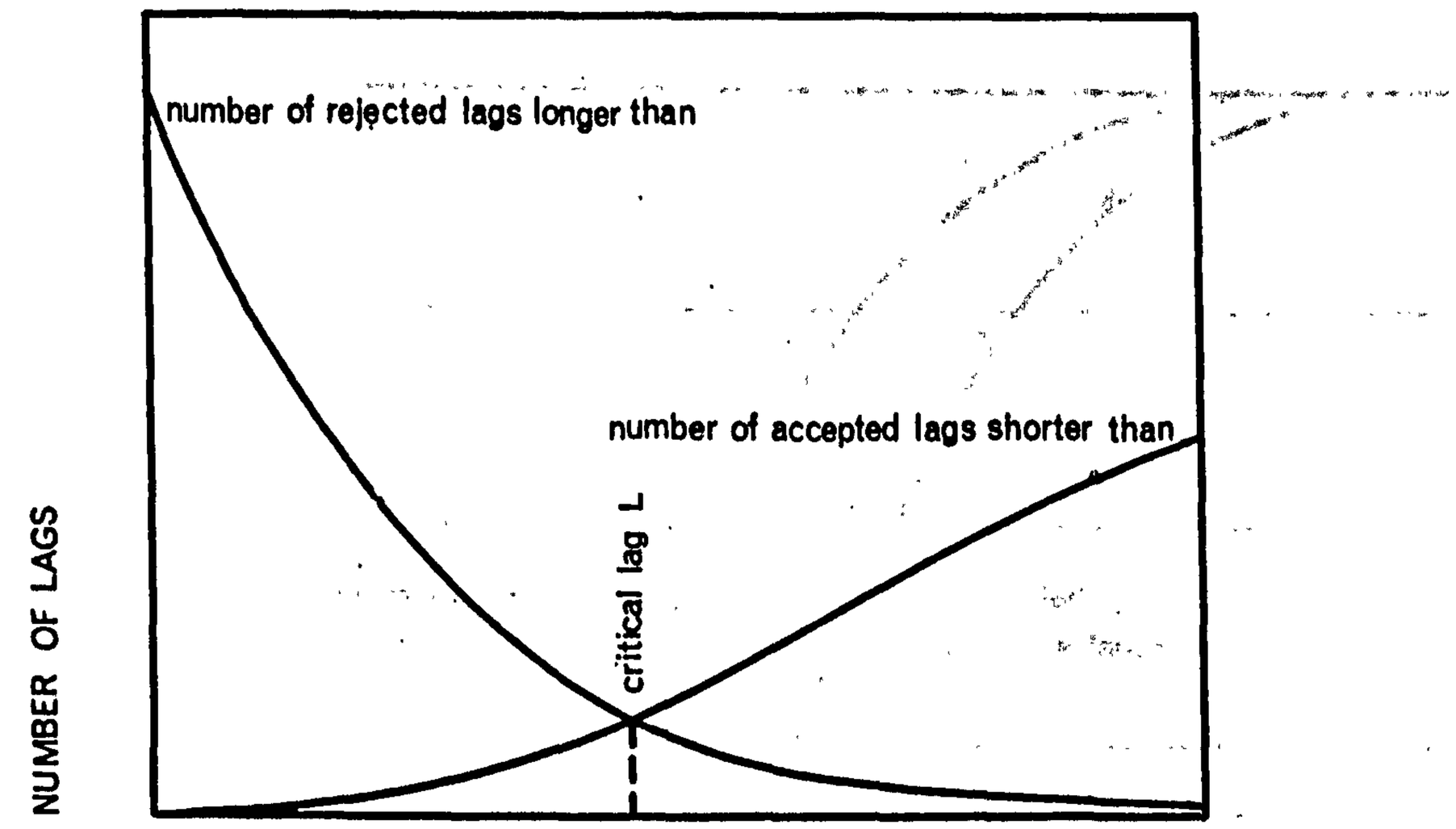


Fig. 2.9 Critical lag (Source : Fig. 7, ref. 2.19)

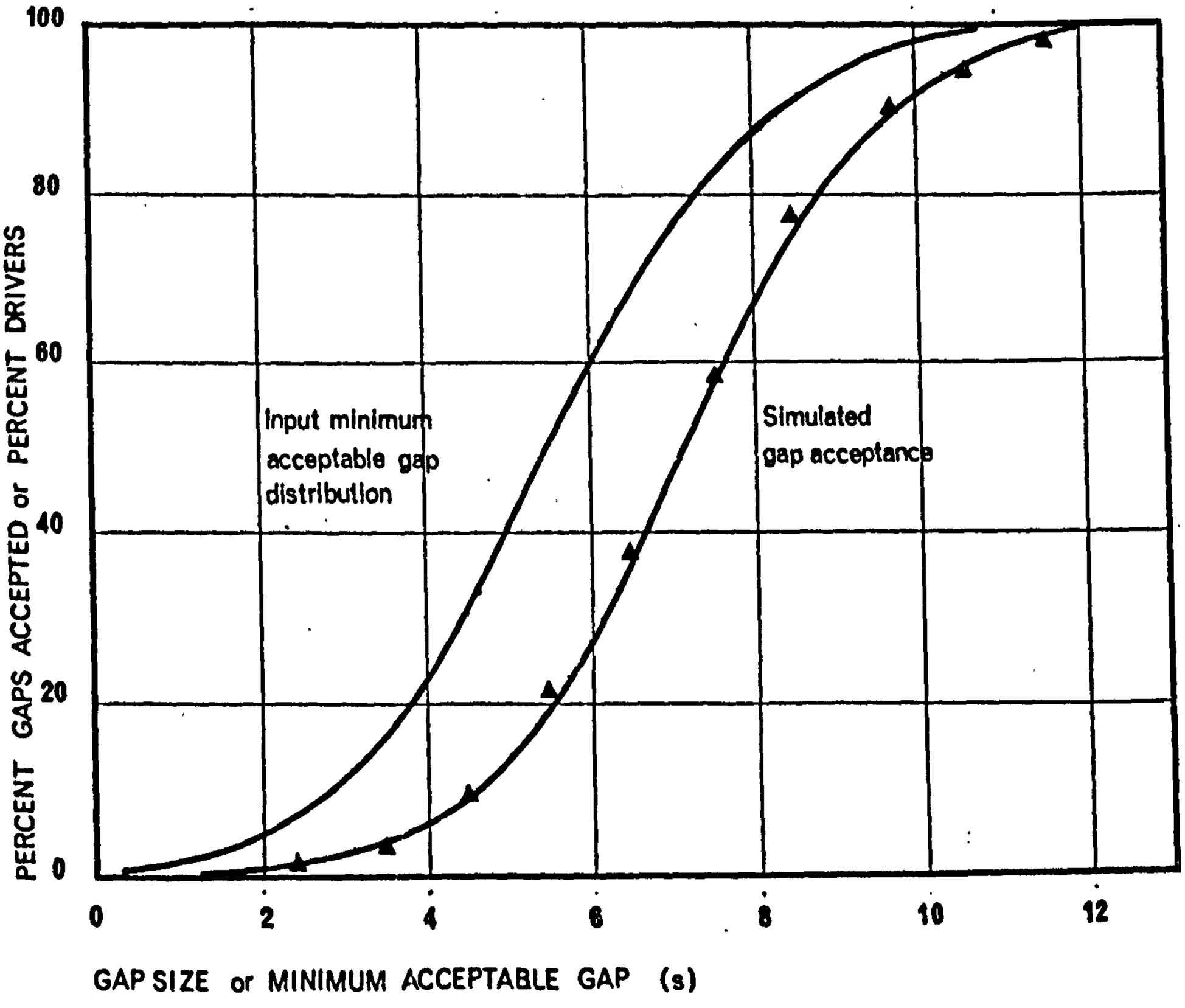


Fig. 2.10 Difference between probability of gap acceptance and minimum acceptable gaps

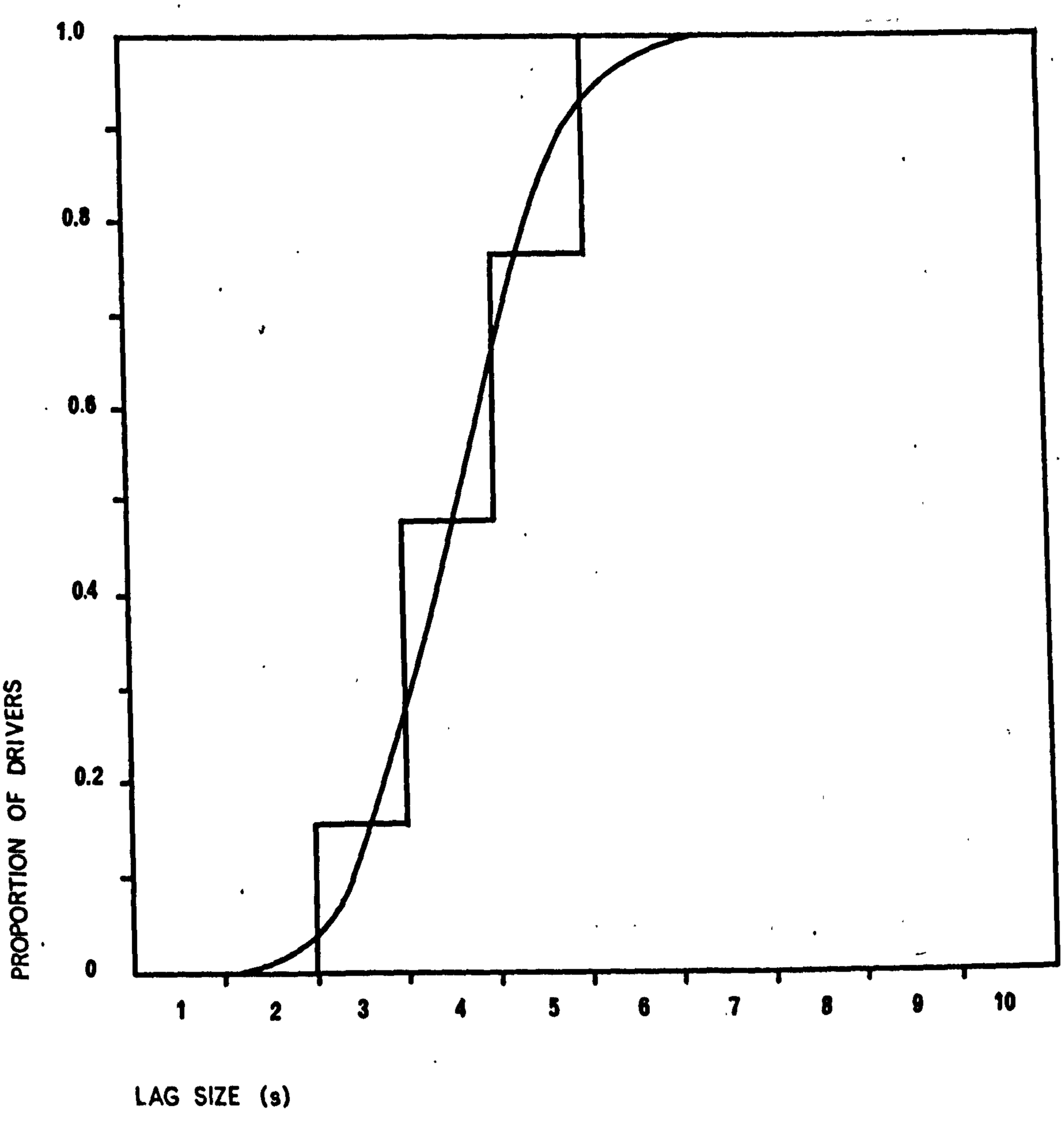


Fig. 2.11 Lag Acceptance Data

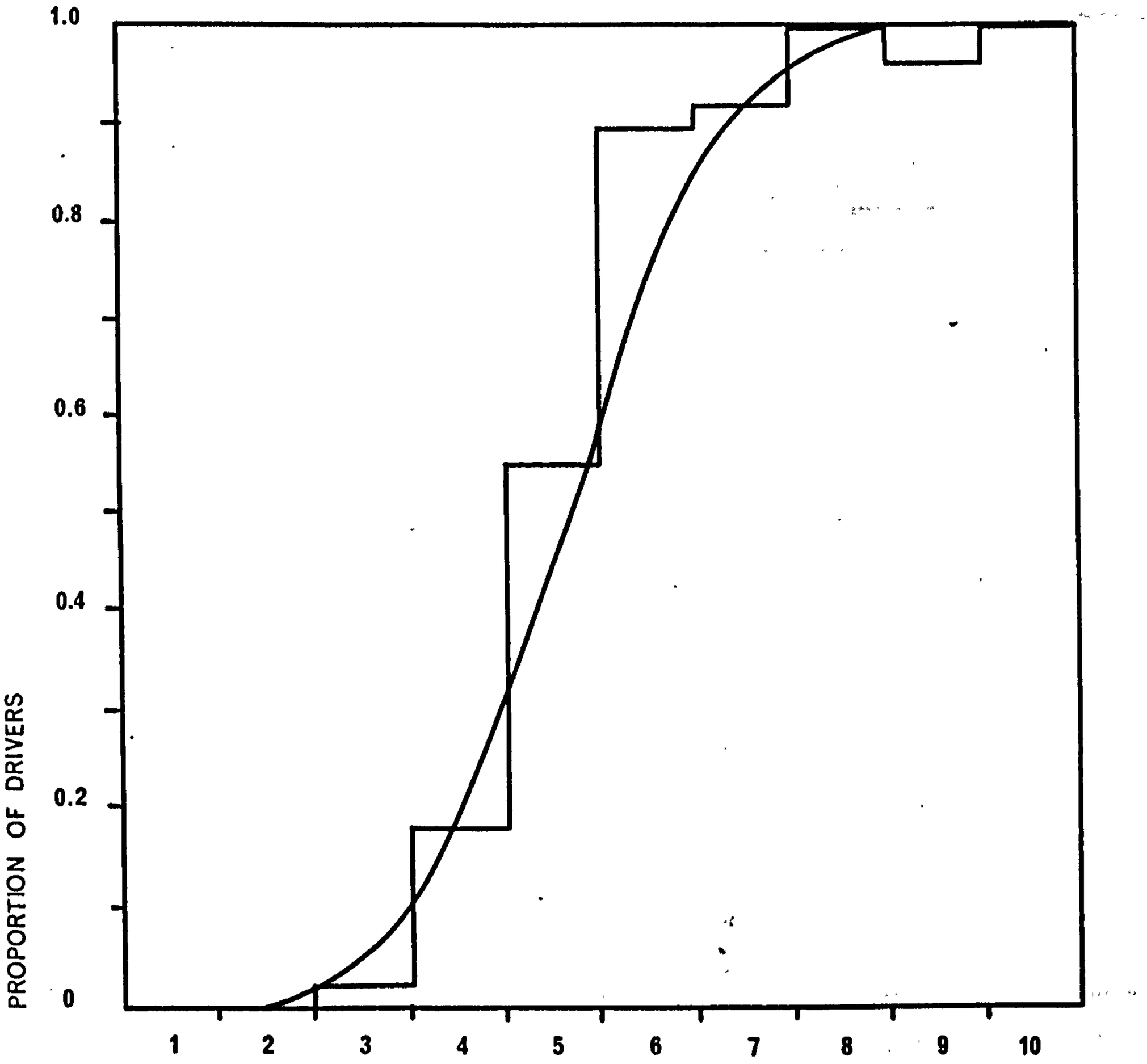


Fig. 2.12 Gap Acceptance Data (First gap only)

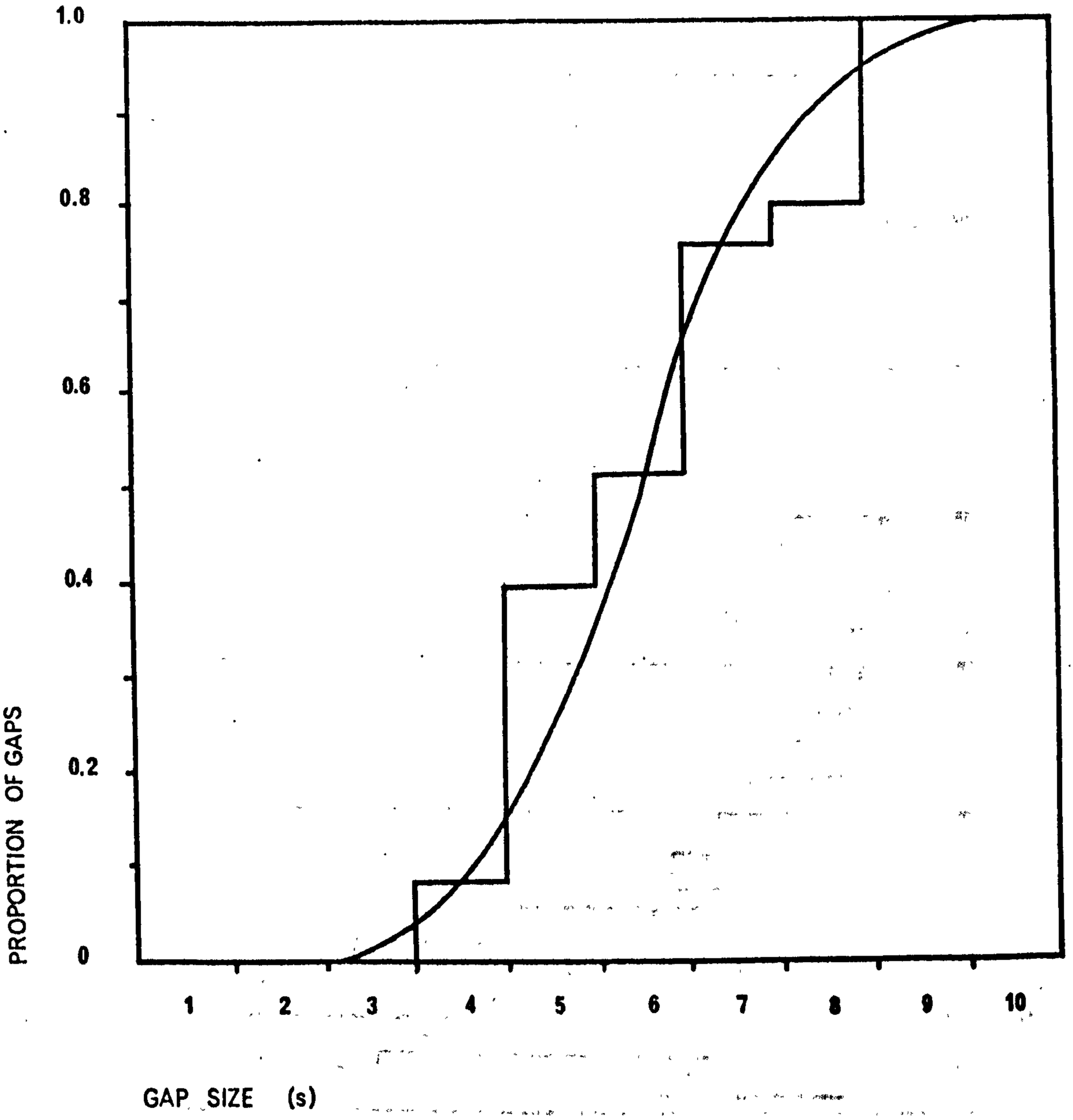


Fig. 2.13 Gap Acceptance Data (All gaps)

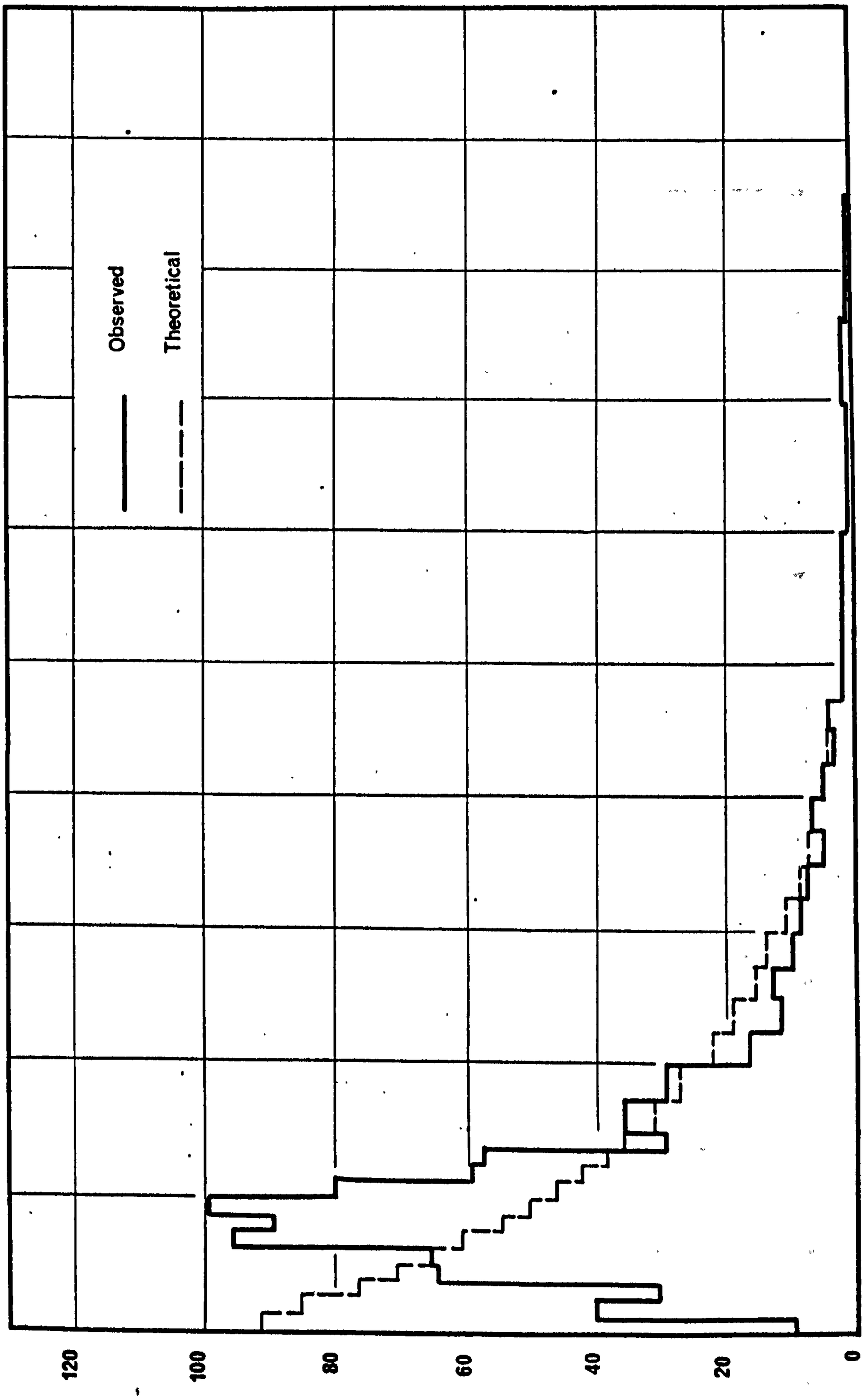


Fig. 2.14 Observed Arrival Distribution compared with Negative Exponential Distribution (Chi-Squared = 264.64, 25d.f.)

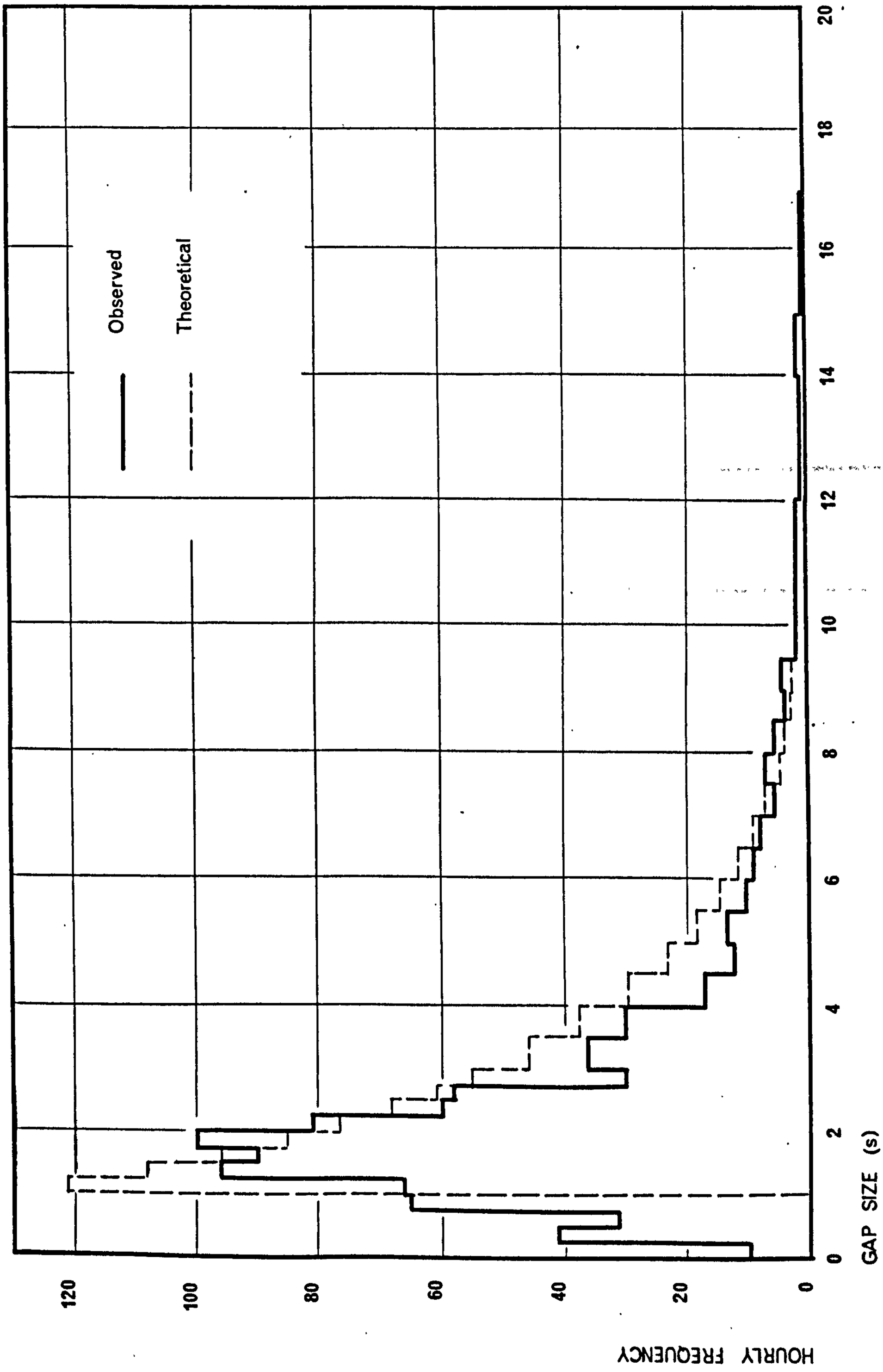


Fig. 2.15 Observed arrival distribution compared with shifted negative exponential distribution

(Minimum headway 1s, Chi Squared = 226.81, 23 d.f.)

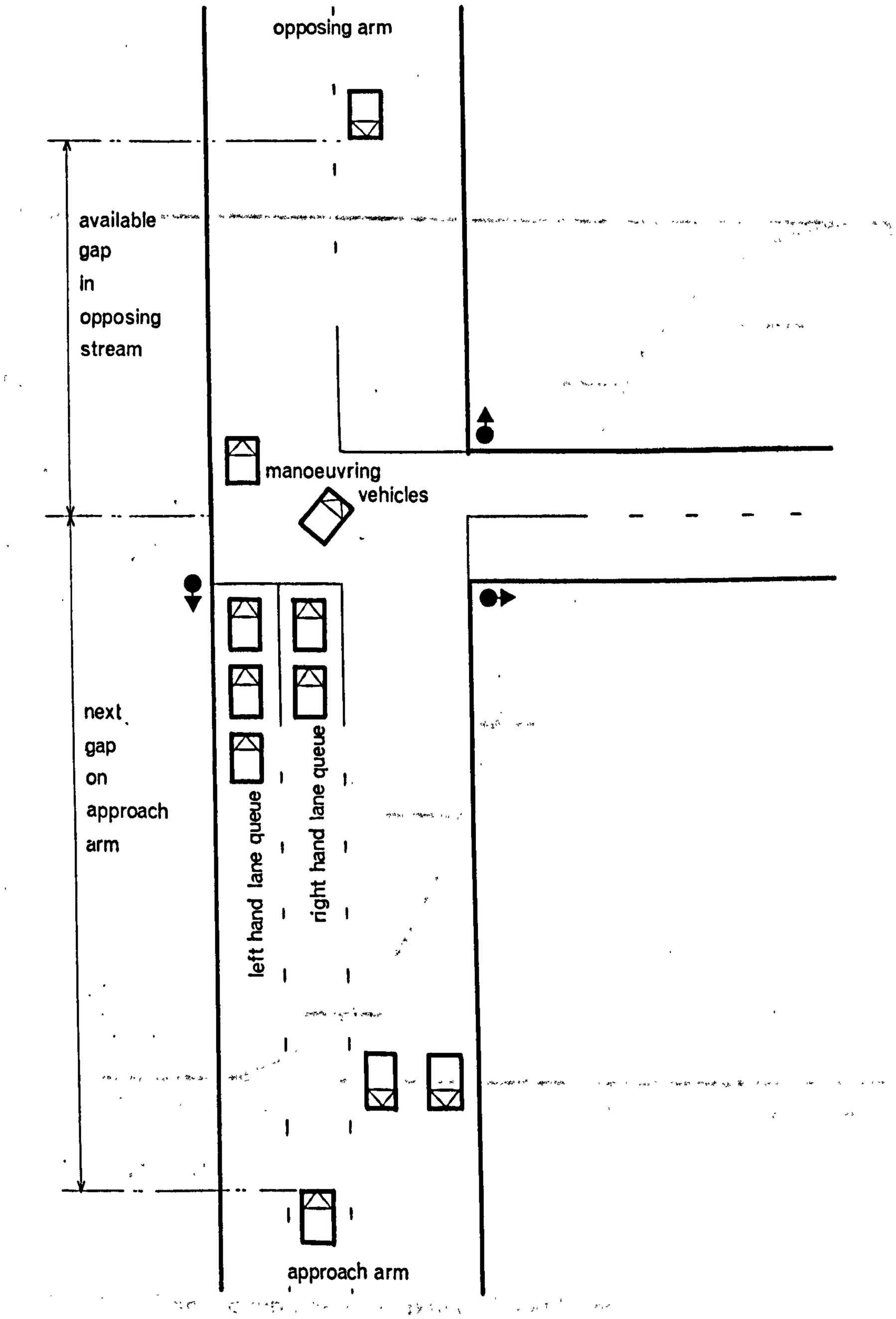


Fig. 2.17 Layout of modelled intersection

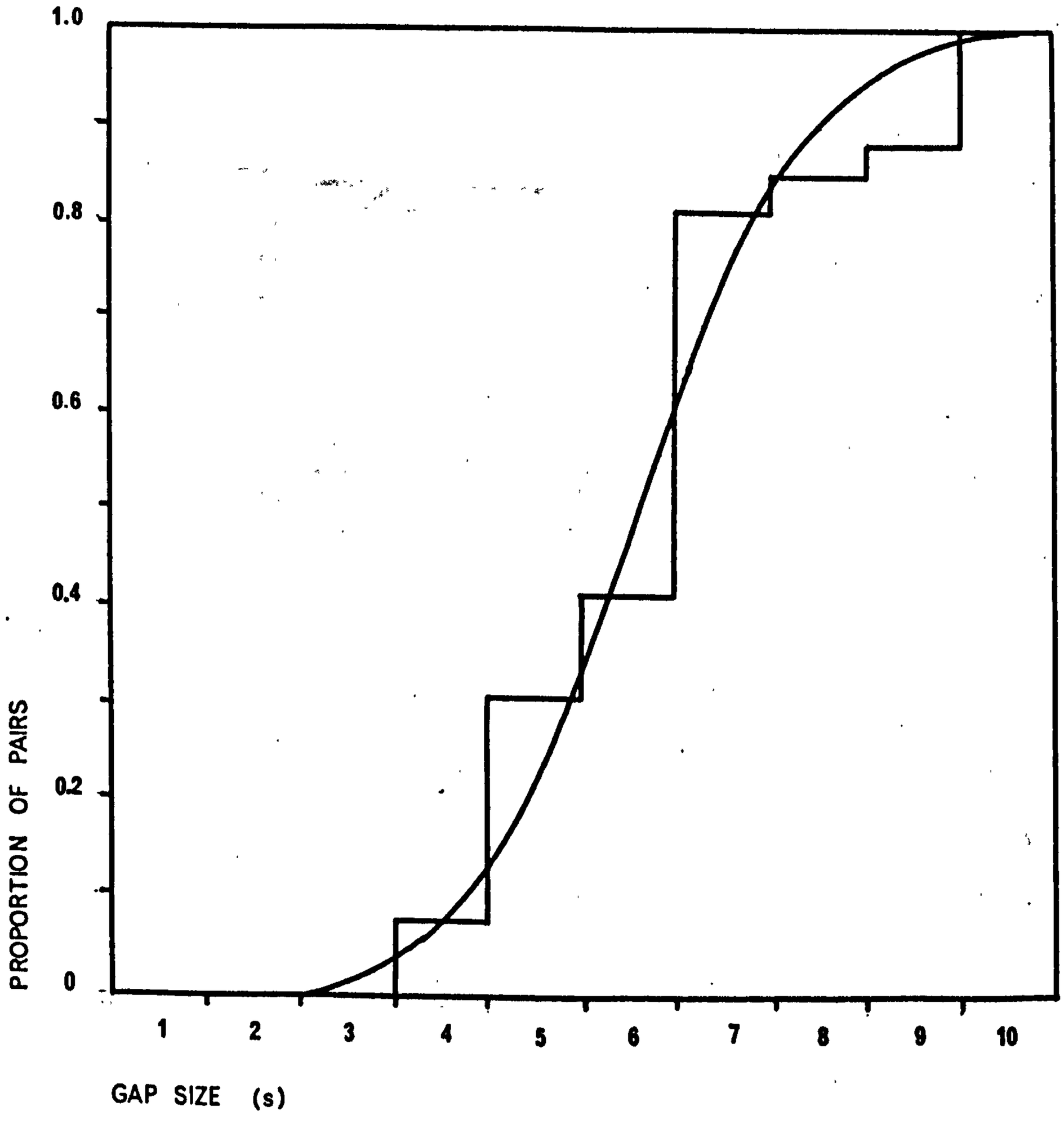


Fig. 2.18 Gap acceptance by pairs of vehicles

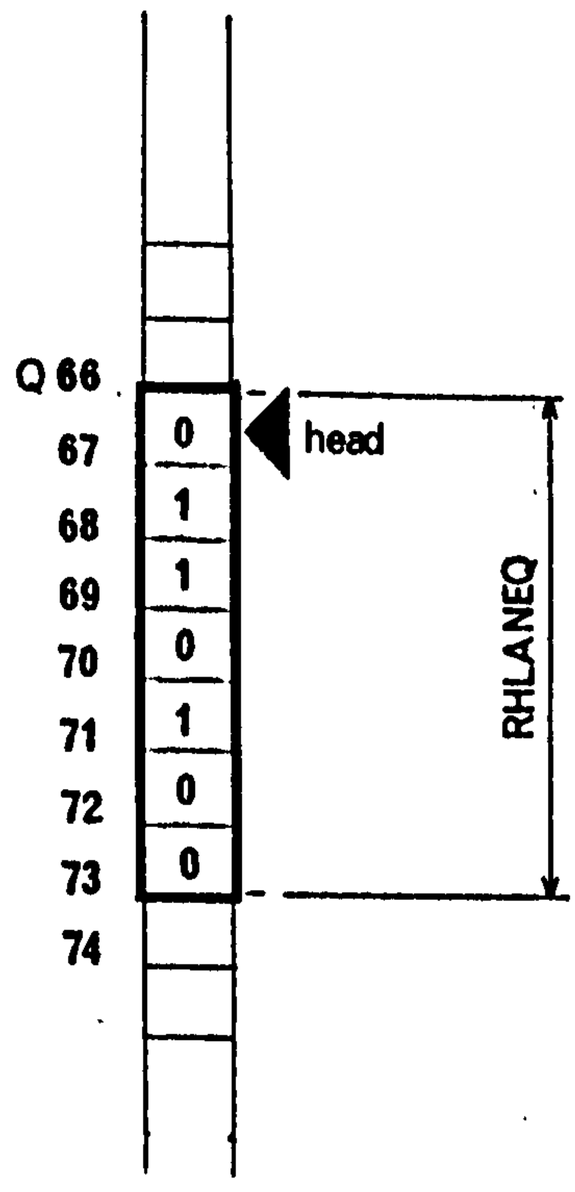


Fig. 2.19 Queueing mechanism

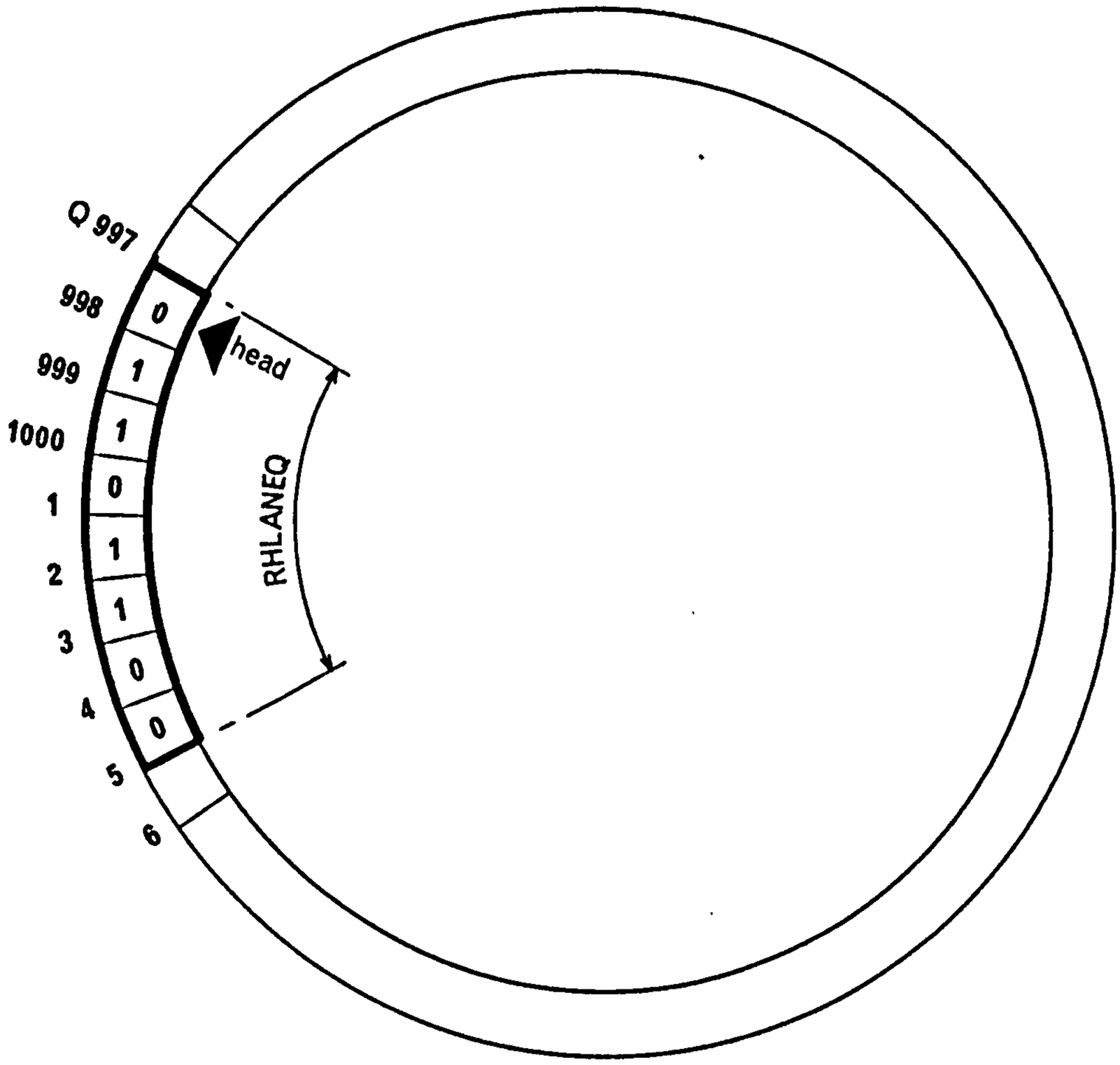


Fig. 2.20 Circular for right hand lane queue

```
2;
77;

2;      18000;32400;
1.0;
20 153 700 495;
60;30;3;27;9;0;0;
1600;1600;900;
0.05;0.25;
3200;1100;
1.0;2.75;
1.0;
1.75;
0;0;
0;
78;

3;      3600;18000;32400;
1.0;
22 196 282 183;
60;30;3;27;9;0;0;
1600;1600;900;
0.05;0.25;
3200;1200;
1.0;2.75;
1.0;
1.75;
0;0;
0;

-1000;→
```

Fig. 2.21 Example data tape for two runs

RUN NUMBER 138

INPUT

SCAN INTERVAL SECS 1.00

FIRST RANDOM NUMBER = 16 908 266 597

CYCLE TIME SECS = 60
RED TIME SECS = 30
AMBER TIME SECS = 3
GREEN TIME SECS = 27
EARLY CUTOFF SECS = 0
LATE START SECS = 0
LOST TIME SECS = 0

VOLUME ROAD B VPH = 1
VOLUME ROAD A VPH = 1000
VOLUME ROAD A RHLANE VPH = 500

MINIMUM HEADWAY SECS = 1.000

TIME TAKEN BY STOPPED VEHICLE TO CLEAR STOPLINE SECS = 2.30
TIME TAKEN BY MOVING VEHICLE TO CLEAR STOPLINE SECS = 1.00

PROPORTION OF RIGHT TURNING VEHICLES = 0.500
PROPORTION OF STRAIGHT AHEAD VEHICLES IN RHLANE = 0.000
PROPORTION OF VEHICLES IN LHLANE = 0.500
PPN OF VEHS TURNING IN FRONT OF OPPOSING QUEUE WHEN FIRST VEHICLE IN RIGHT HAND QUEUE IS RIGHT TURNING = 0.000

1 SIMULATION TIME SECS = 10800

RESULTS

2 NO OF VEHICLES DELAYED = 2 281

TOTAL DELAY SECS = 36 635.89 (ROAD A) 3 30.11 (ROAD B) 4 36 666.00 (ROAD A+ROAD B) 5

6 AVE DELAY PER DISCHARGED VEH SECS = 12.166

AVE DELAY PER ARRIVED VEH SECS = 12.167 (ROAD A) 7 10.037 (ROAD B) 8 12.165 (ROAD A + ROAD B) 9

10 AVE DELAY PER DELAYED VEH SECS = 16.06

11 NO RIGHT TURNERS VEH = 1494

12 NO LEFT AND STRAIGHT AHEAD VEH = 1517

13 NO RIGHT TURNERS TURNING IN FRONT OF OPPOSING QUEUE = 0

14 NO RIGHT TURNERS TURNING AFTER LIGHTS HAVE CHANGED TO RED = 0

15 MAX RHLANE QUEUE LENGTH VEH = 8

16 NO VEHS REMAINING IN RH QUEUE AT END OF SIMULATION = 0

17 MAX LHLANE QUEUE LENGTH VEH = 12.56

18 NO VEHS REMAINING IN LH QUEUE AT END OF SIMULATION = -0.33

SATURATION FLOWS

19 INPUT SATURATION FLOW LHLANE PCU PER HOUR = 1600

20 INPUT SATURATION FLOW RHLANE PCU PER HOUR = 1600

21 INPUT SATURATION FLOW OPPOSING ARM PCU PER HOUR = 3200

BOTH LANES

22 NO OF RIGHT TURNERS VEH = 803

23 NO OF LEFT AND STRAIGHT AHEAD VEH = 807

24 SATURATION FLOW TIME SECS = 1846

SATURATION FLOW VPH

25 UNCOMPENSATED FOR LONGER RIGHT TURNING MANEUVER TIME = 3140

26 COMPENSATED FOR LONGER RIGHT TURNING MANEUVER TIME = 3210

SINGLE LANES

27 NO OF RIGHT TURNERS VEH = 819

28 NO OF LEFT AND STRAIGHT AHEAD VEH = 812

29 SATURATION FLOW TIME SECS = 1894

30 SATURATION FLOW VPH = 3101

31 RIGHT TURNING VEHICLE FACTOR = 1.0638

DEGREES OF SATURATION

ROAD A			ROAD B	
RIGHT TURN FACTOR	INPUT VOLUMES	OUTPUT VOLUMES	INPUTVOLUMES ONLY	NO RIGHT TURNERS
1.7500 32	0.859433	0.860834	0.0006 35	
1.0638 36	0.645037	0.647238		

THEORETICAL DELAYS CALCULATED BY RRL FORMULA

39 RIGHT TURNING VEHICLE FACTOR = 1.7500

40 DELAY PER VEHICLE = 13.1404

41 DELAY PER DELAYED VEHICLE = 17.2825

OPPOSING APPROACH

42 DELAY PER VEHICLE = 7.5023

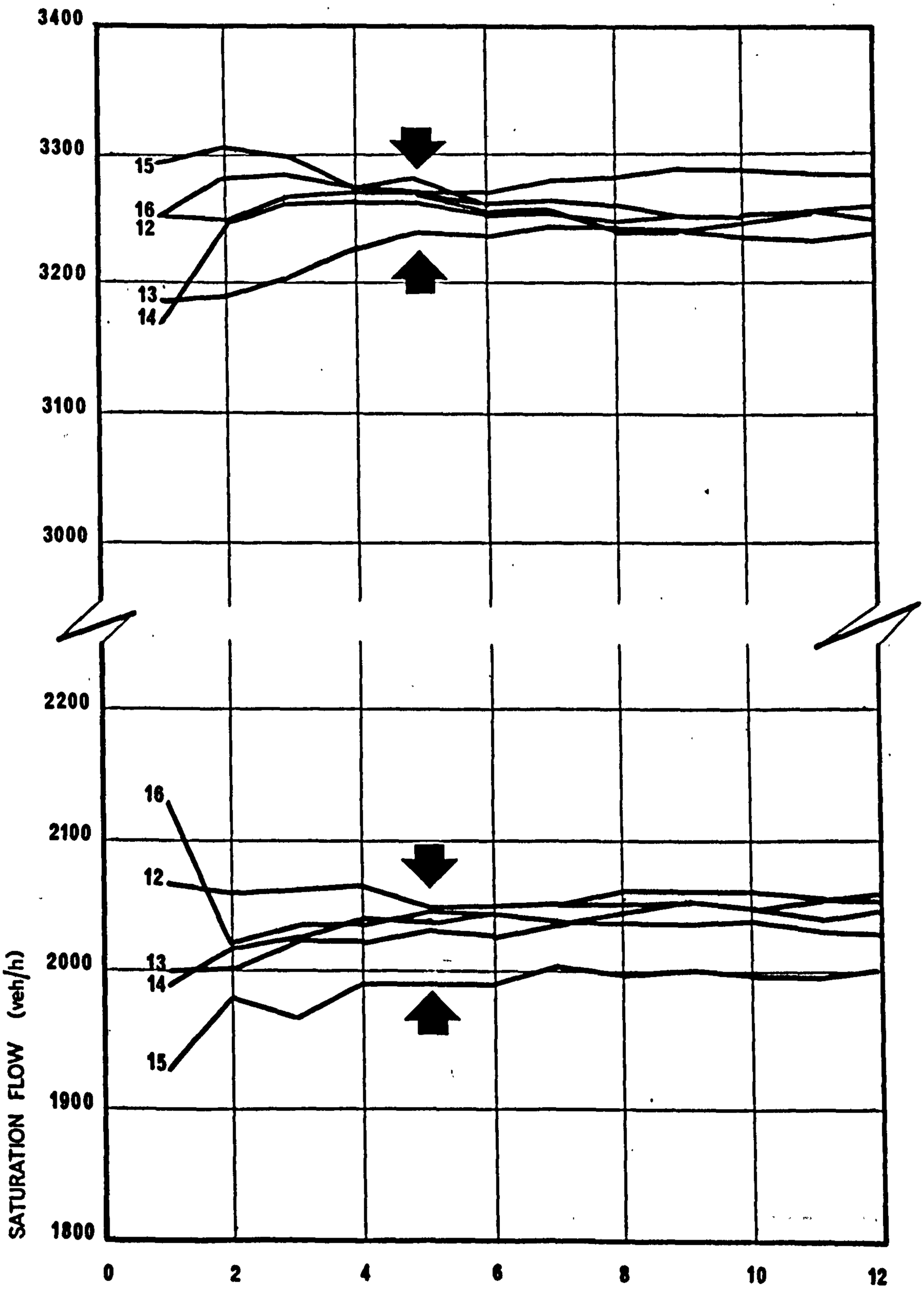


Fig. 2.24 Effect of starting random number and Simulation time on saturation flow

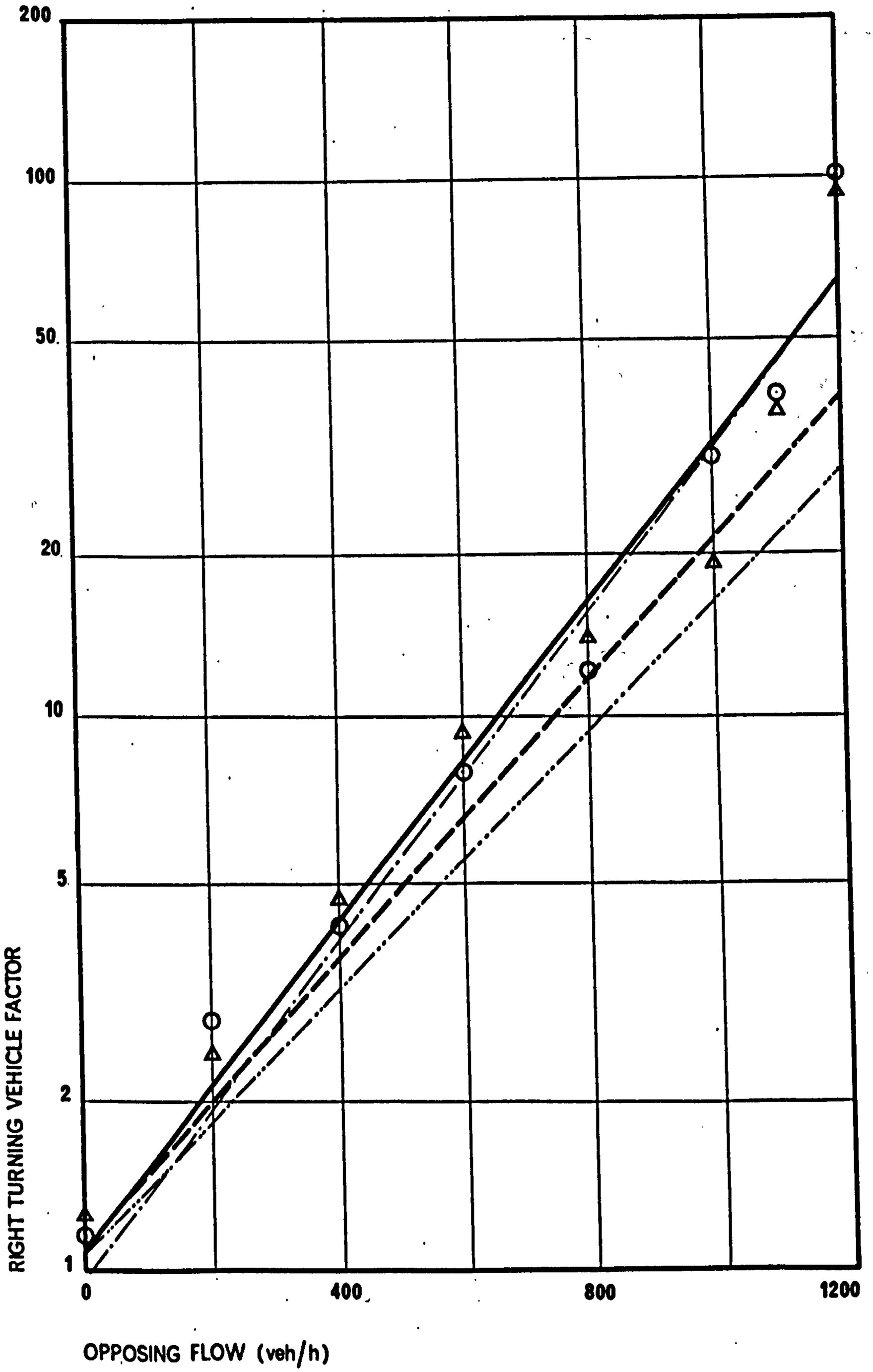


Fig. 2.25 Effect of opposing flow on right turning vehicle factor (5% right turns)

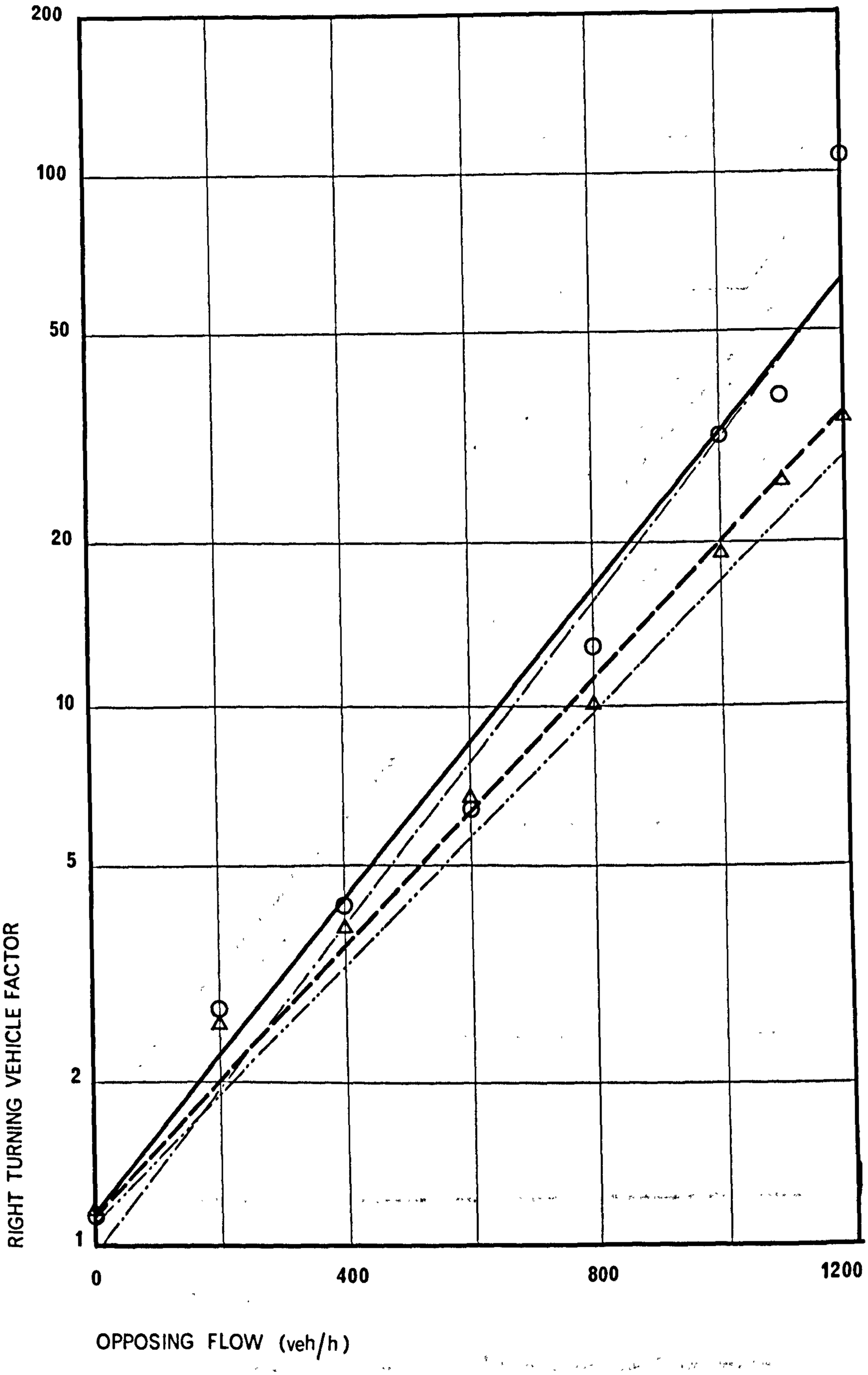


Fig. 2.26 Effect of opposing flow on right turning vehicle factor (10% right turns, runs 26-33, 74-81)

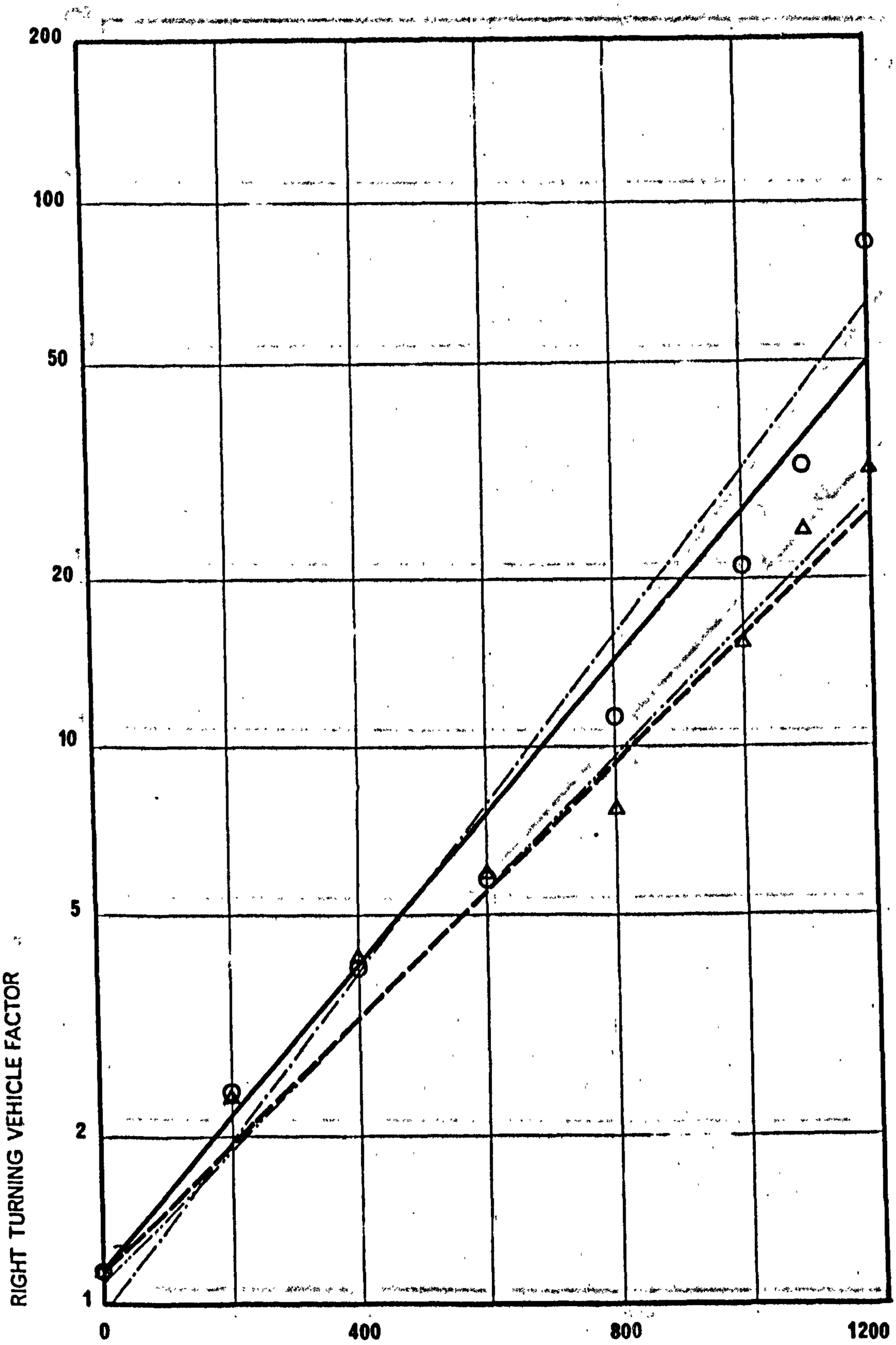


Fig. 2.27 Effect of opposing flow on right turning vehicle factor (15% right turns, runs 34–41, 82–89)

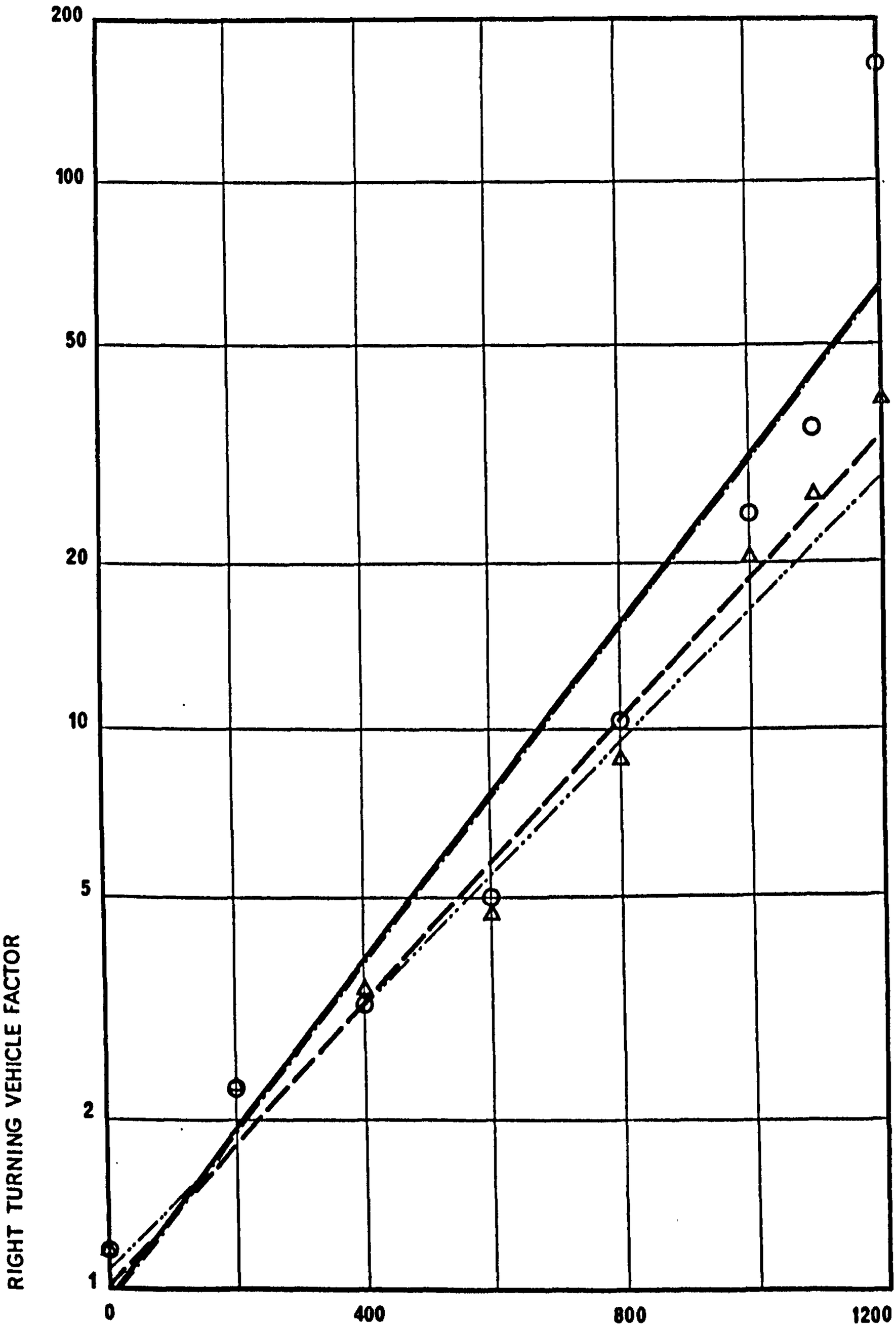


Fig. 2.28 Effect of opposing flow on right turning vehicle factor (20% right turns, runs 42–49, 90–97)

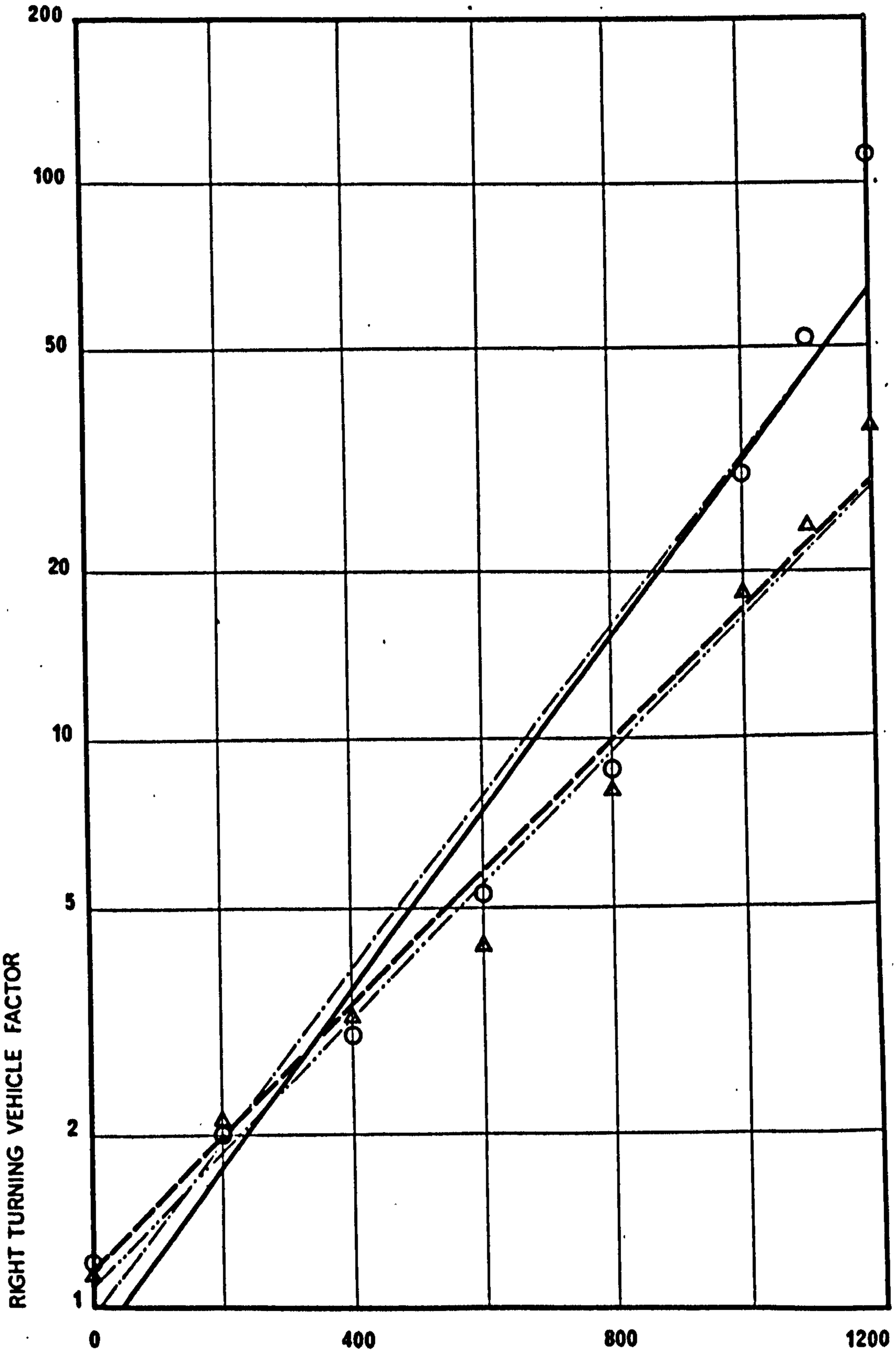


Fig. 2.29 Effect of opposing flow on right turning vehicle factor (25% right turns, runs 50-57, 98-105)

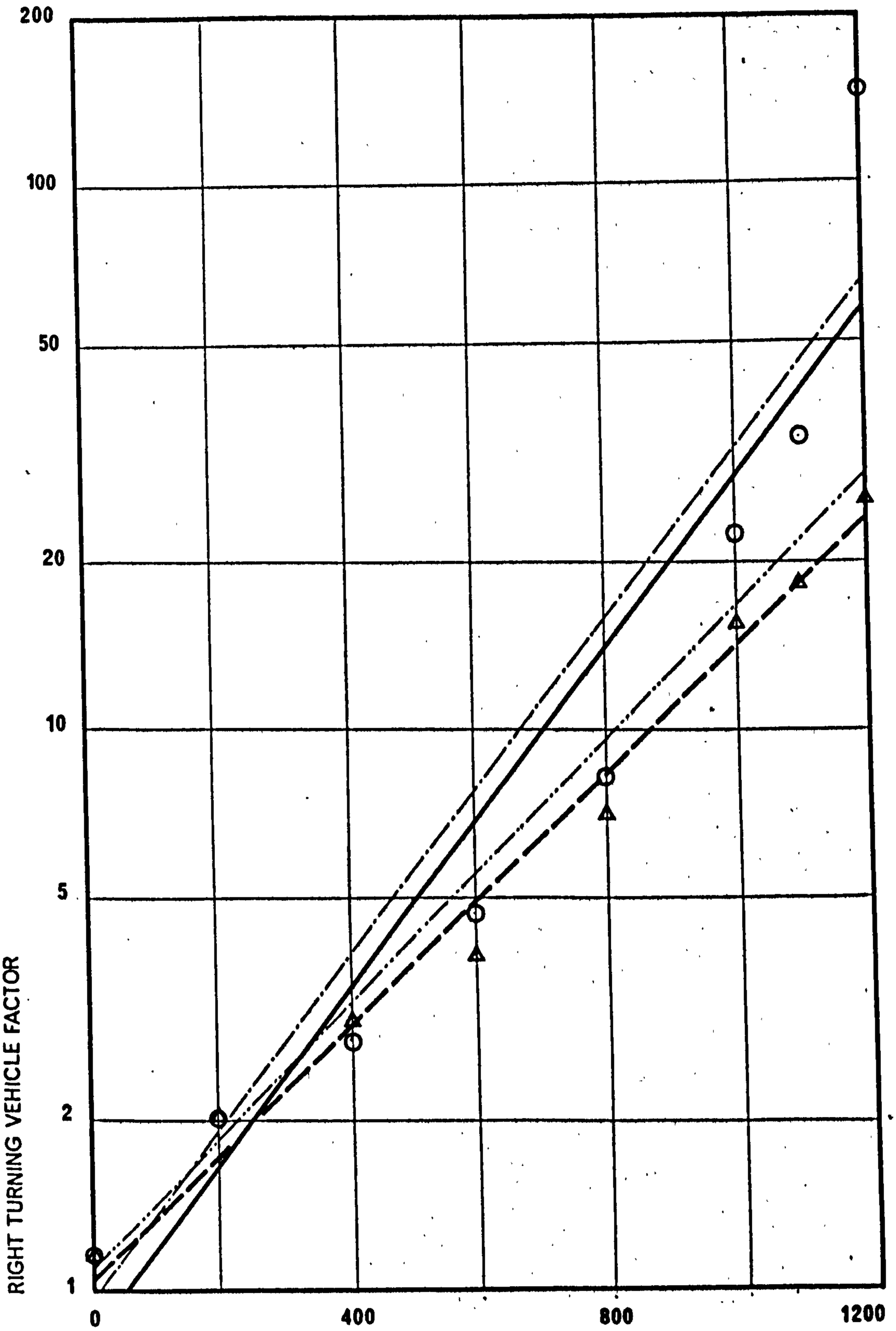


Fig. 2.30 Effect of opposing flow on right turning vehicle factor (30% right turns, runs 58-65, 106-113)

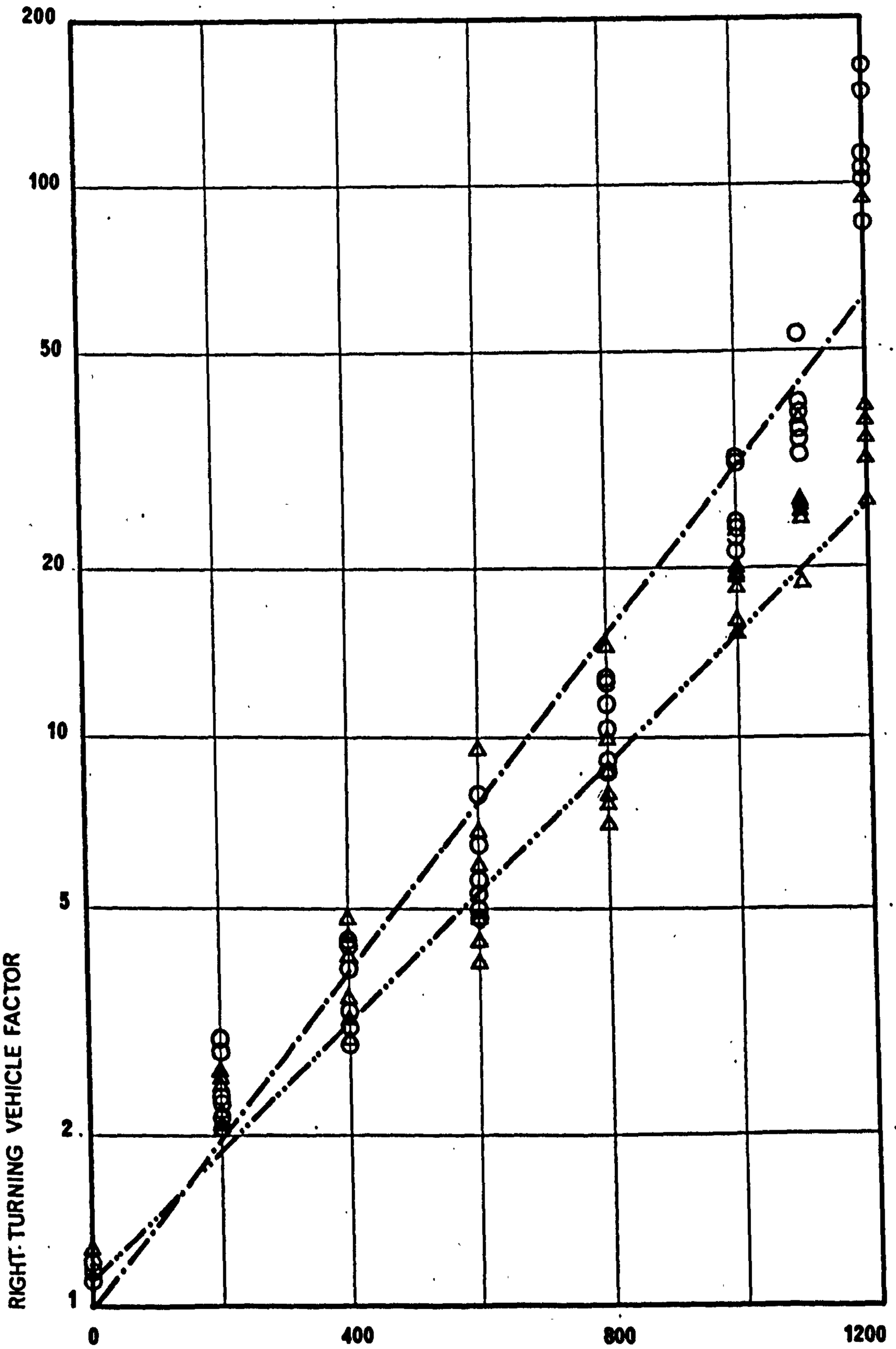


Fig. 2.31 Effect of opposing flow on right turning vehicle factor (5-30% right turns)

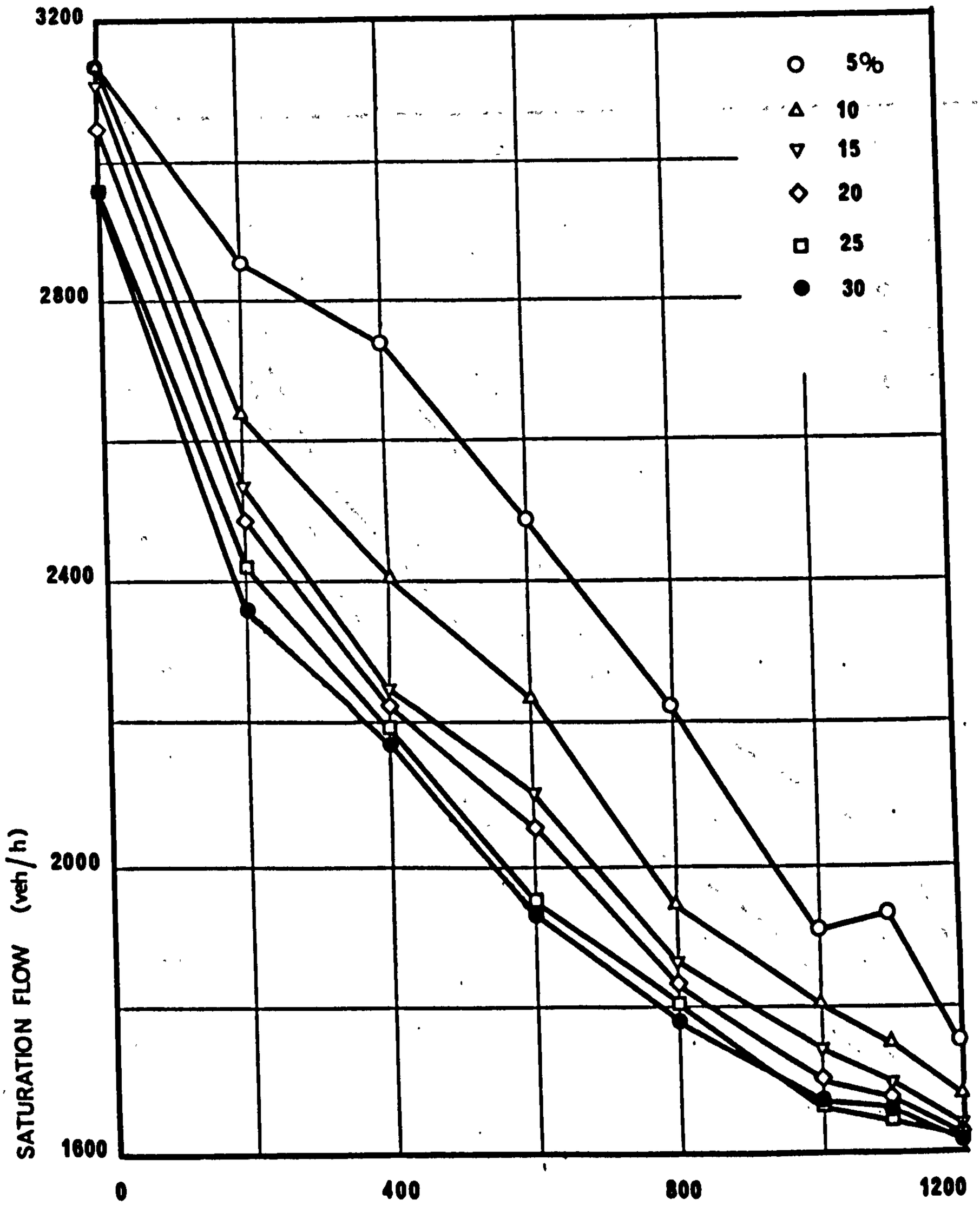


Fig. 2.32 Saturation flows at various proportions of right turning vehicles (no special right turning phase)

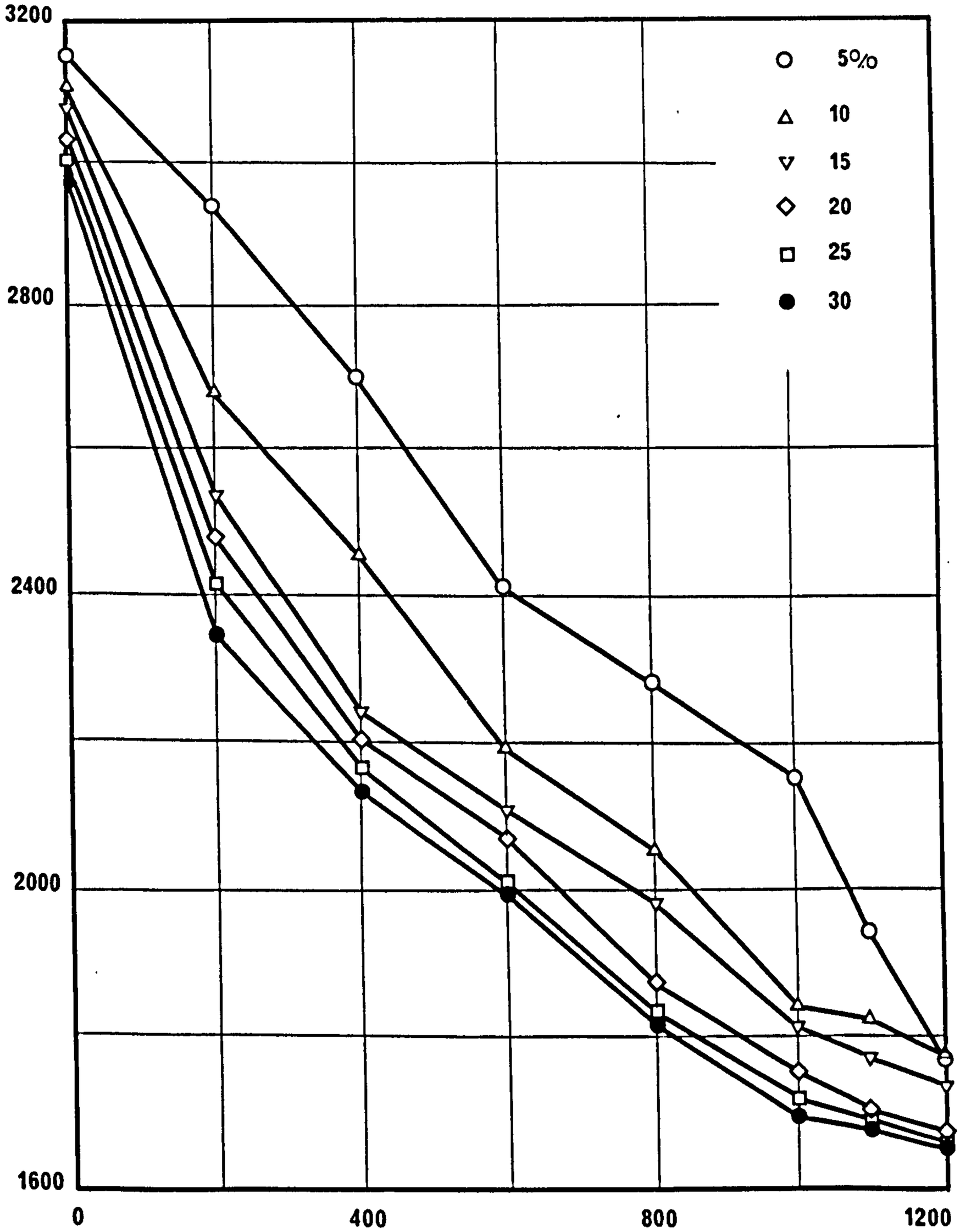


Fig. 2.33 Saturation flows at various proportions of right turning vehicles (9s early cut off, runs 66-113)

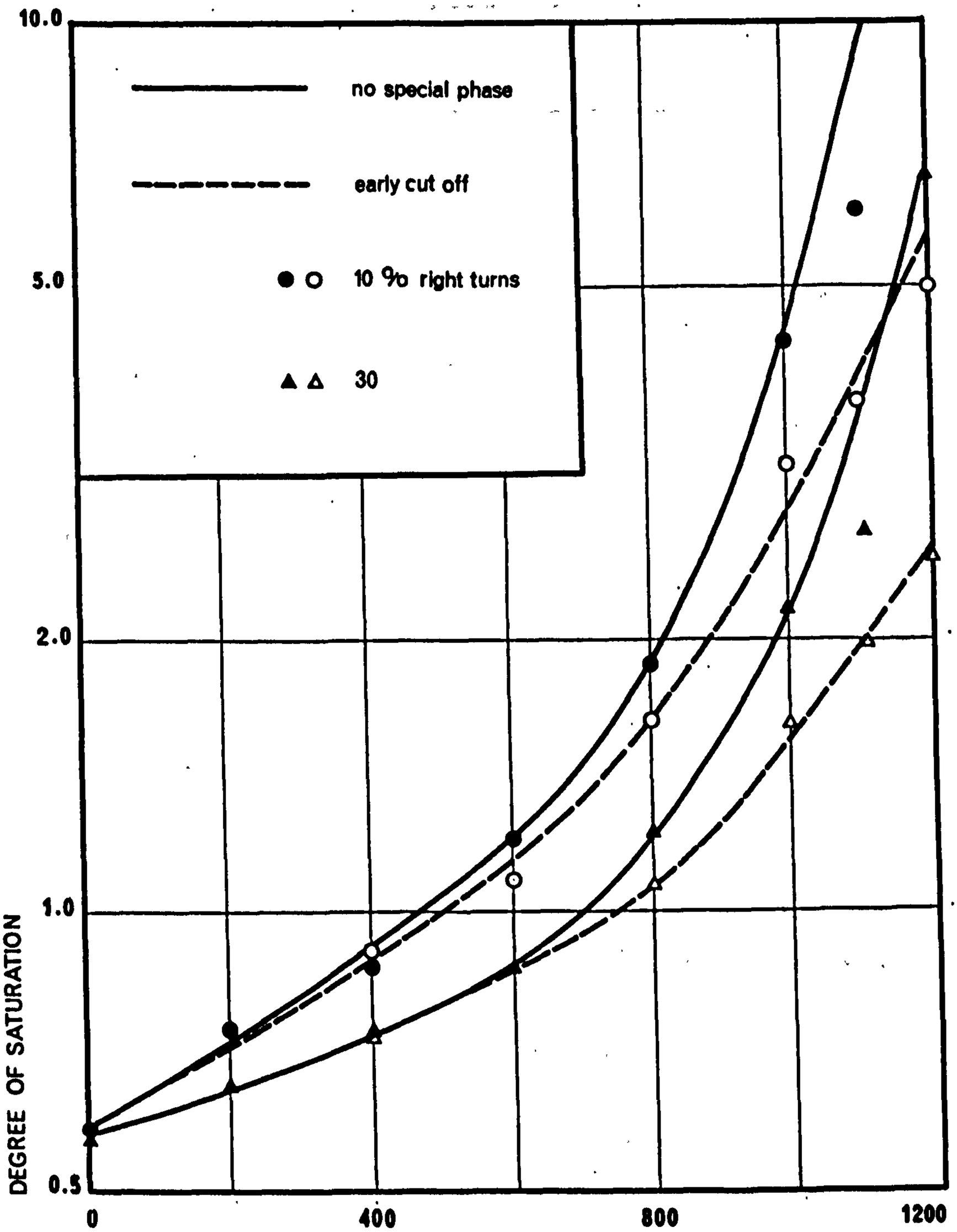


Fig. 2.34 Degree of saturation and opposing flow (10 and 30% right turns)

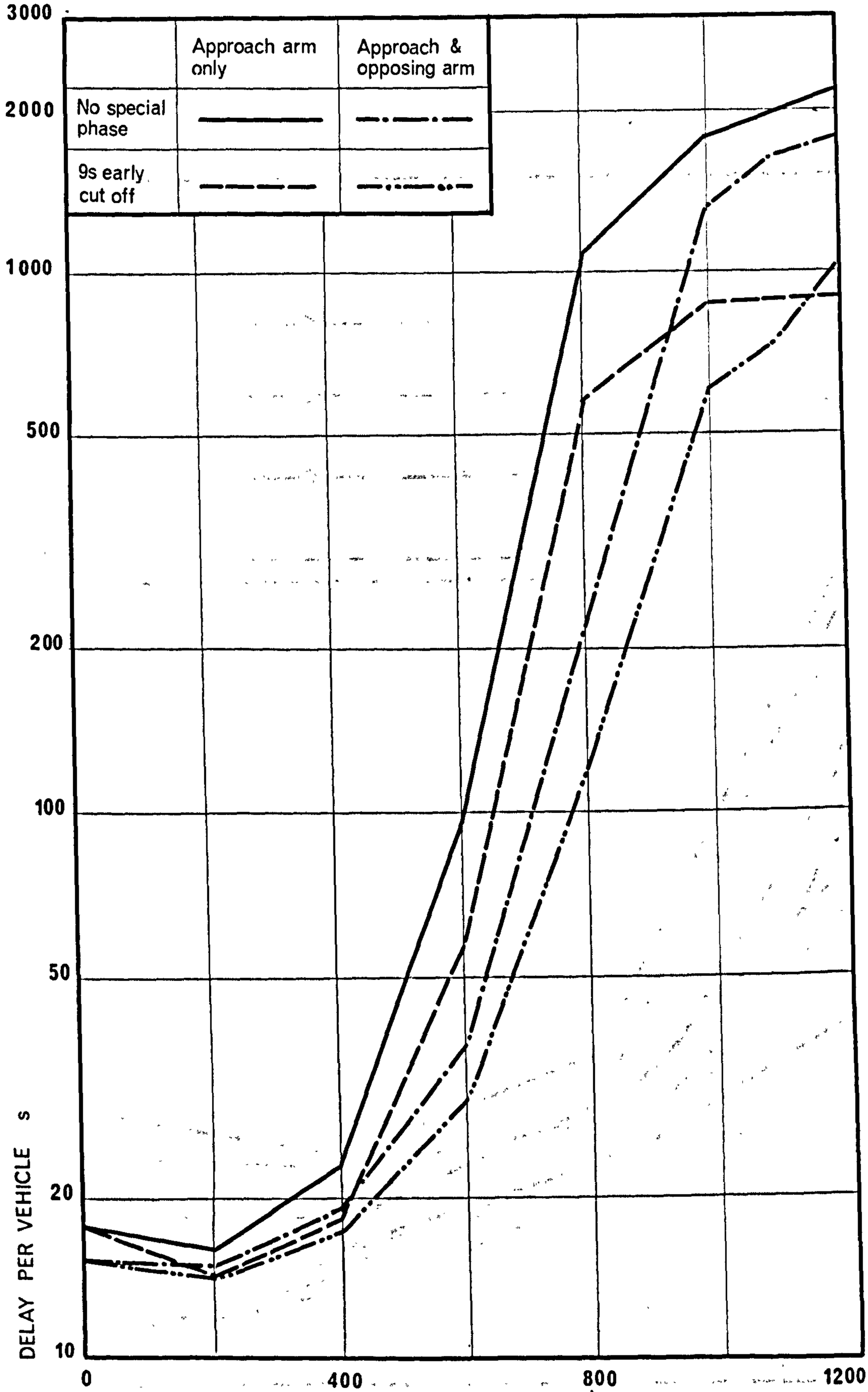


Fig. 2.35 Simulated delays, 15% right turns

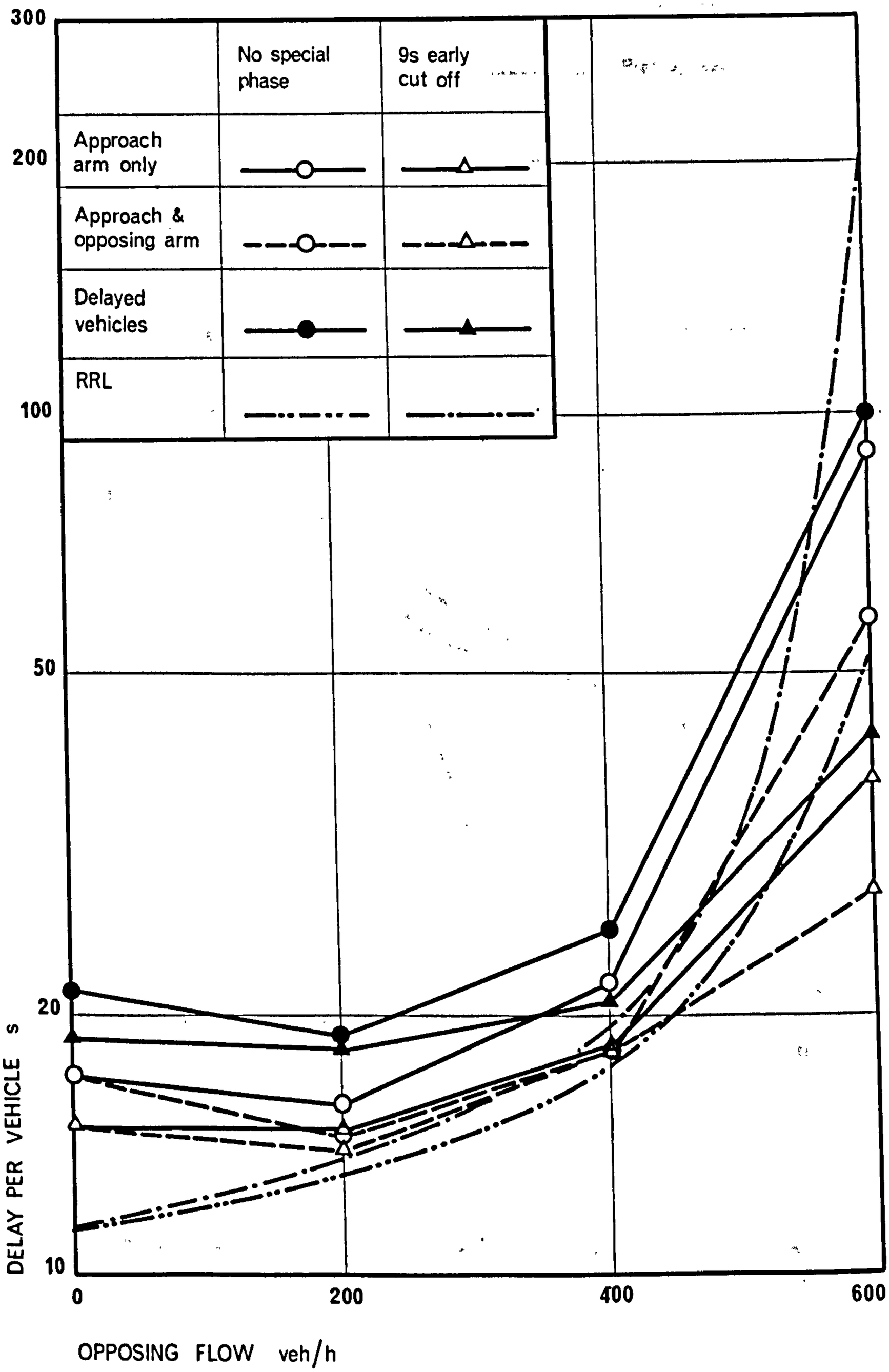


Fig. 2.36 Simulated delays, 15% right turns (unsaturated conditions)

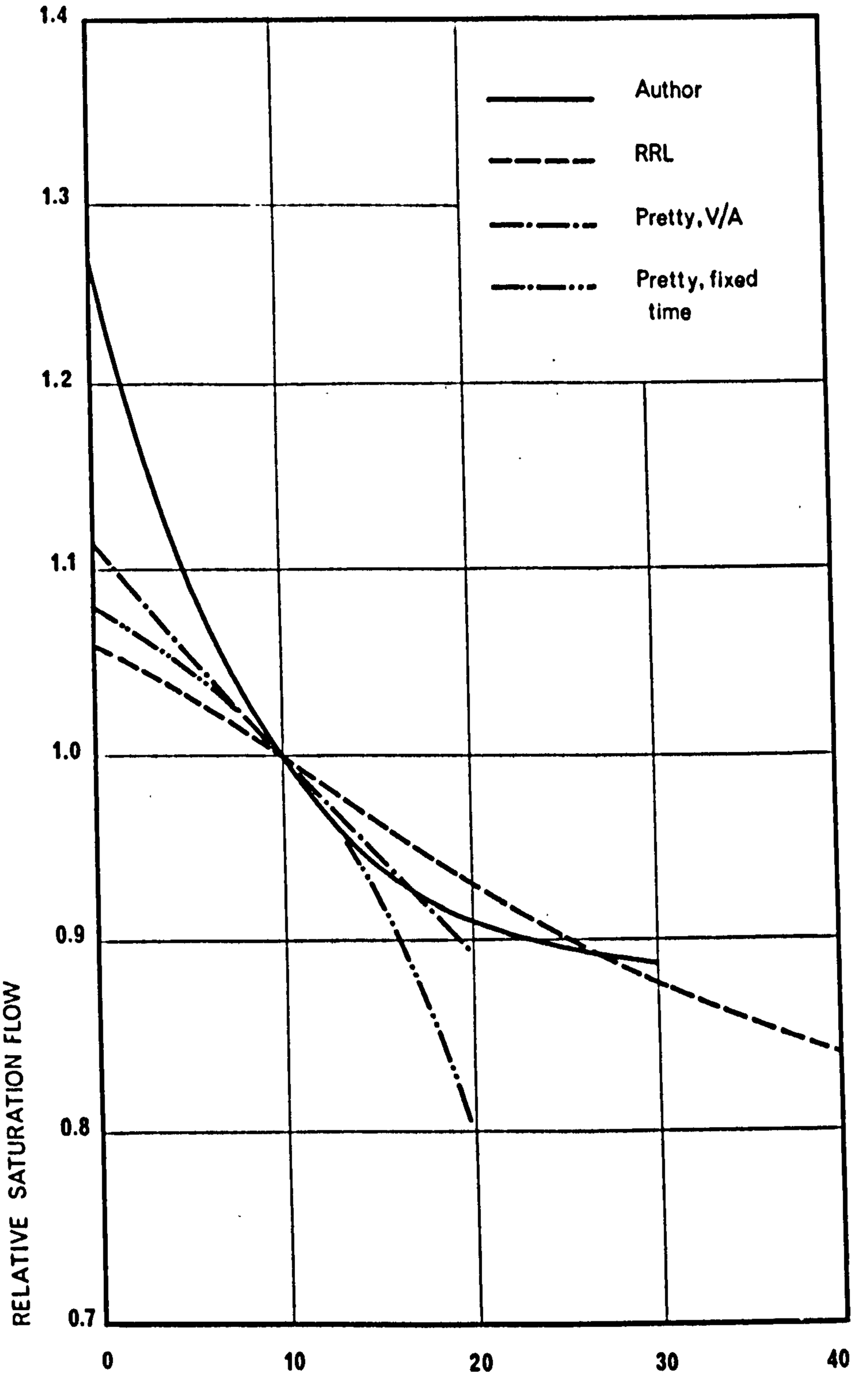


Fig. 2.37 Comparison between observed and simulated saturation flows

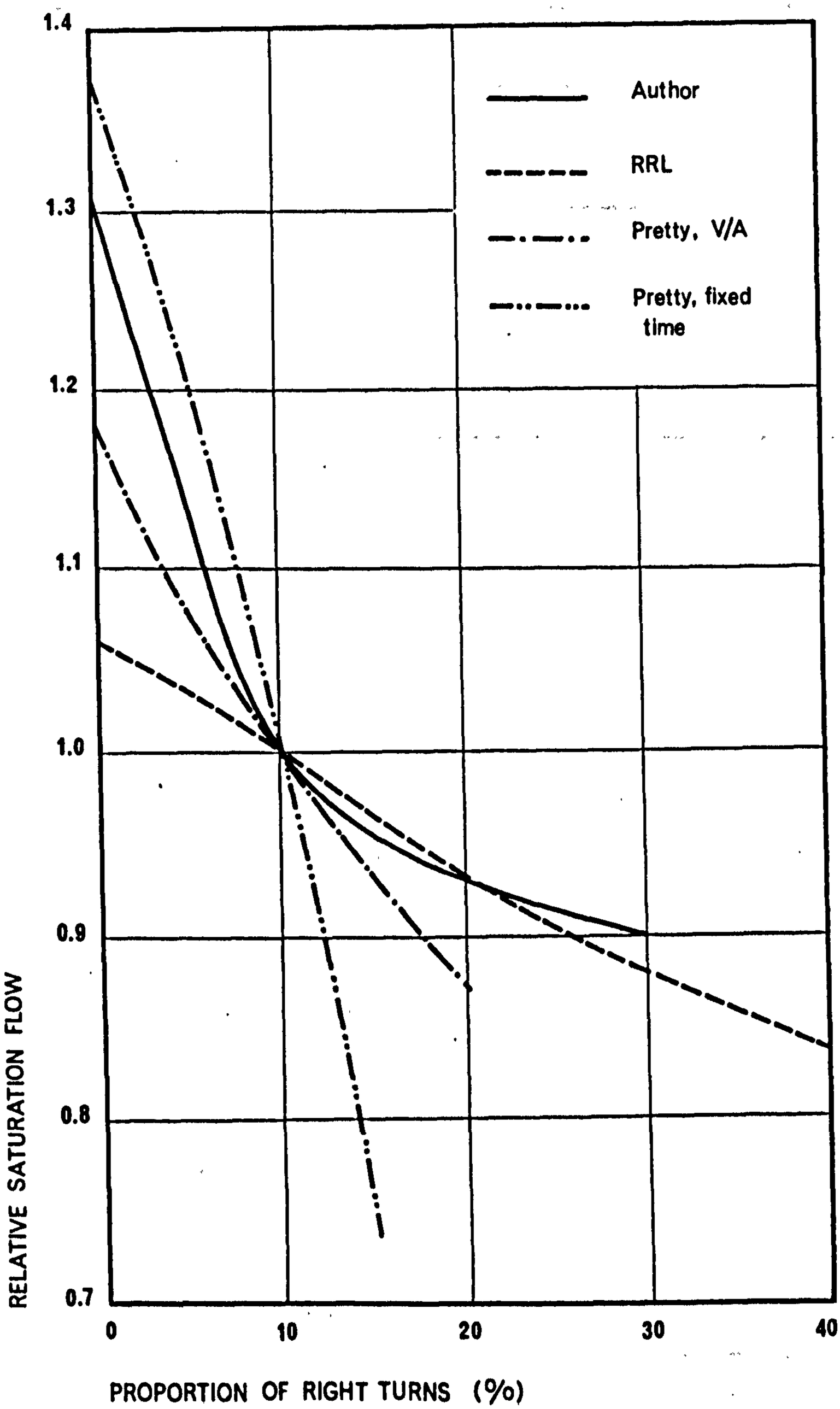


Fig. 2.38 Comparison between observed and simulated relative saturation flows

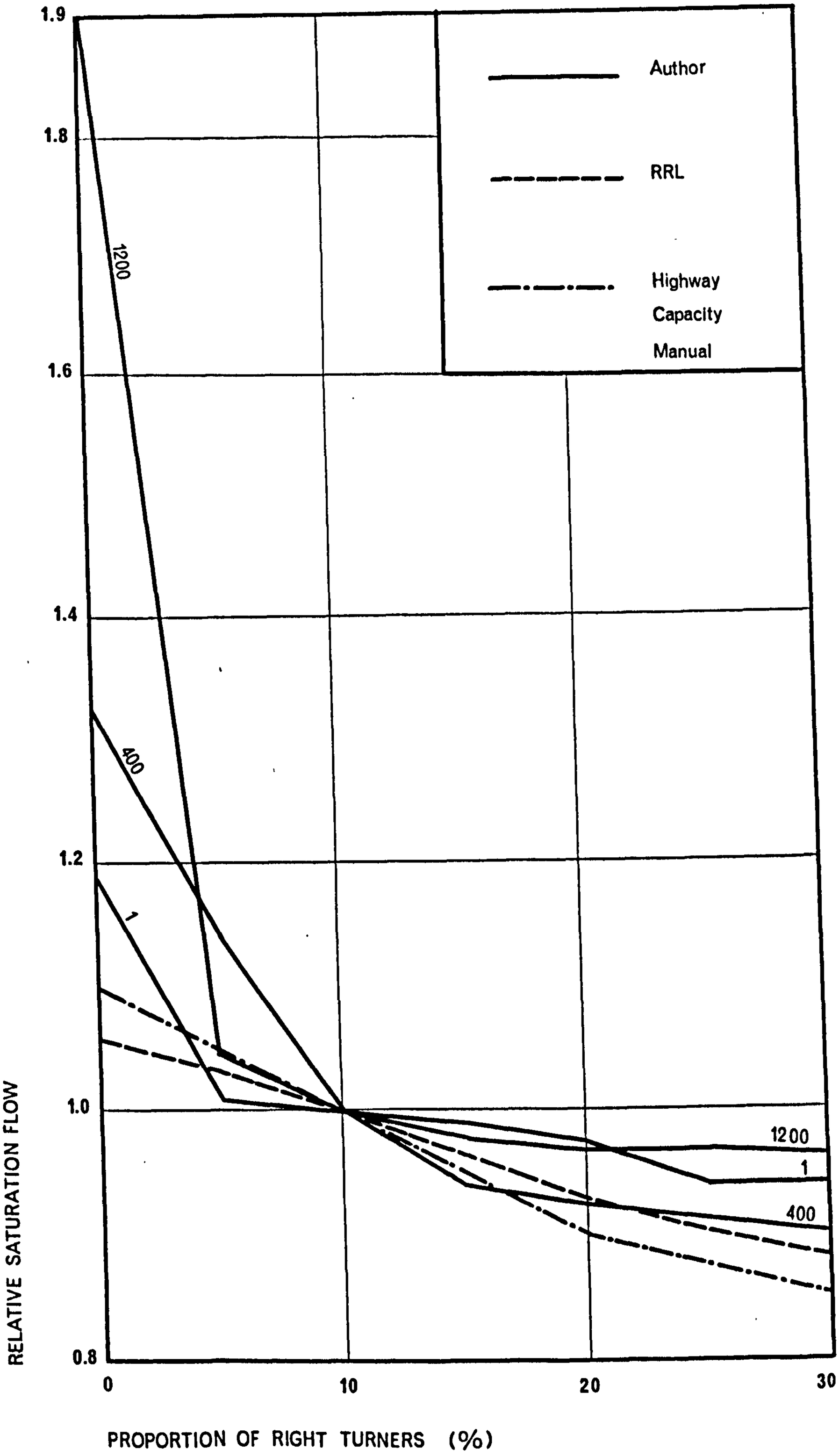


Fig. 2.39 Comparison of observed and simulated relative saturation flows

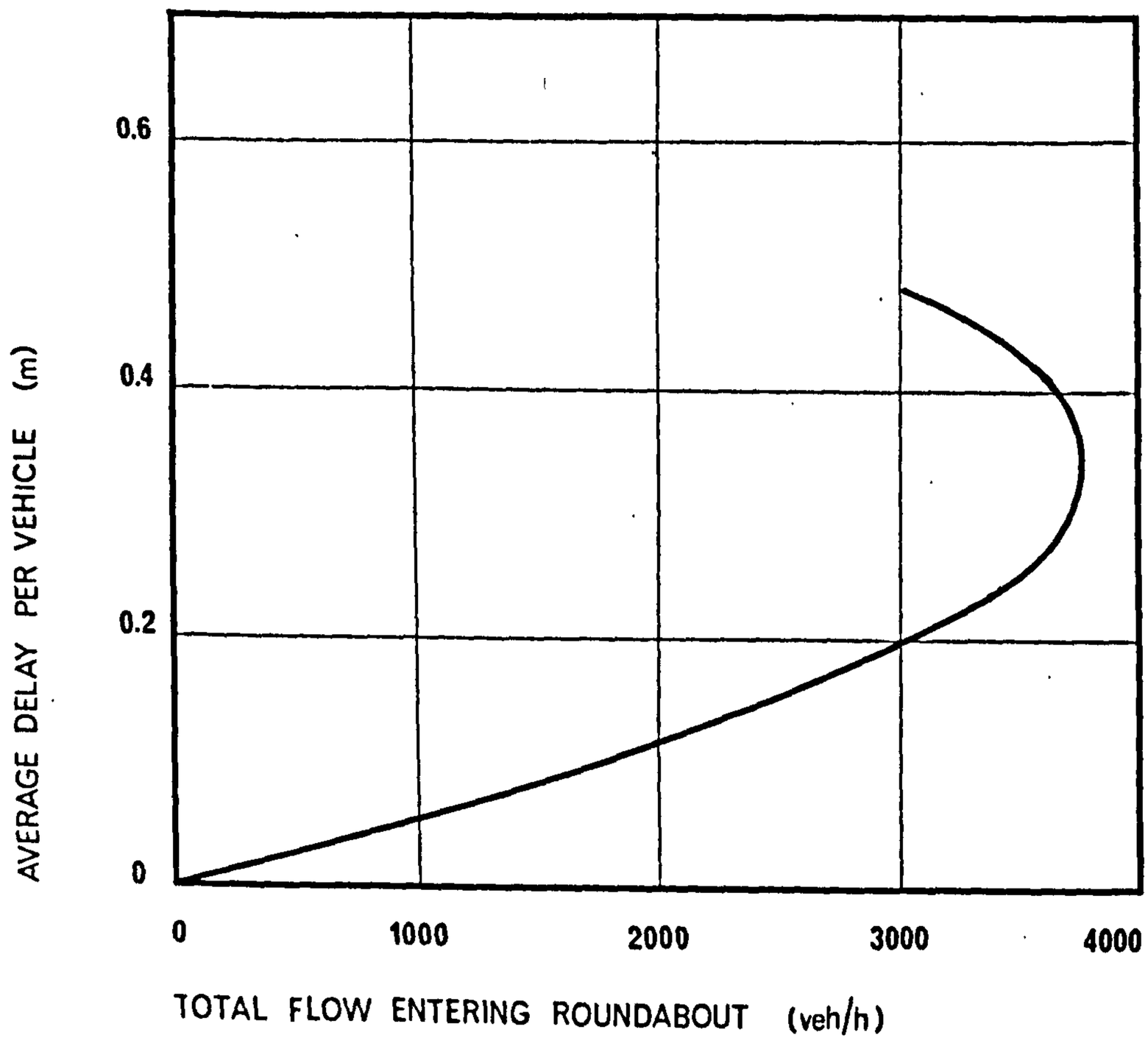


Fig. 3.1 Observed delay at roundabouts

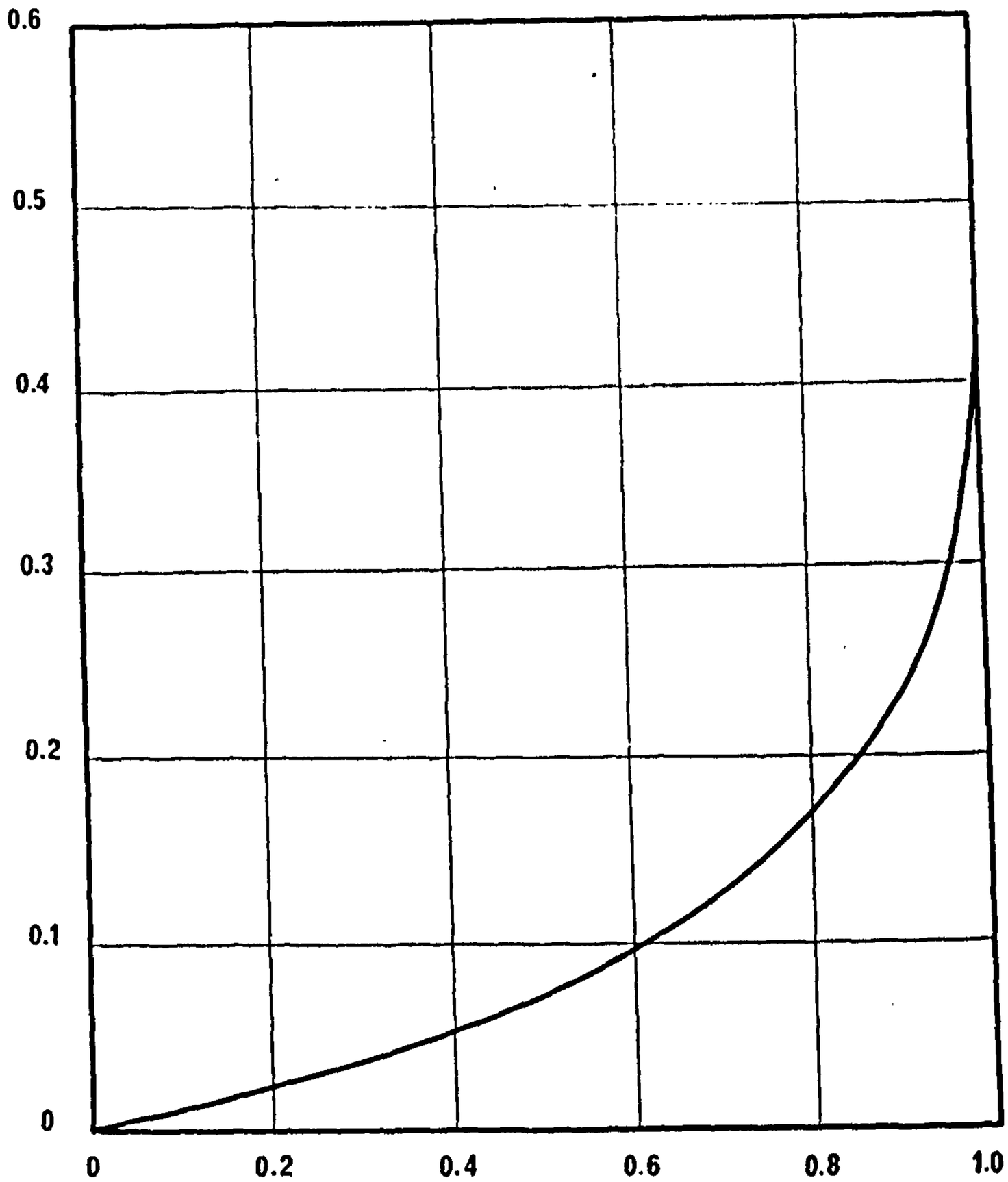


Fig. 3.2 Observed average delays at roundabouts

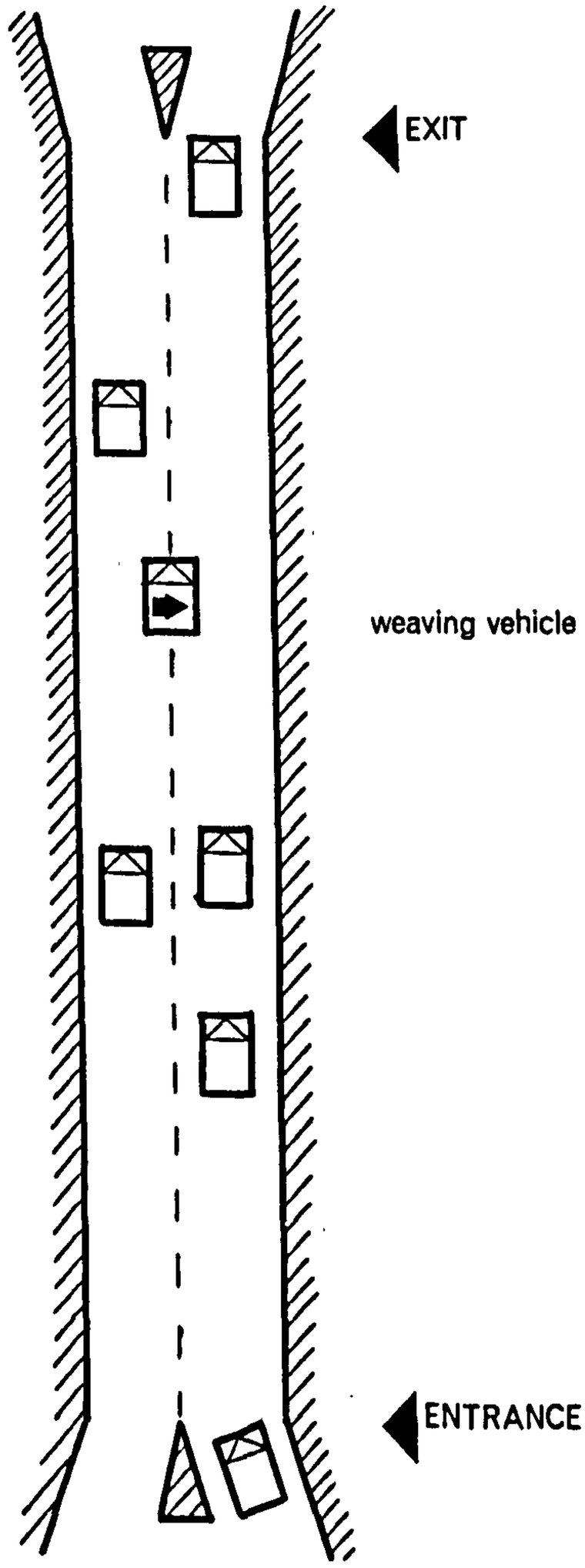


Fig. 3.3 Weaving section arrangement

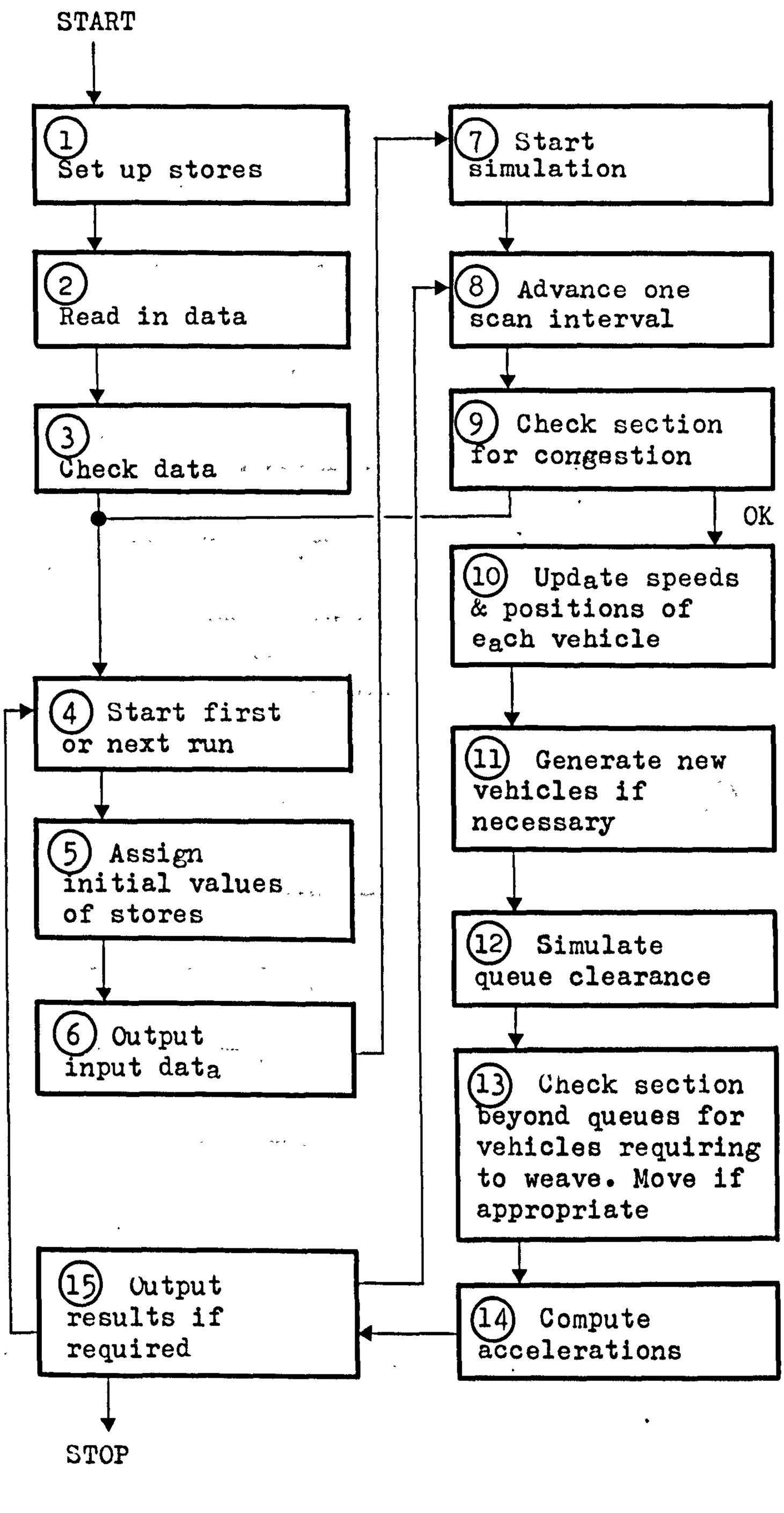


Fig. 3.4 Program arrangement

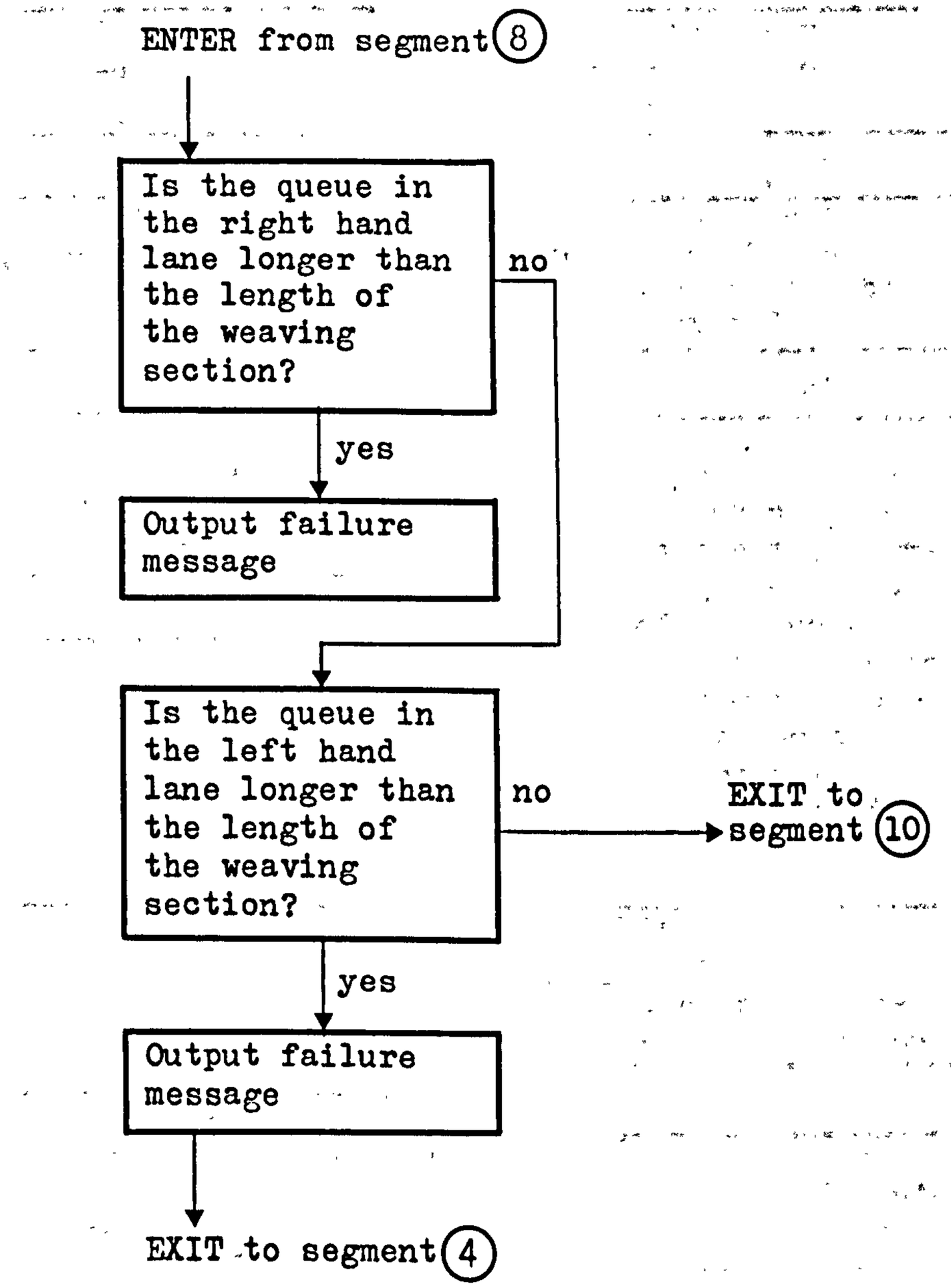


Fig. 3.5 Flow diagram for segment 9

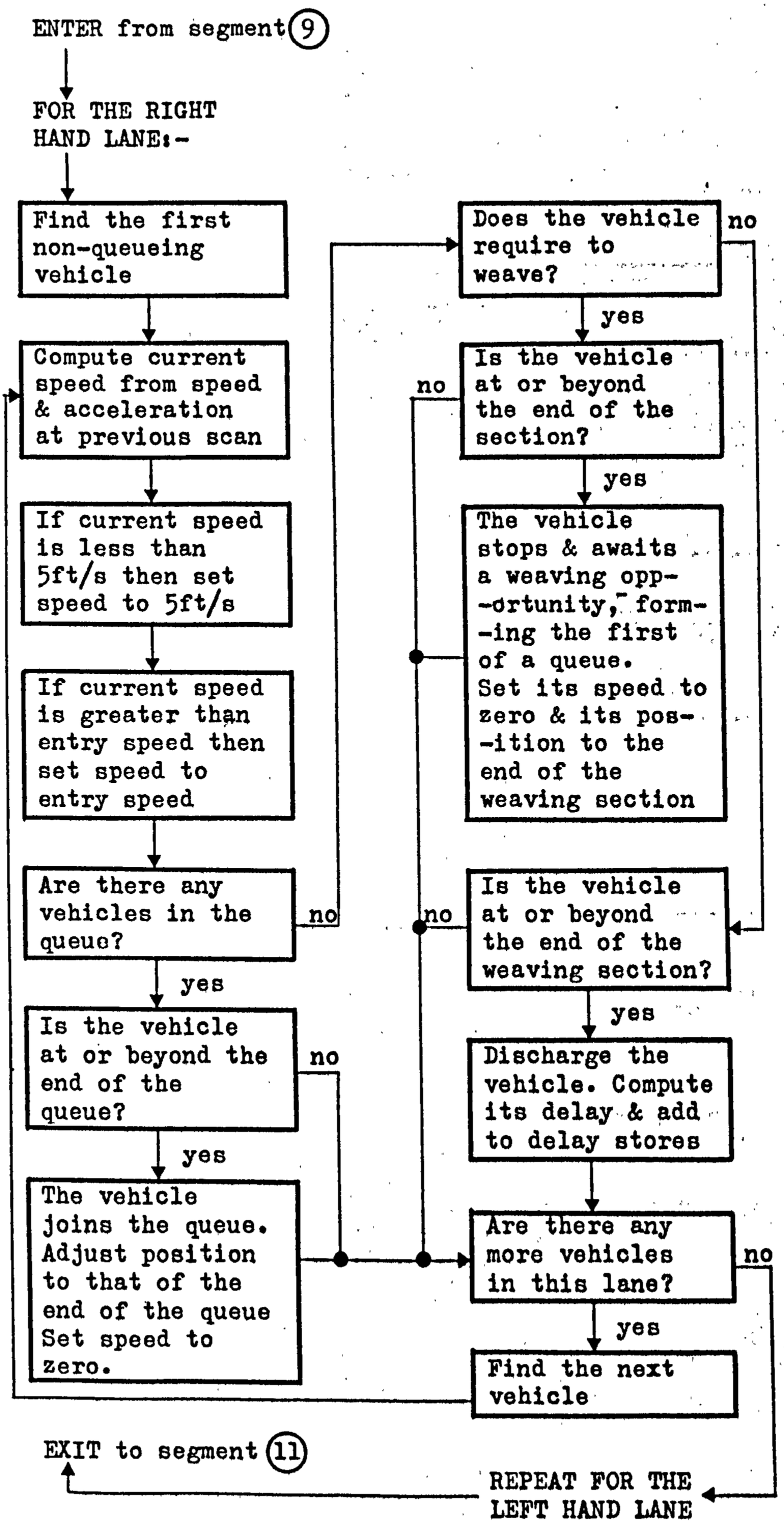


Fig. 3.6 Flow diagram for segment 10

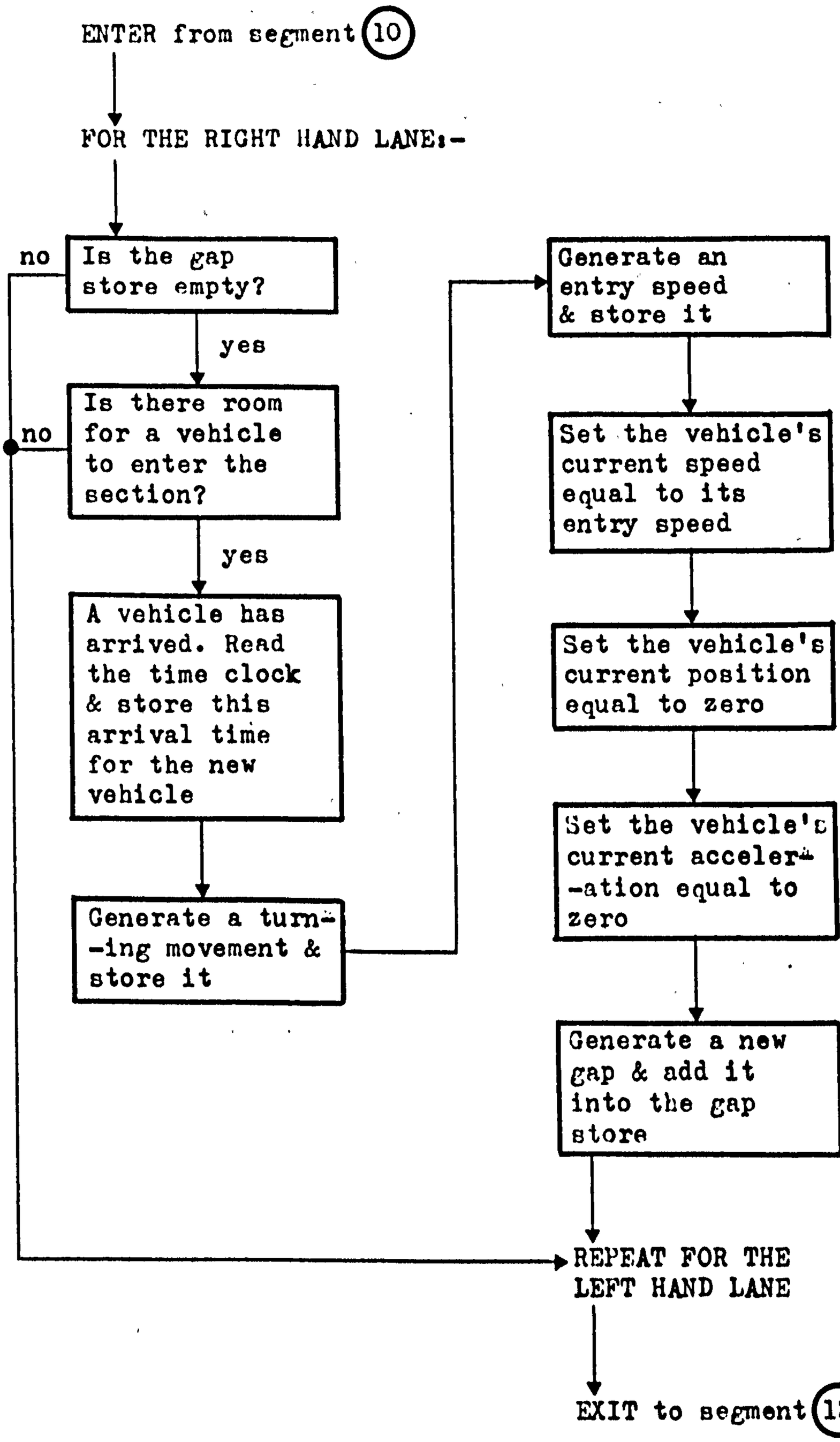


Fig. 3.7 Flow diagram for segment 11

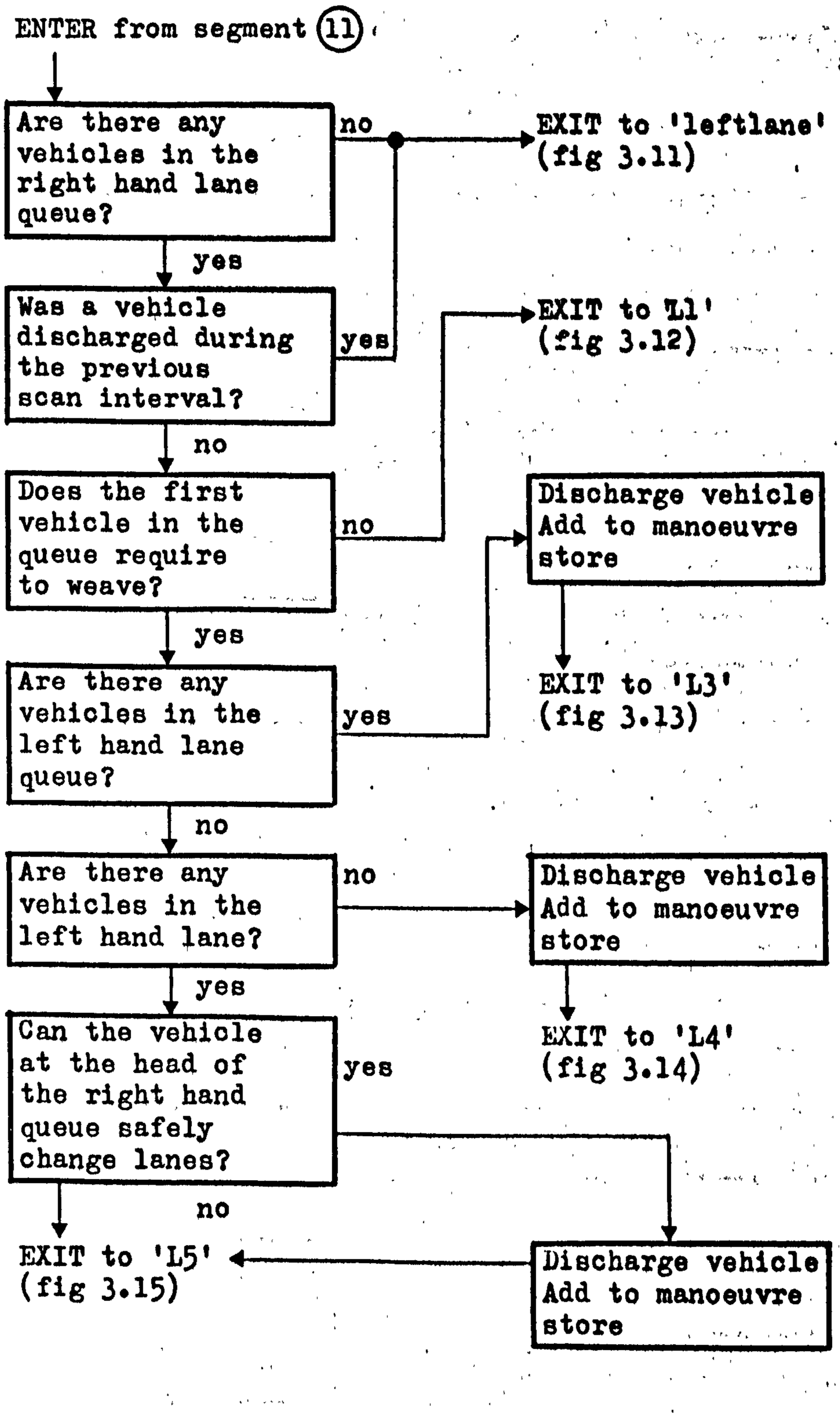


Fig. 3.8 Flow diagram for first part of segment 12

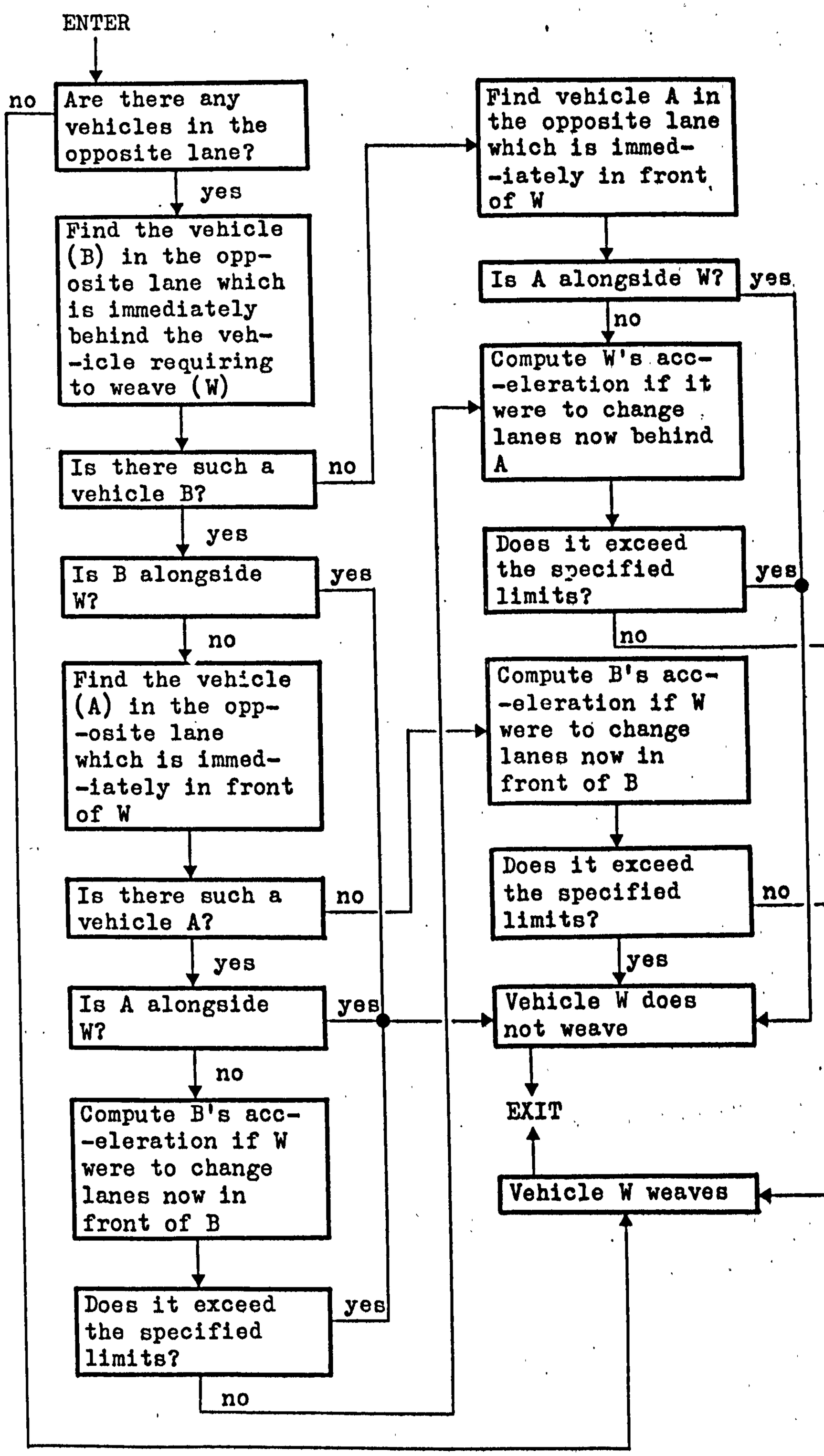


Fig. 3.9 Flow diagram showing logic of lane changing decision (to be read in conjunction with top diagram in fig. 3.10)

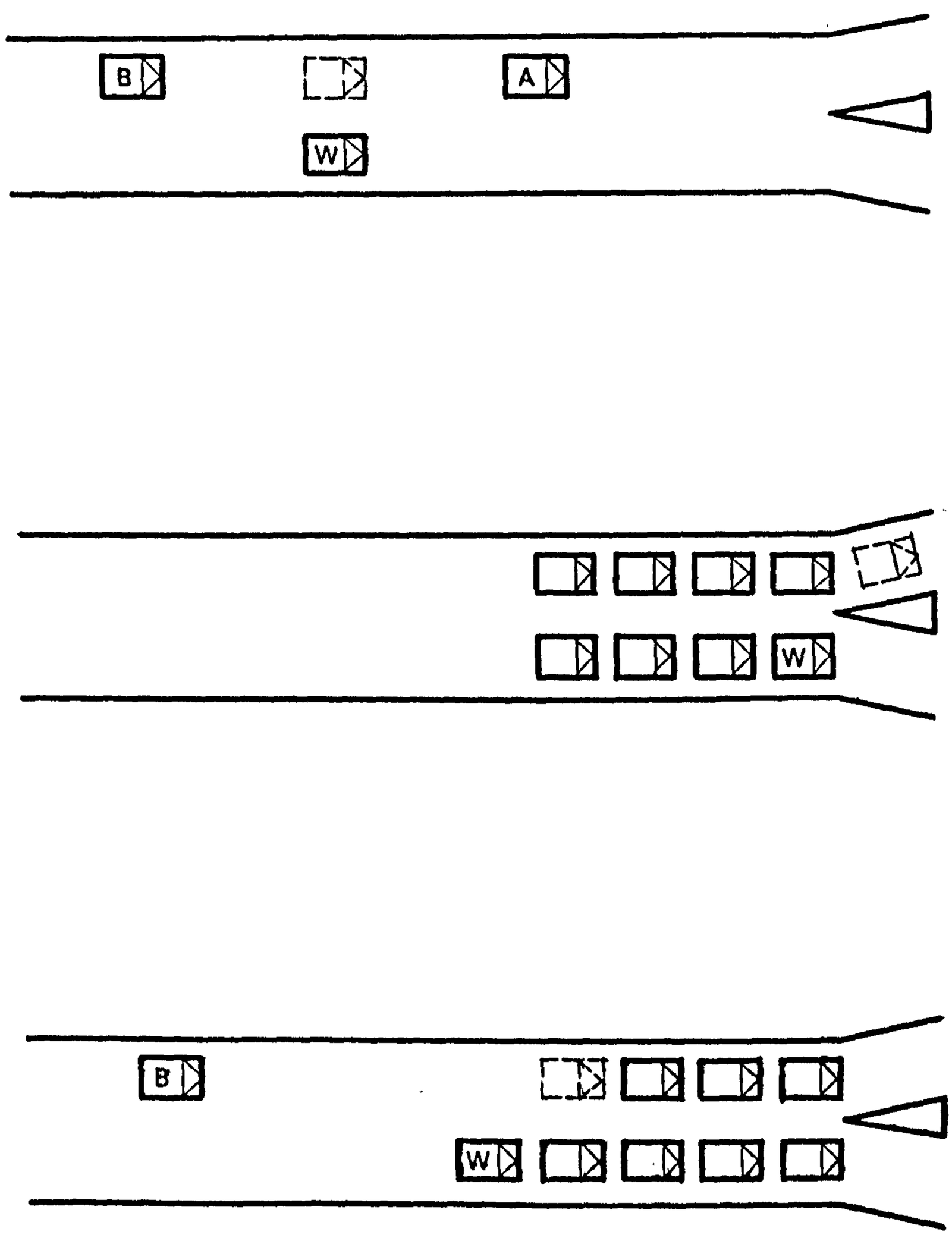


Fig. 3.10 Weaving manoeuvres

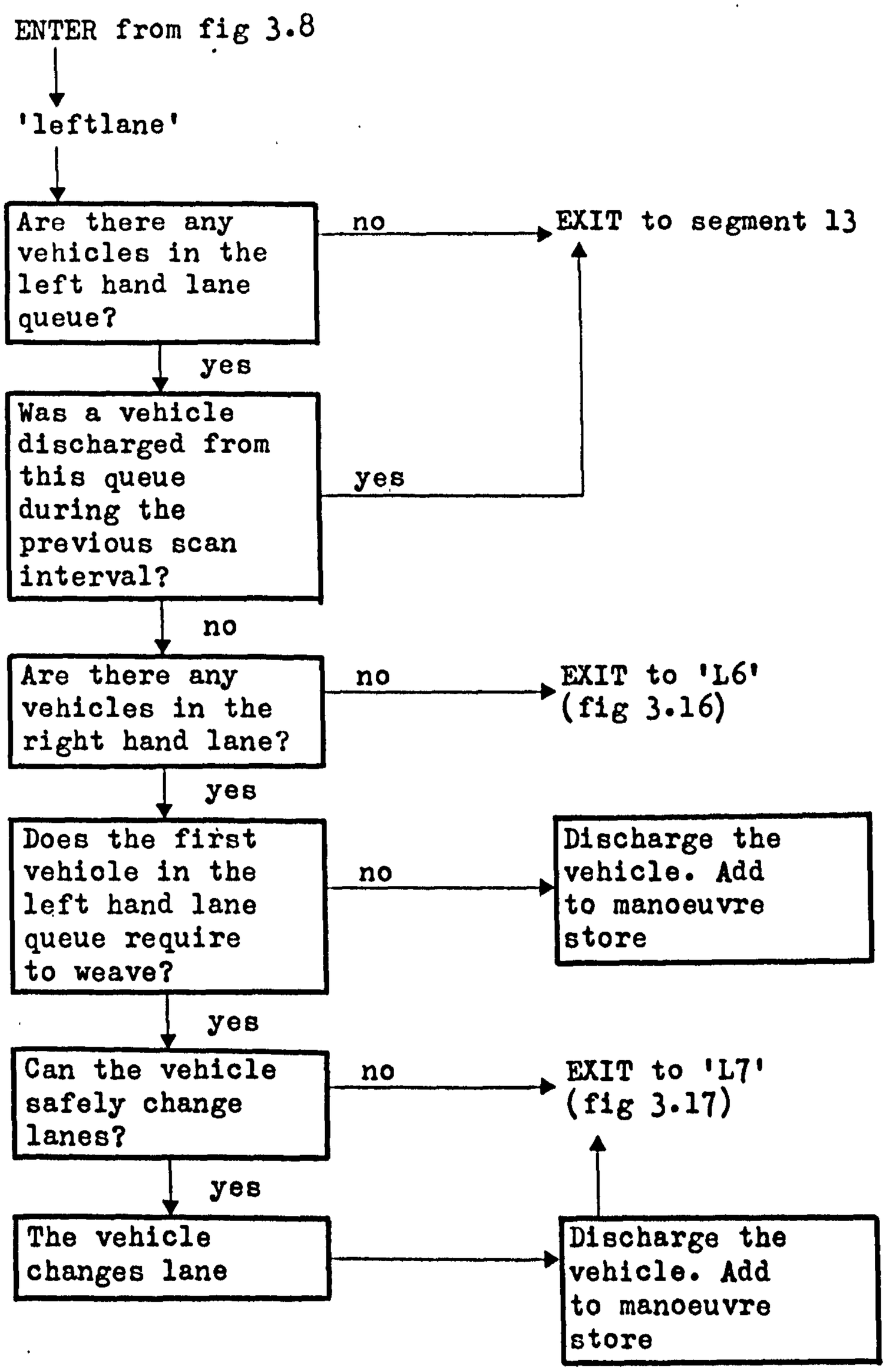


Fig. 3.11 Flow diagram for label 'leftlane' (Segment 12 continued)

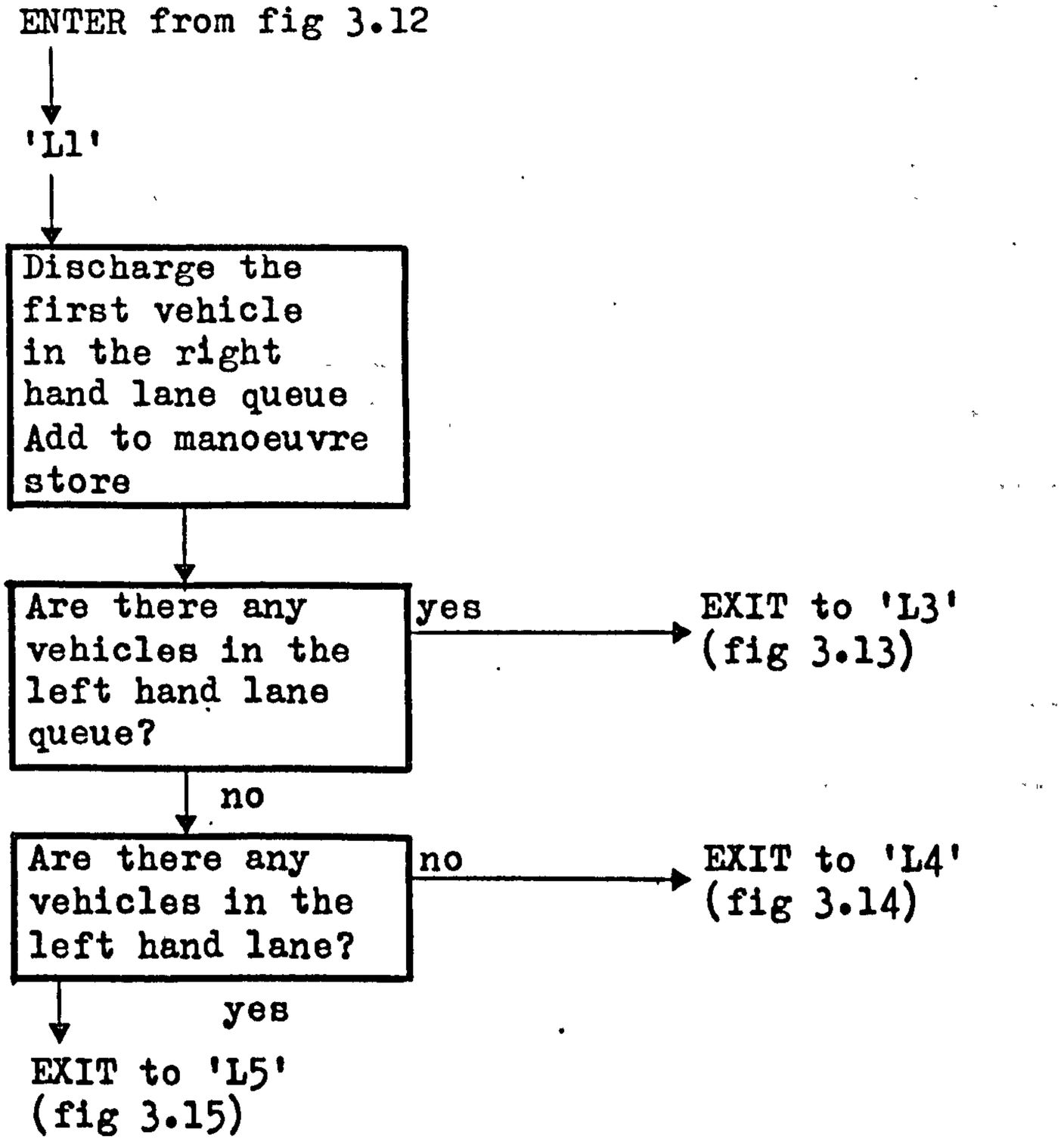


Fig. 3.12 Flow diagram for label 'LI' segment 12 continued

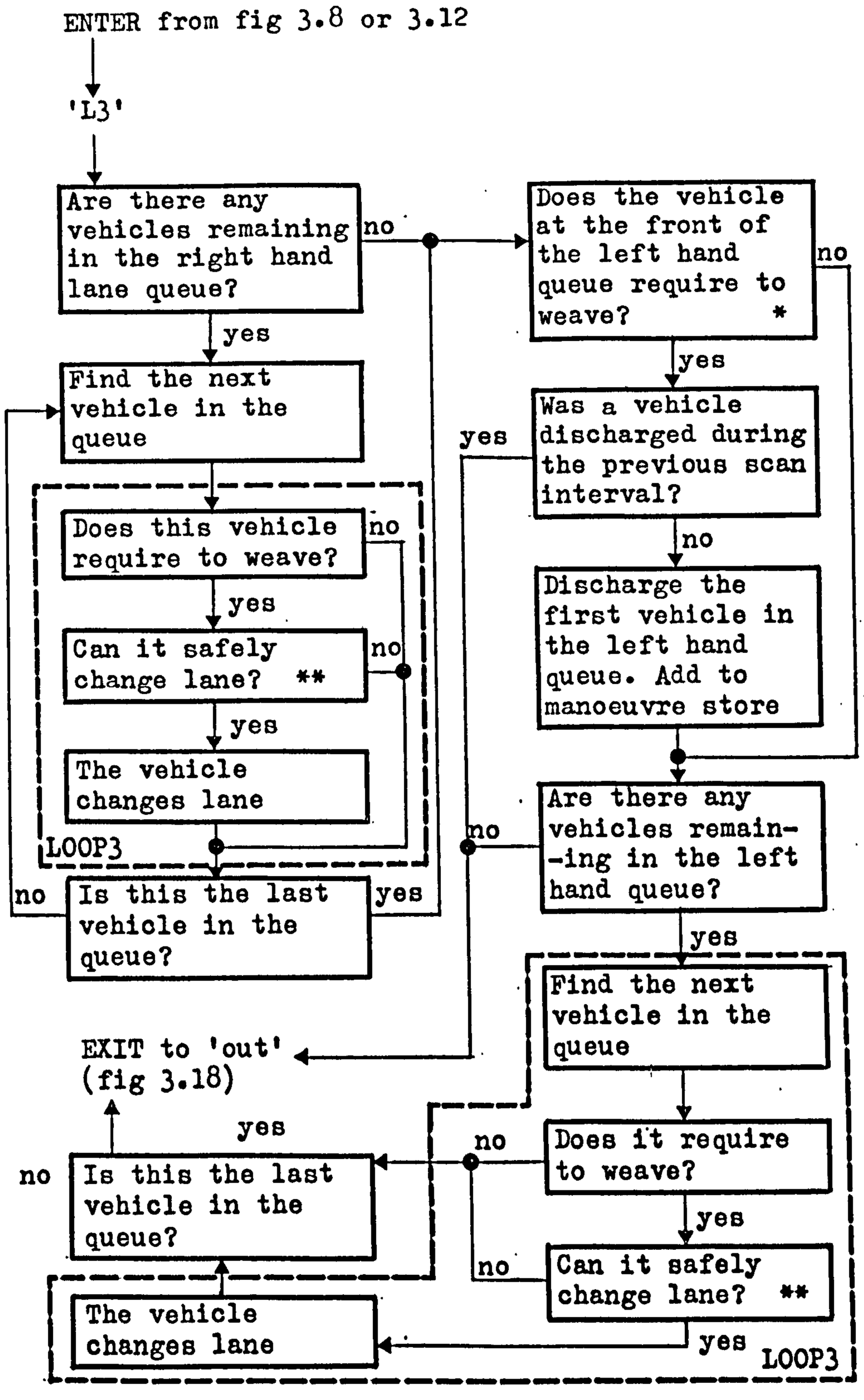


Fig. 3.13 Flow diagram for label 'L3' - segment 12 continued

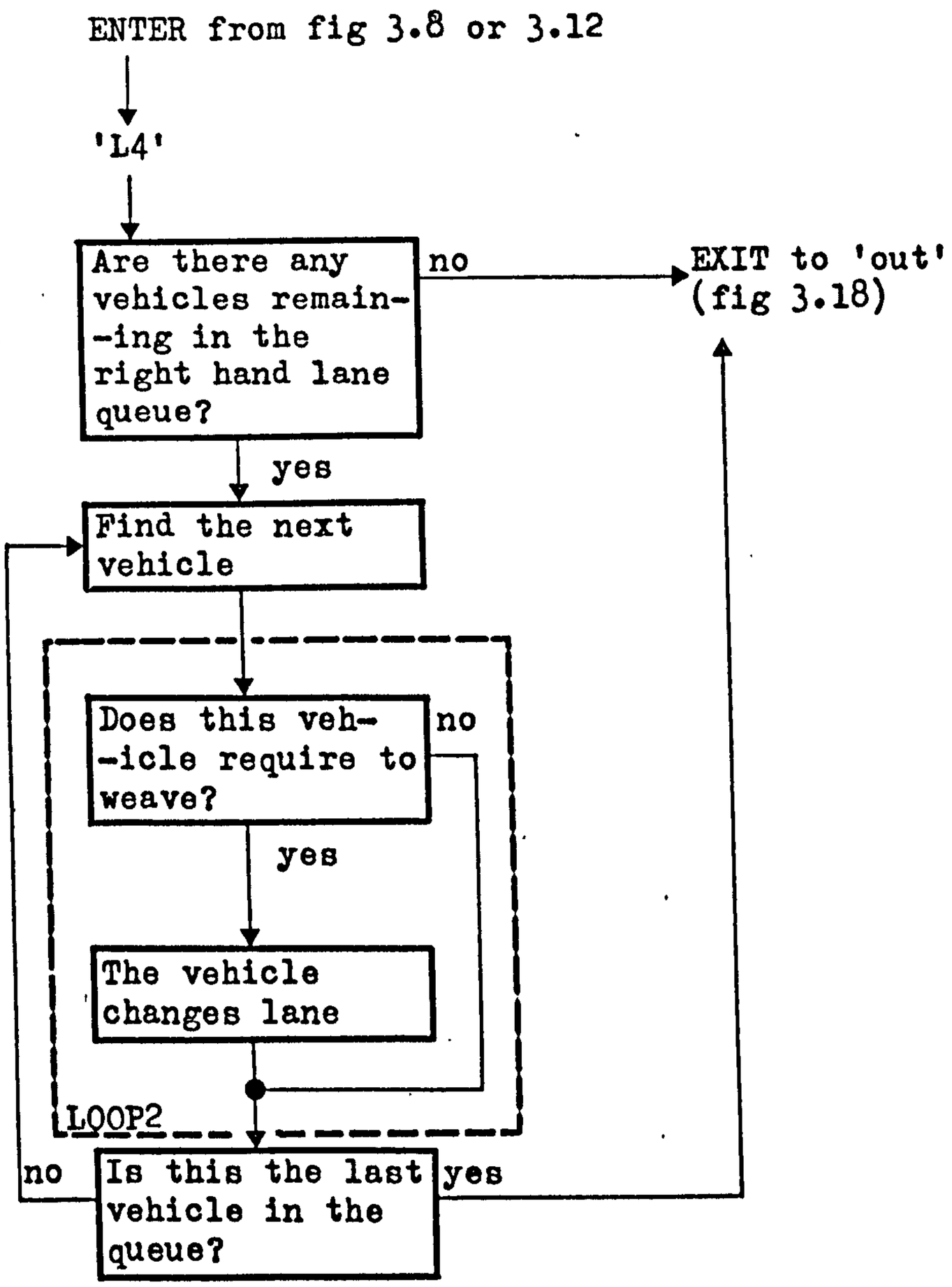


Fig. 3.14 Flow diagram for label 'L4' - segment 12 continued

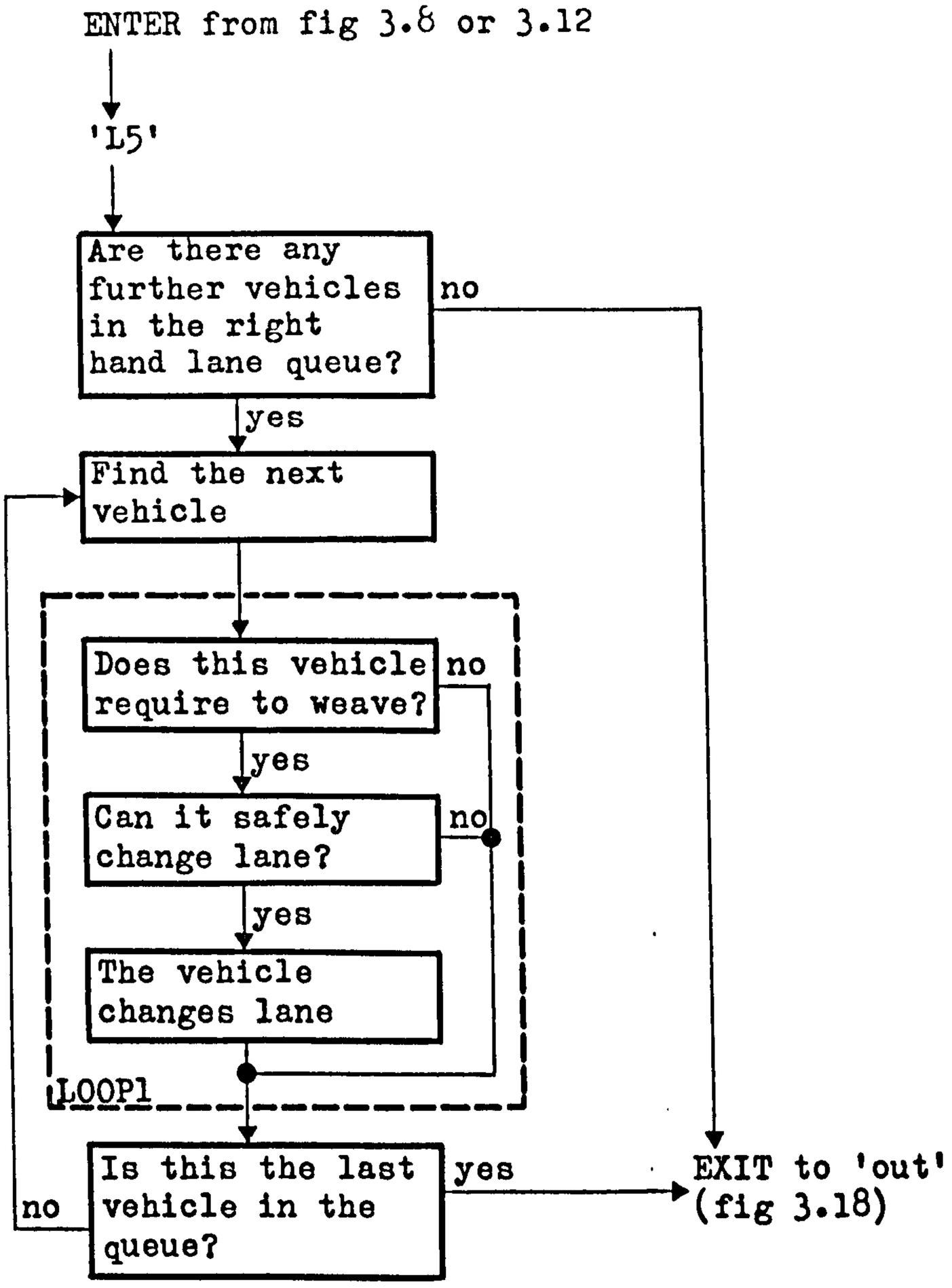


Fig. 3.15 Flow diagram for label 'L5' - segment 12 continued

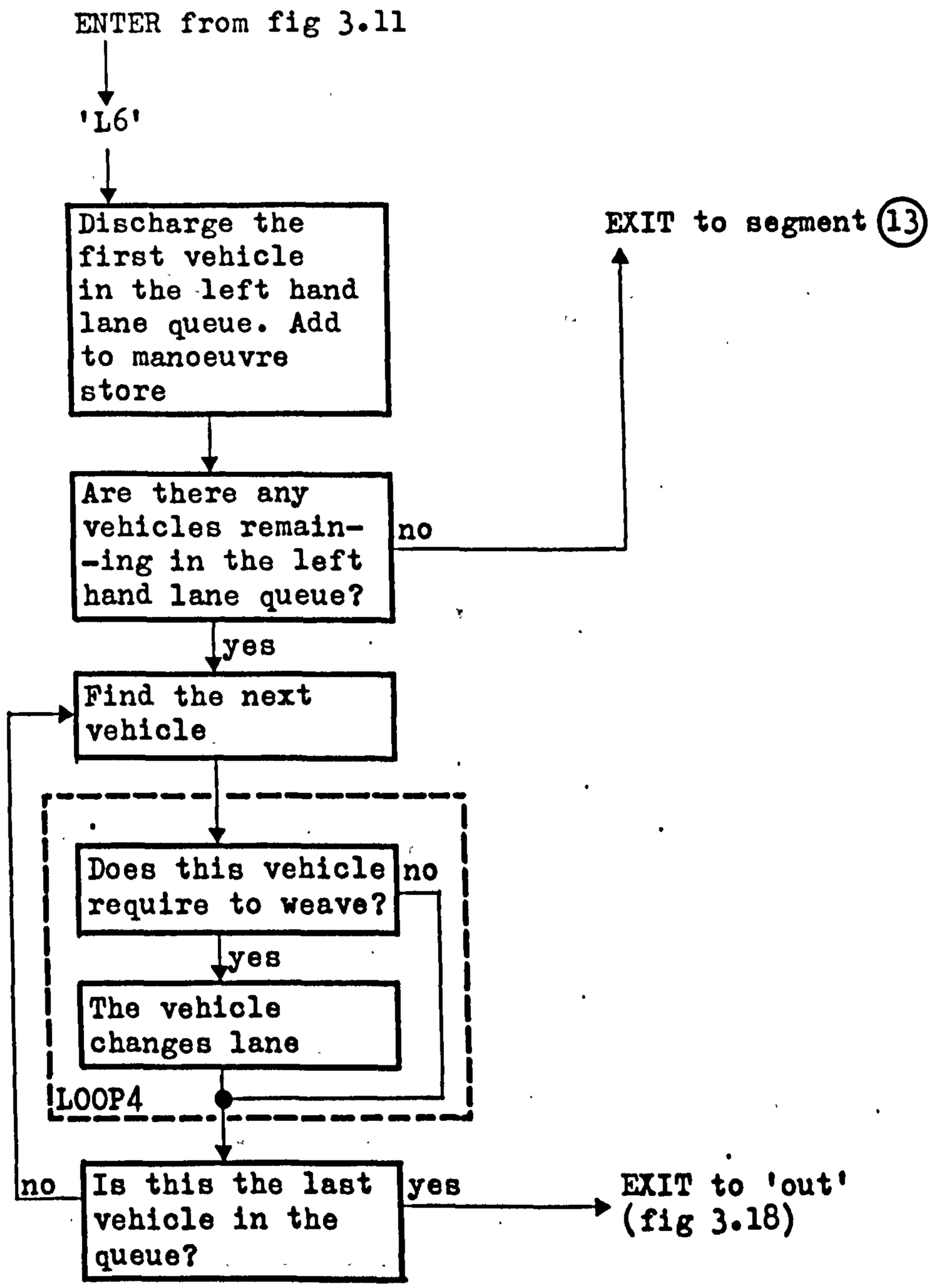


Fig. 3.16 Flow diagram for label 'L6' - segment 12 continued

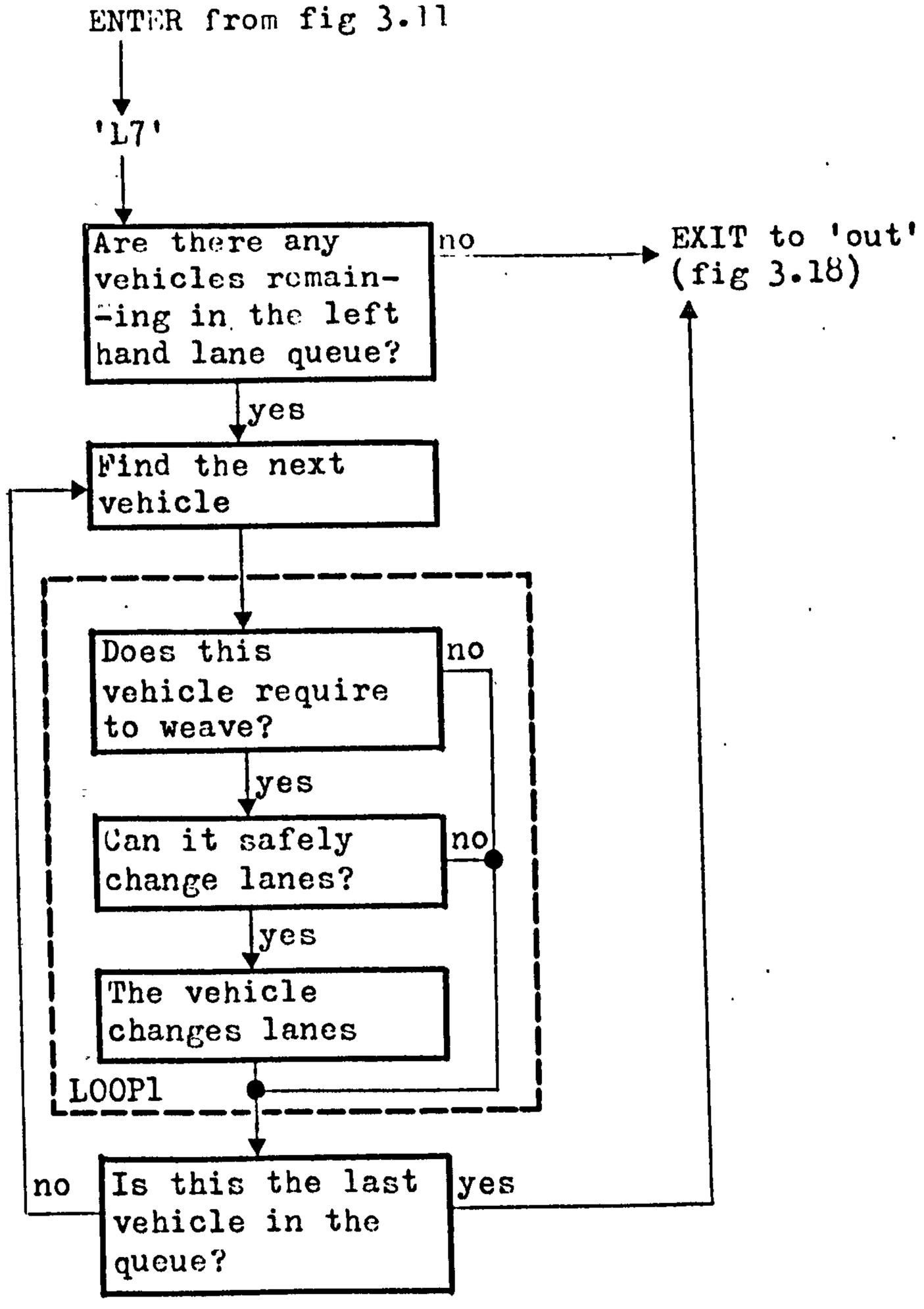


Fig. 3.17 Flow diagram for label 'L7' - segment 12 continued

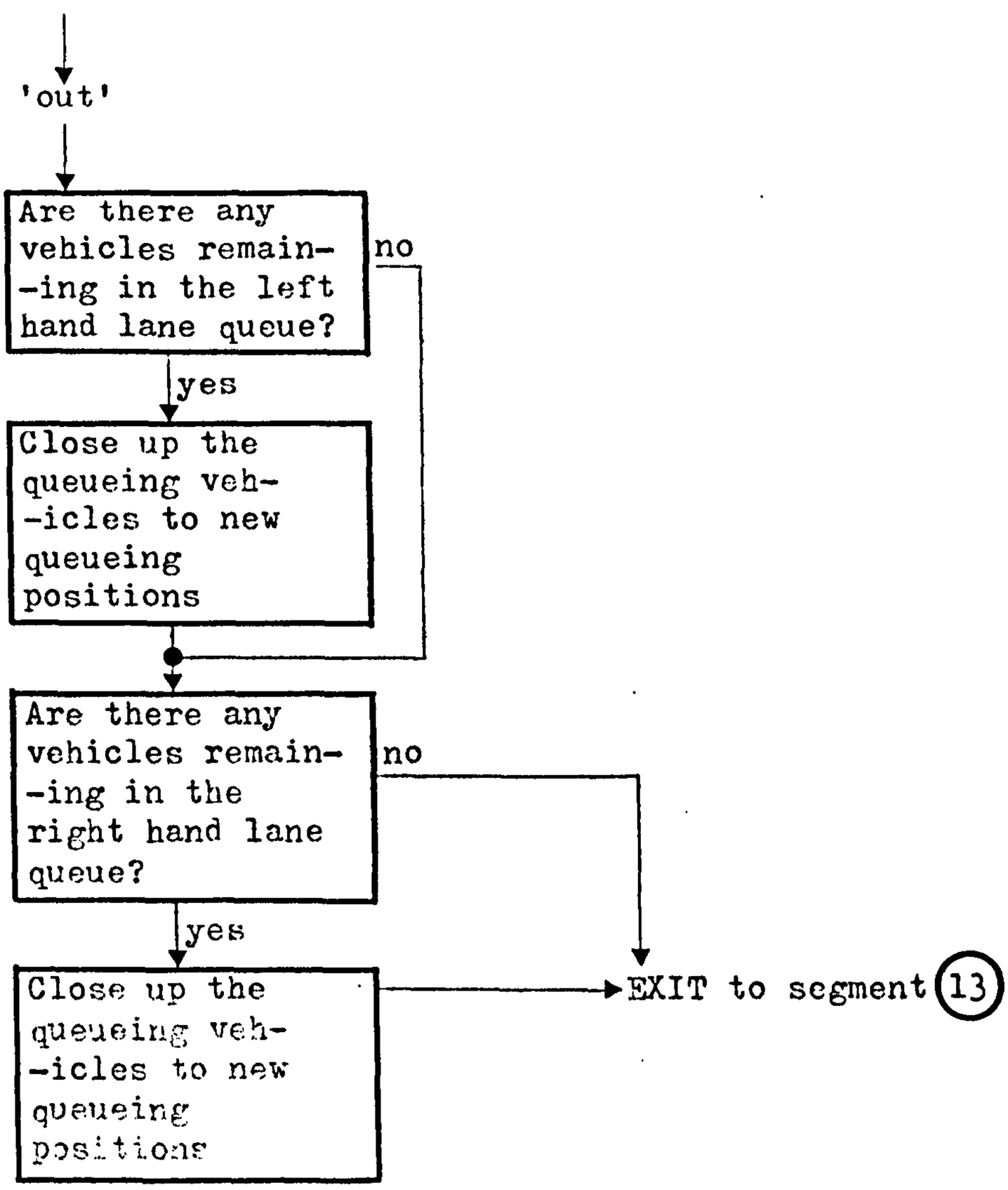


Fig. 3.18 Flow diagram for label 'out' - segment 12 concluded

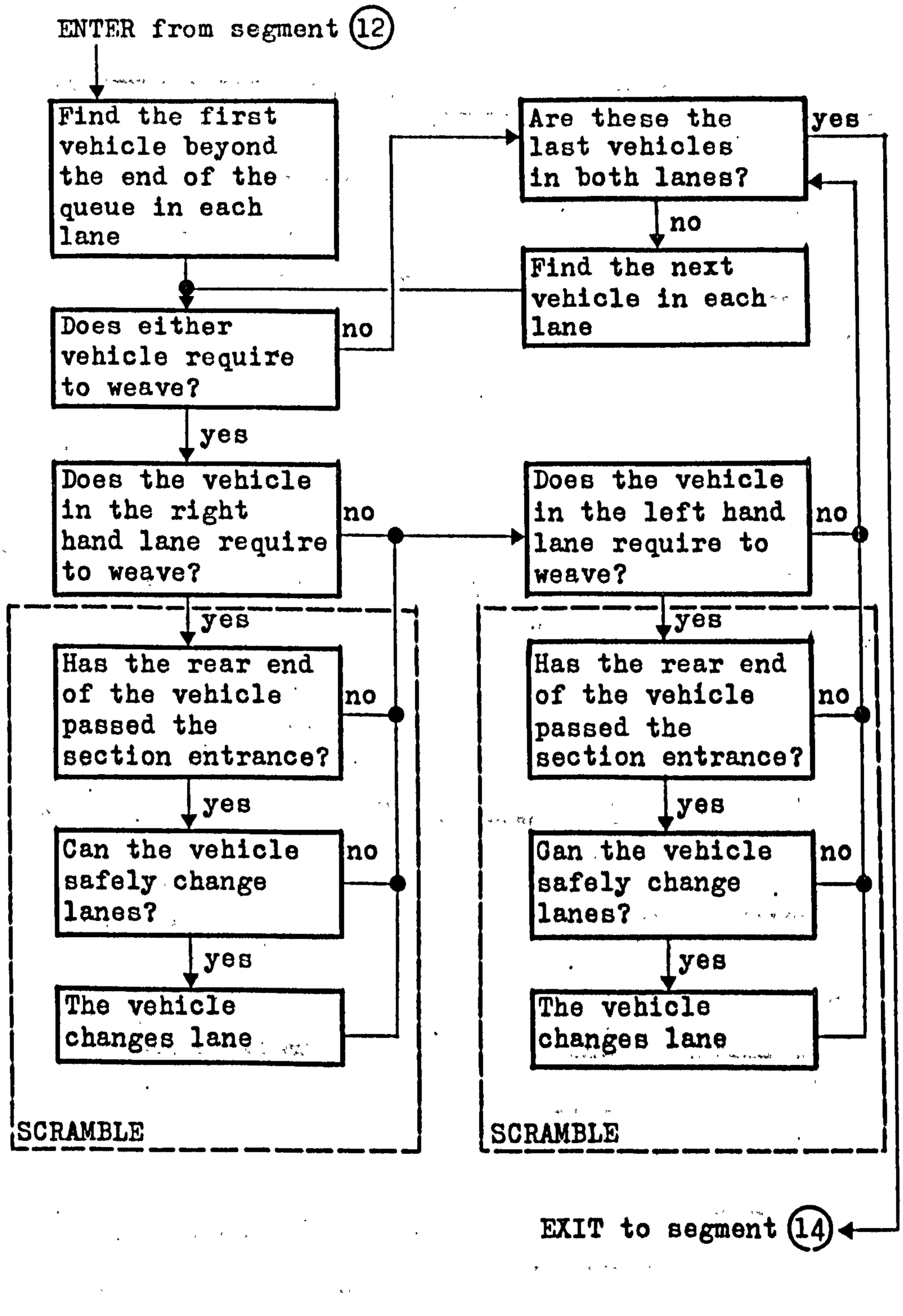


Fig. 3.19 Flow diagram for segment 13

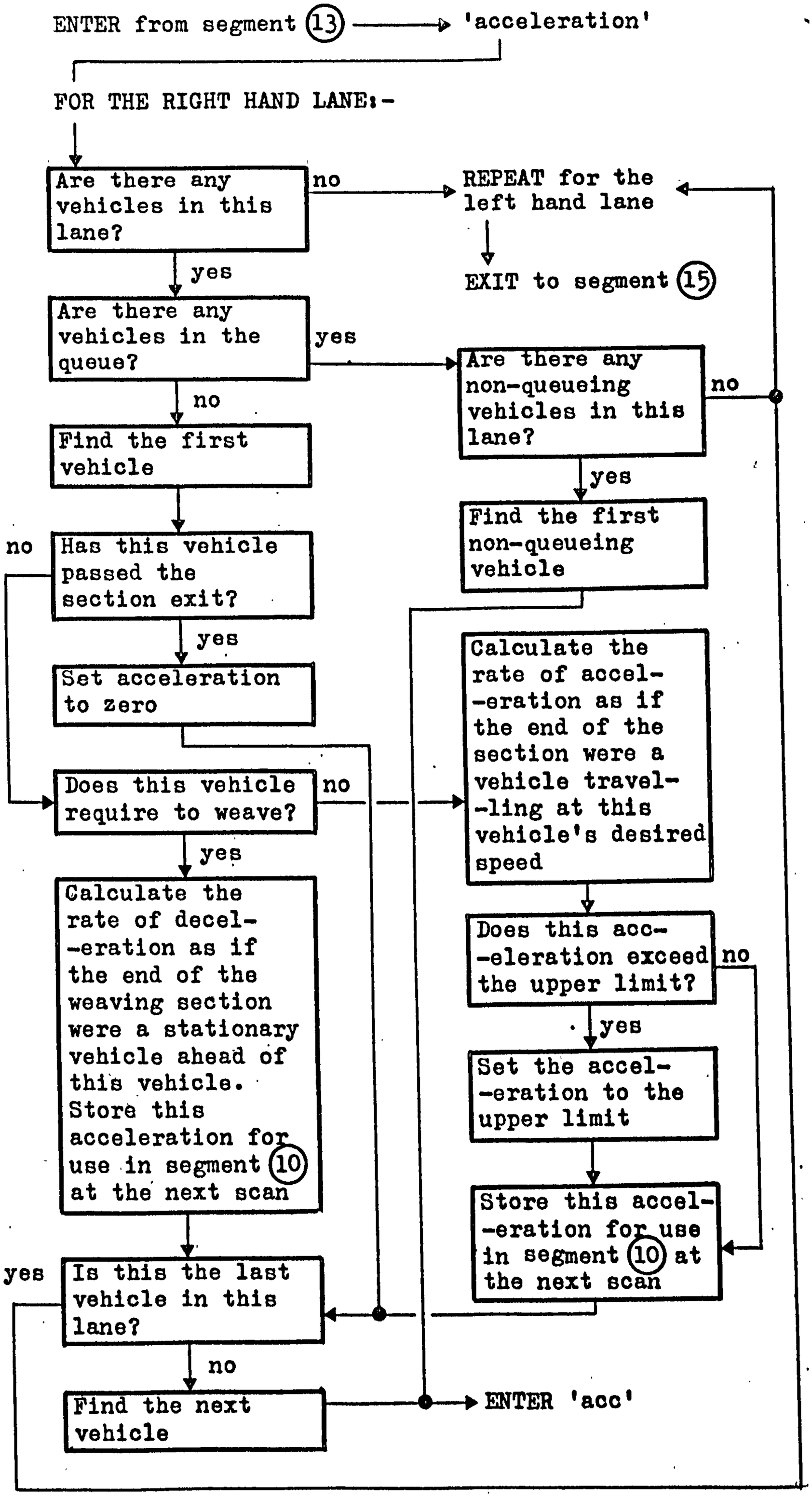


Fig. 3.20 Flow diagram for first part of segment 14

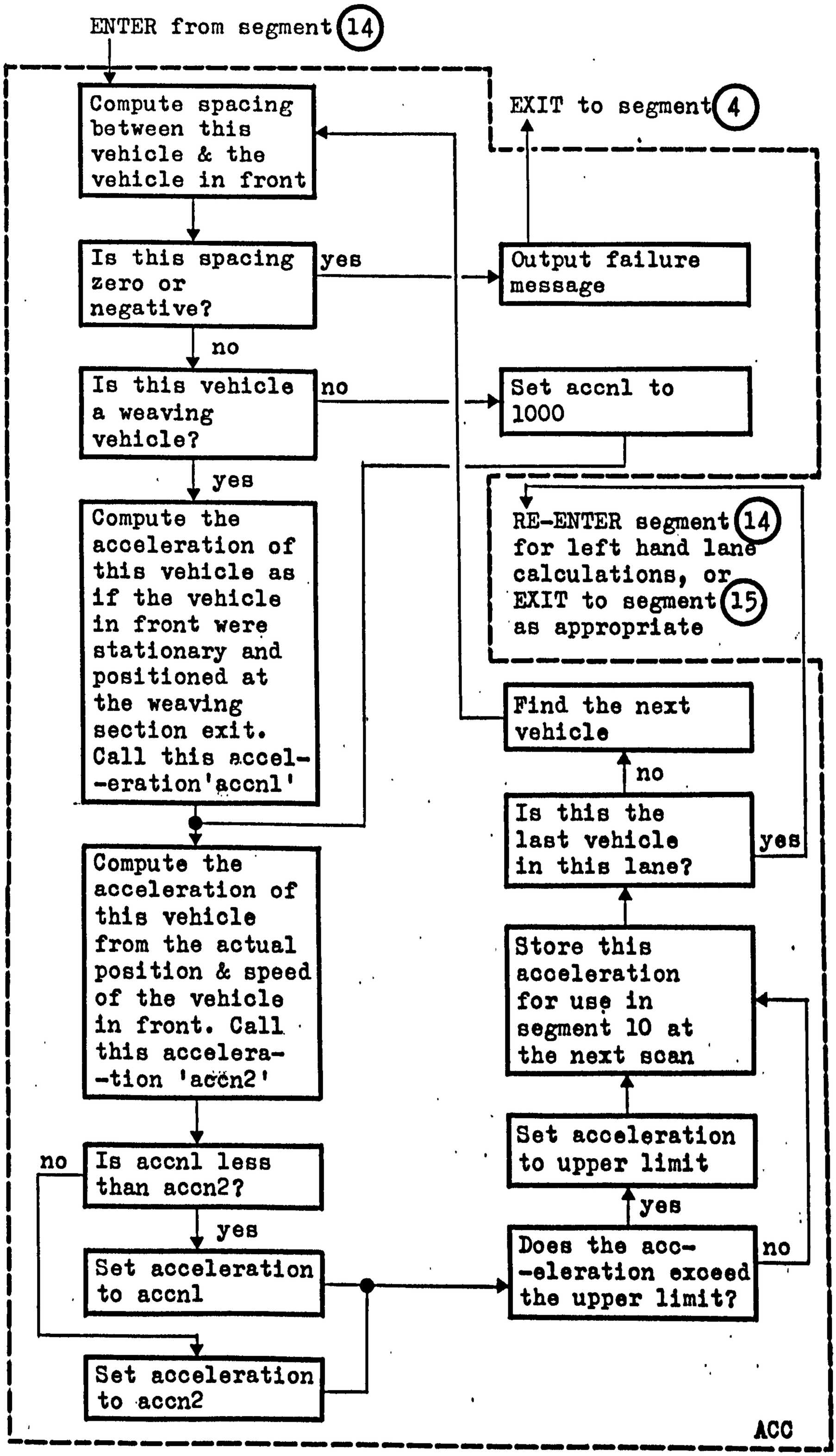


Fig. 3.21 Flow diagram for second and final part of segment 14

AT TIME 1000.30

	LEFT HAND LANE							RIGHT HAND LANE						
NUMBER OF VEHICLES DISCHARGED SINCE START OF RUN =	138							125						
QUEUE LENGTH	0							0						
NUMBER	ARRIVAL TIME	TURN	ENTRY SPEED	PRESENT SPEED	POSITION		ACCELERATION	NUMBER	ARRIVAL TIME	TURN	ENTRY SPEED	PRESENT SPEED	POSITION	ACCELERATION
43	975.10	0	32.37	25.54	539	+	2.02	28	950.60	1	29.88	5.00	500	- 0.90
44	979.30	0	25.87	22.71	438	+	0.63	29	955.50	2	30.86	5.00	454	0.00
45	980.00	2	31.24	19.44	319	+	0.60	30	967.40	2	24.70	5.01	377	0.00
46	999.60	0	32.69	32.08	22	-	0.82	31	968.10	0	24.00	5.01	350	0.00
								32	972.30	0	31.46	5.02	310	- 0.01
								33	977.20	2	27.09	5.03	259	- 0.01
								34	989.80	0	31.75	7.83	182	- 0.89
								35	994.70	0	24.63	14.19	108	- 2.16

DELAYS AT TIME 1 000.30 SECONDS

	TOTAL DELAY (SECS)	NUMBER OF VEHICLES DELAYED	UNDELAYED	TOTAL	AVERAGE DELAY (SECS) PER VEHICLE	PER DELAYED VEHICLE
RIGHT HAND LANE						
NON-WEAVING TRAFFIC ONLY	408.54	67	27	94	4.35	6.10
WEAVED TRAFFIC ARRIVING IN THIS LANE	294.02	26	5	31	9.48	11.31
LEFT HAND LANE						
NON-WEAVING TRAFFIC ONLY	787.07	81	14	95	8.28	9.72
WEAVED TRAFFIC ARRIVING IN THIS LANE	398.08	35	8	43	9.26	11.37

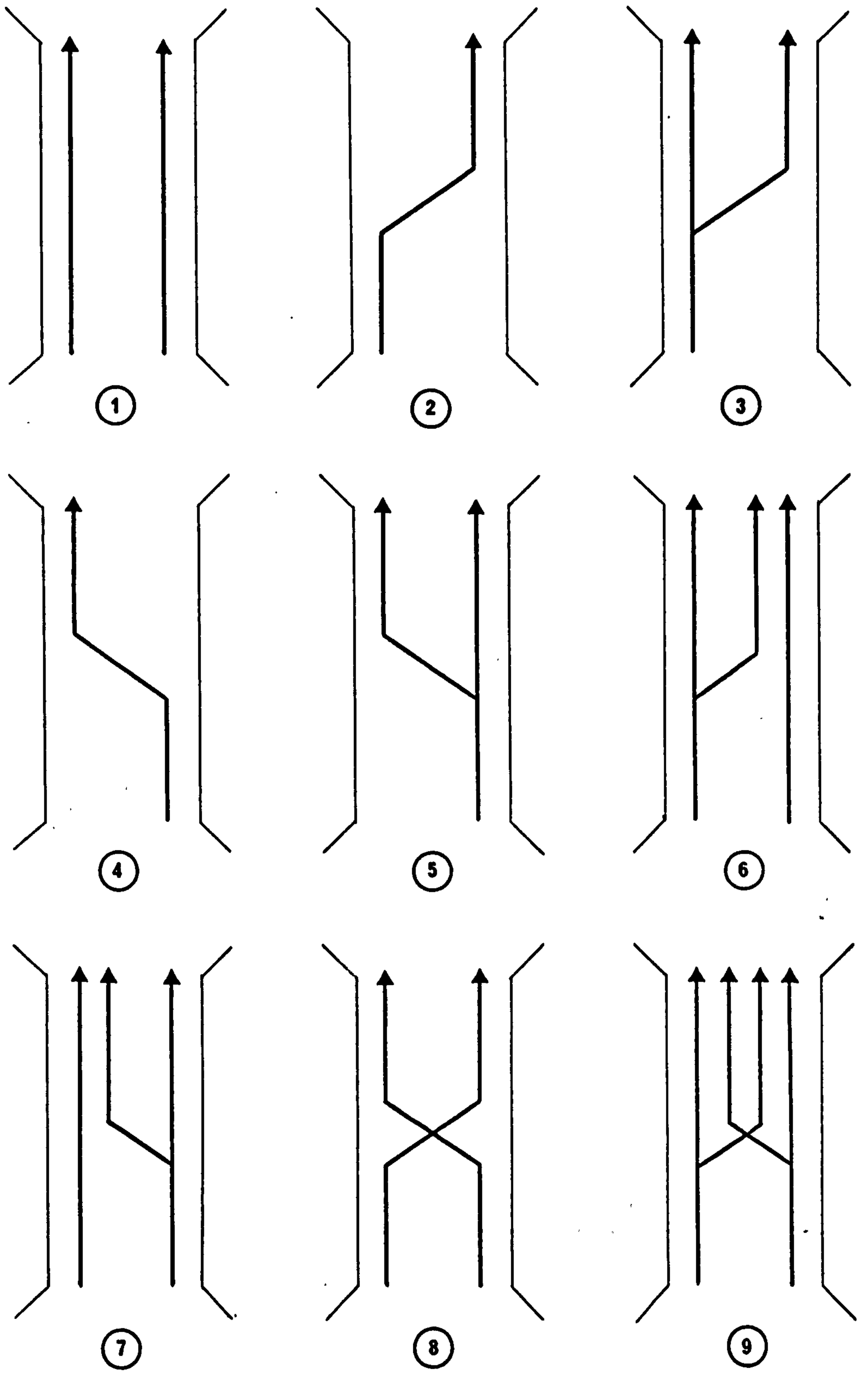


Fig. 3.23 Traffic loadings for runs 1-9 (mechanical tests)

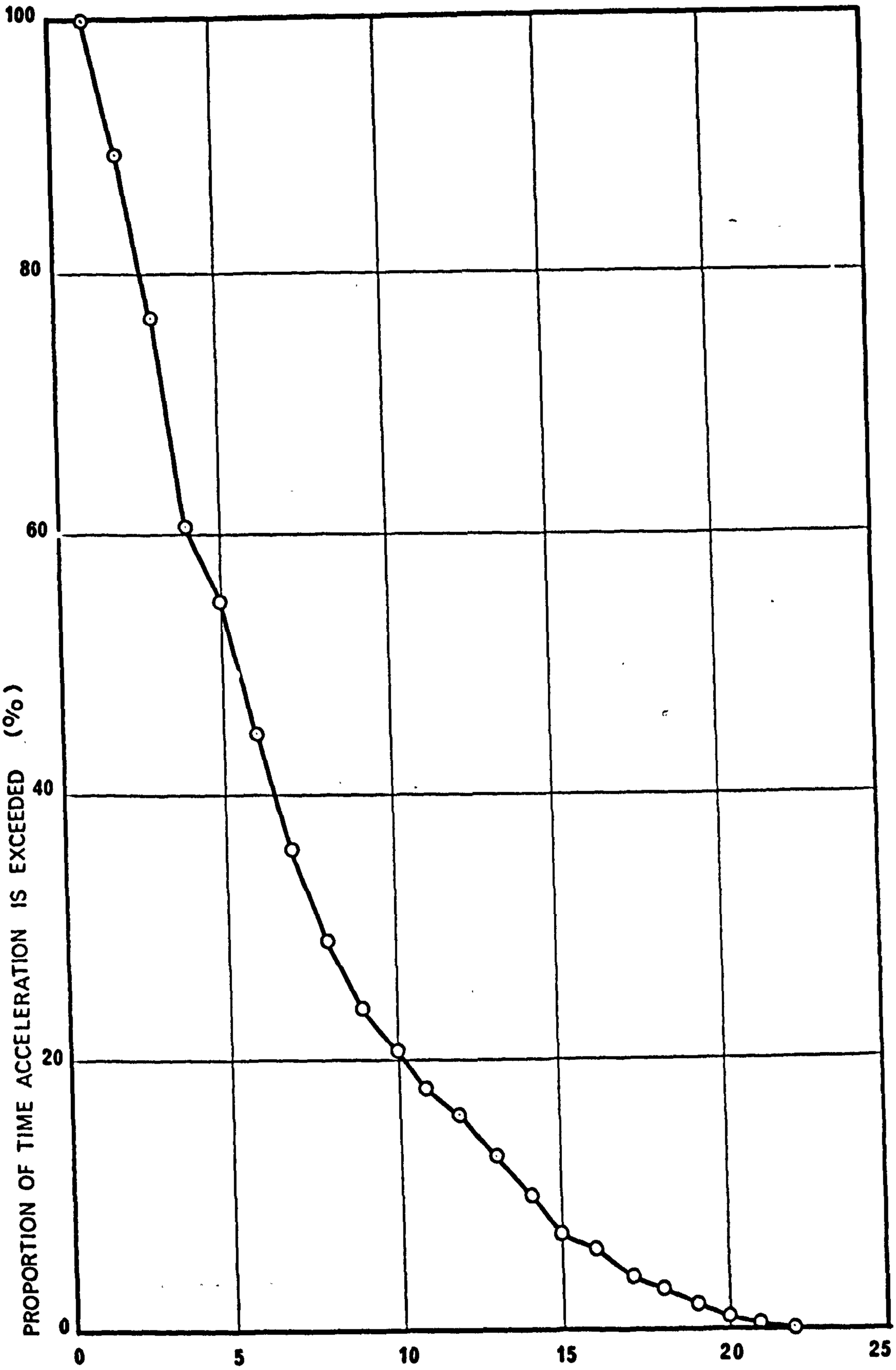


Fig. 3.24 Observed accelerations

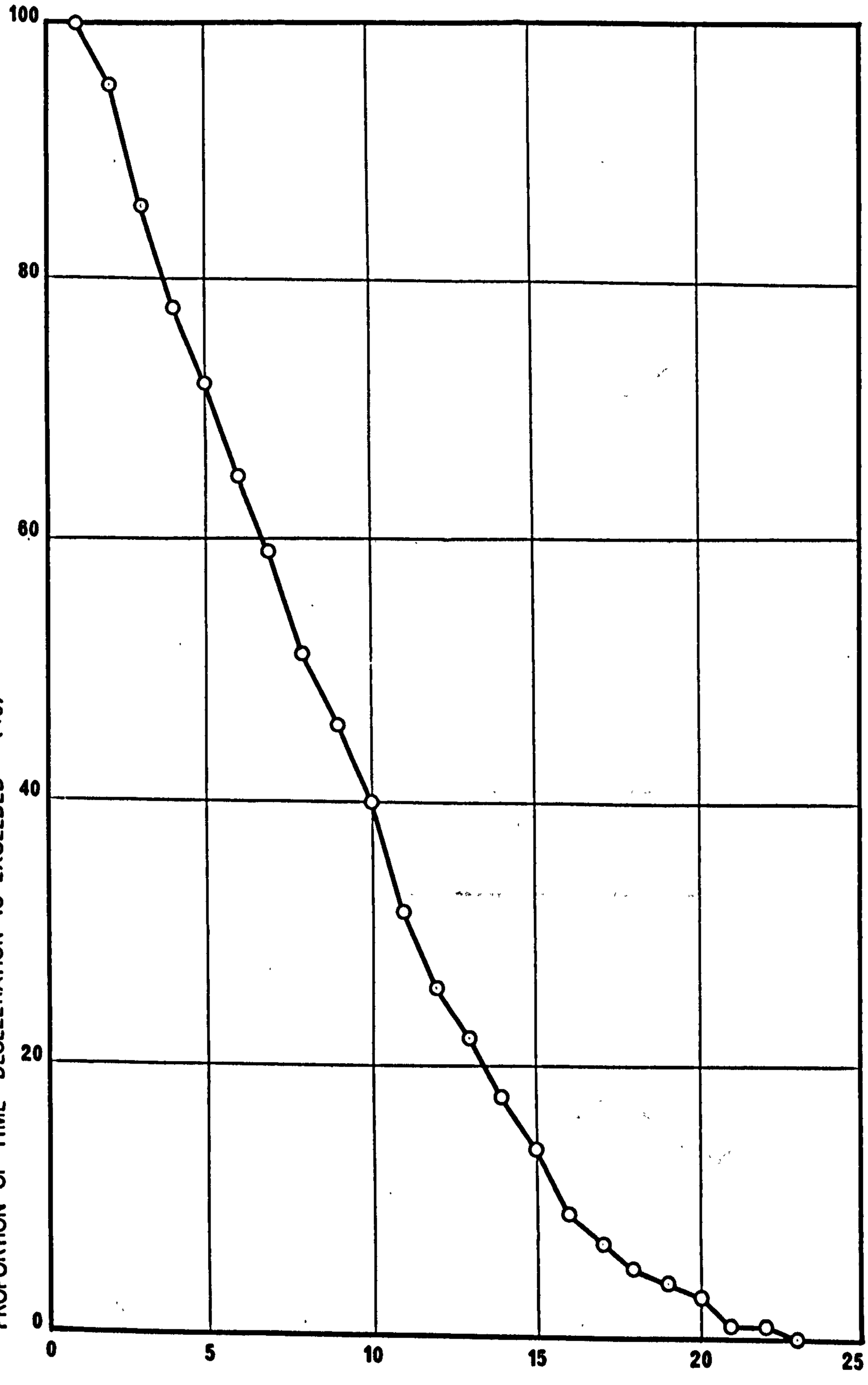


Fig. 3.25 Observed decelerations

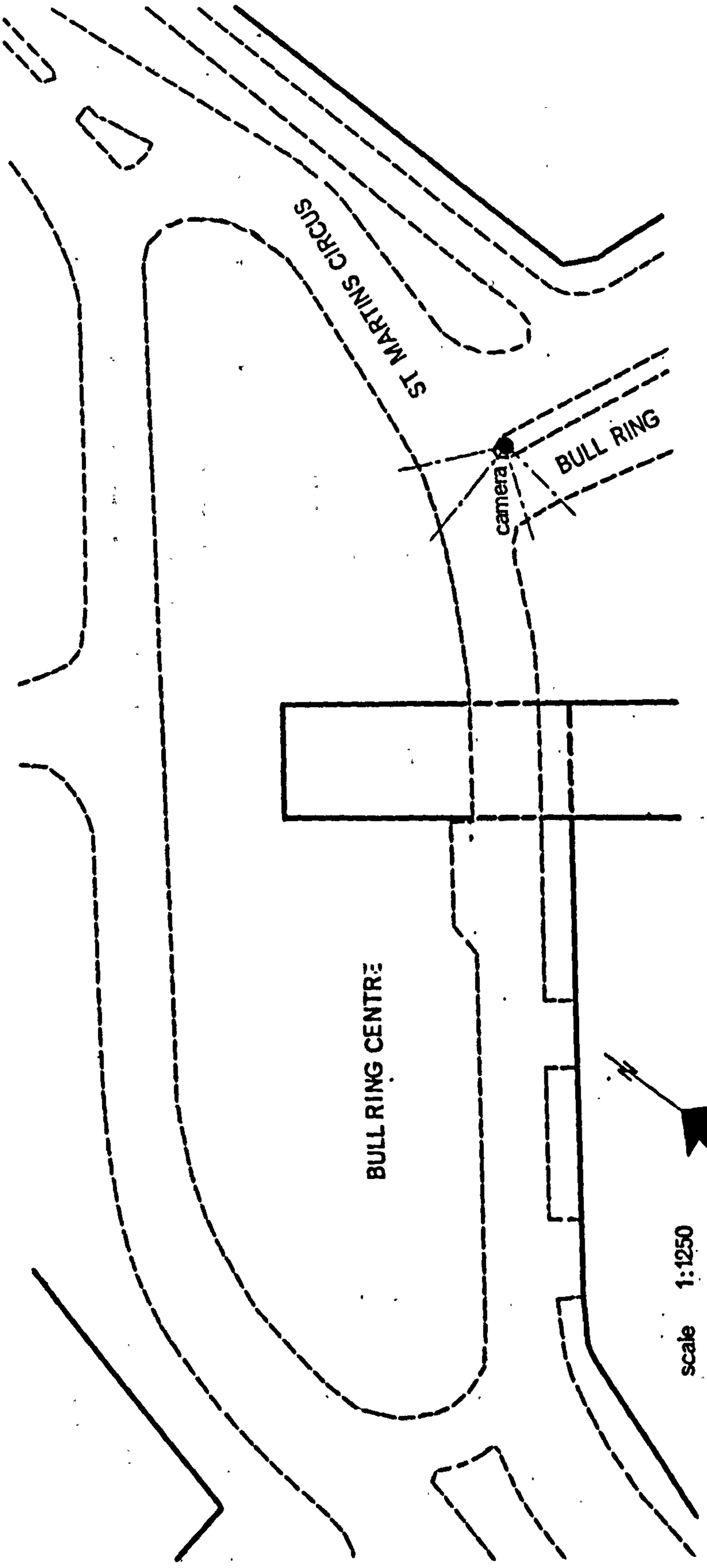
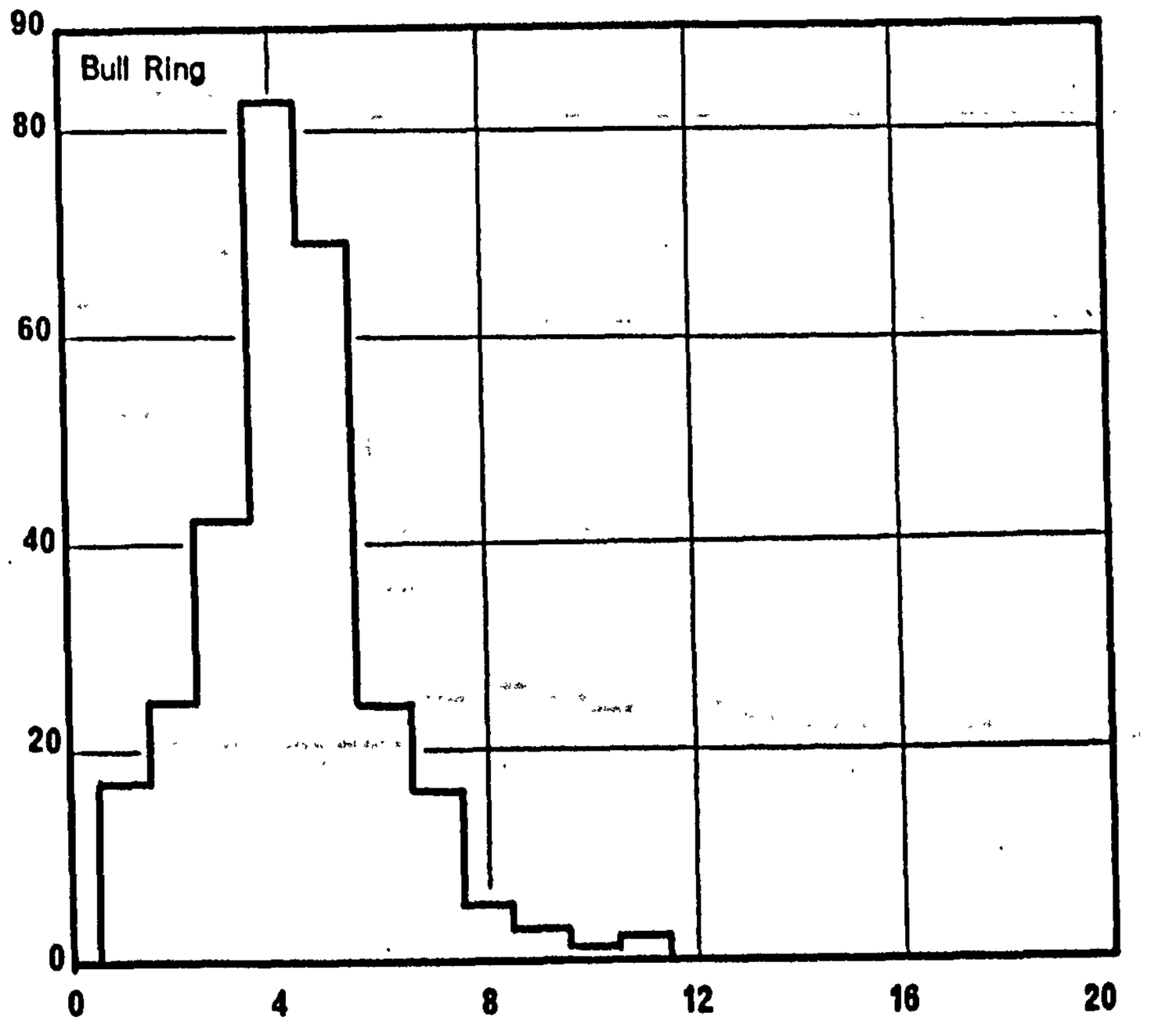


Fig. 3.26 Layout of site of camera observations



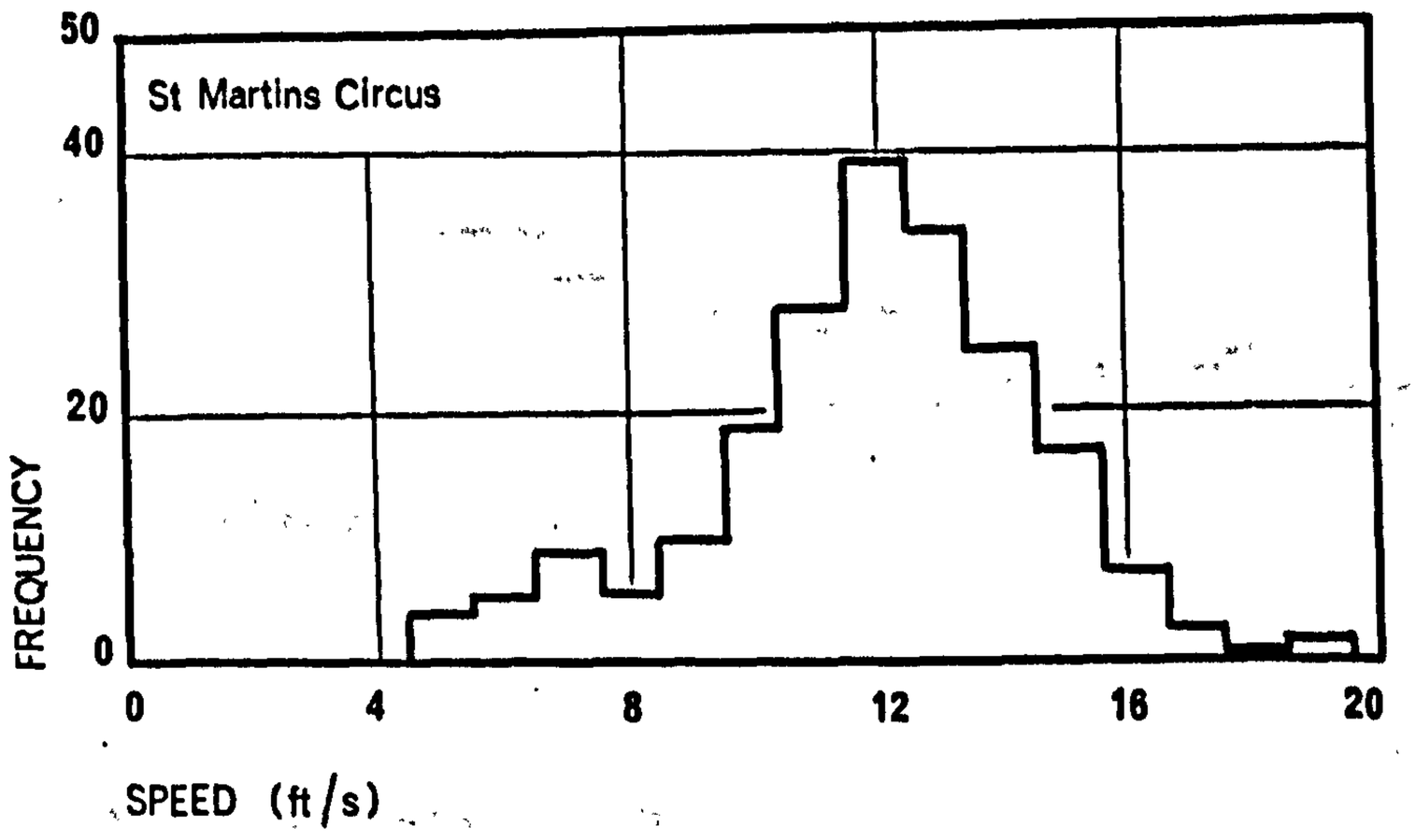
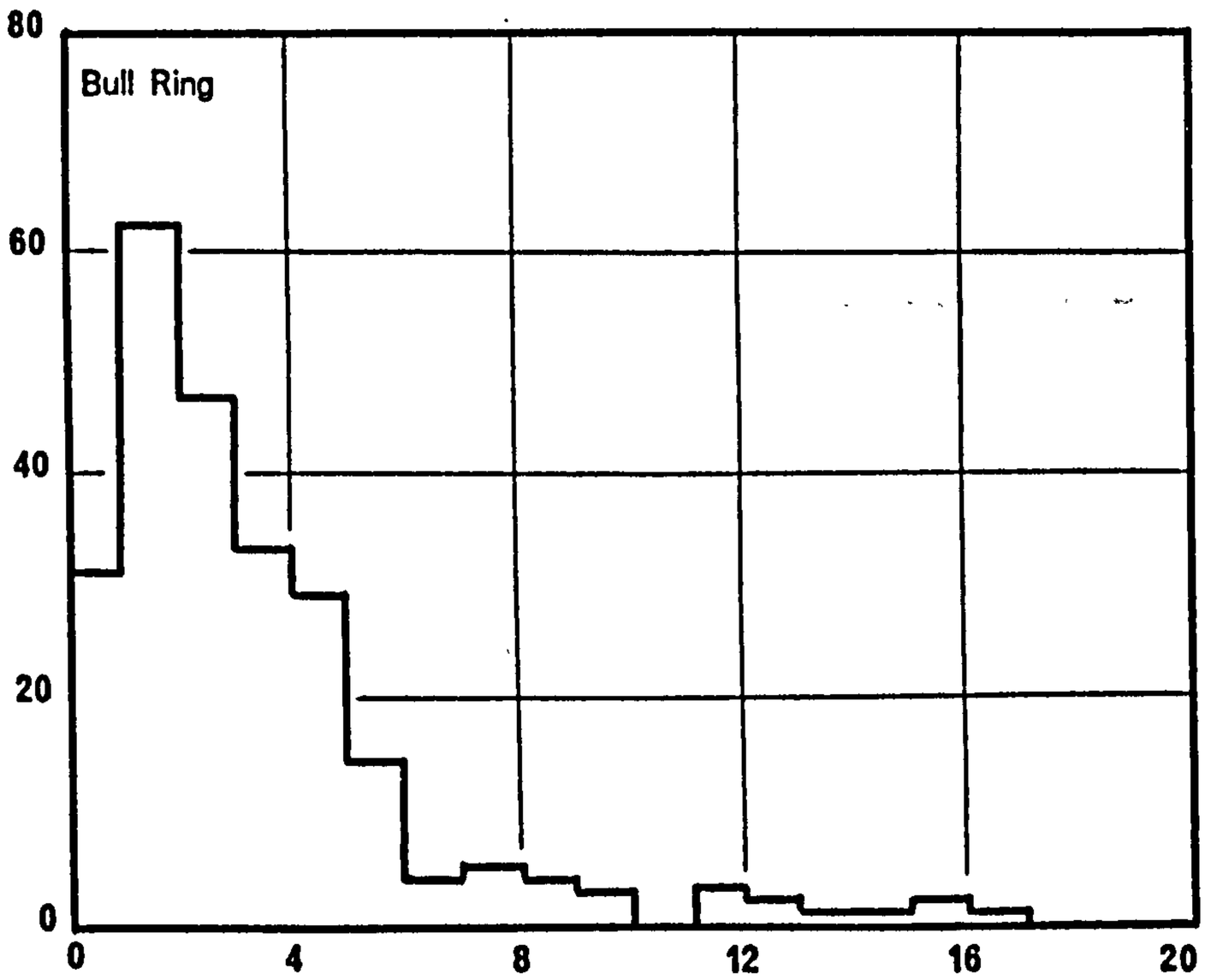


Fig. 3.27 Observed Speed distributions



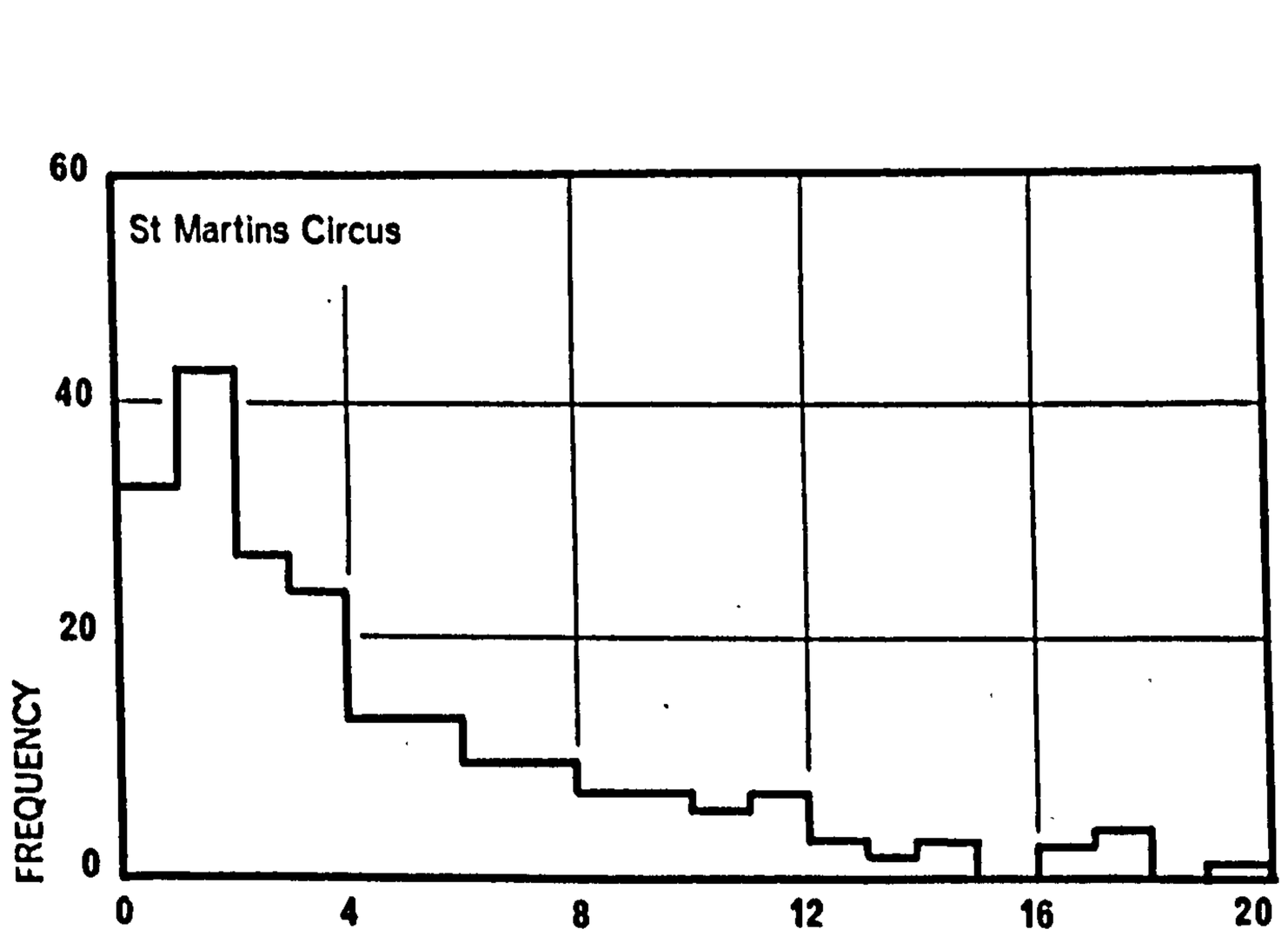


Fig. 3.28 Observed headway distributions

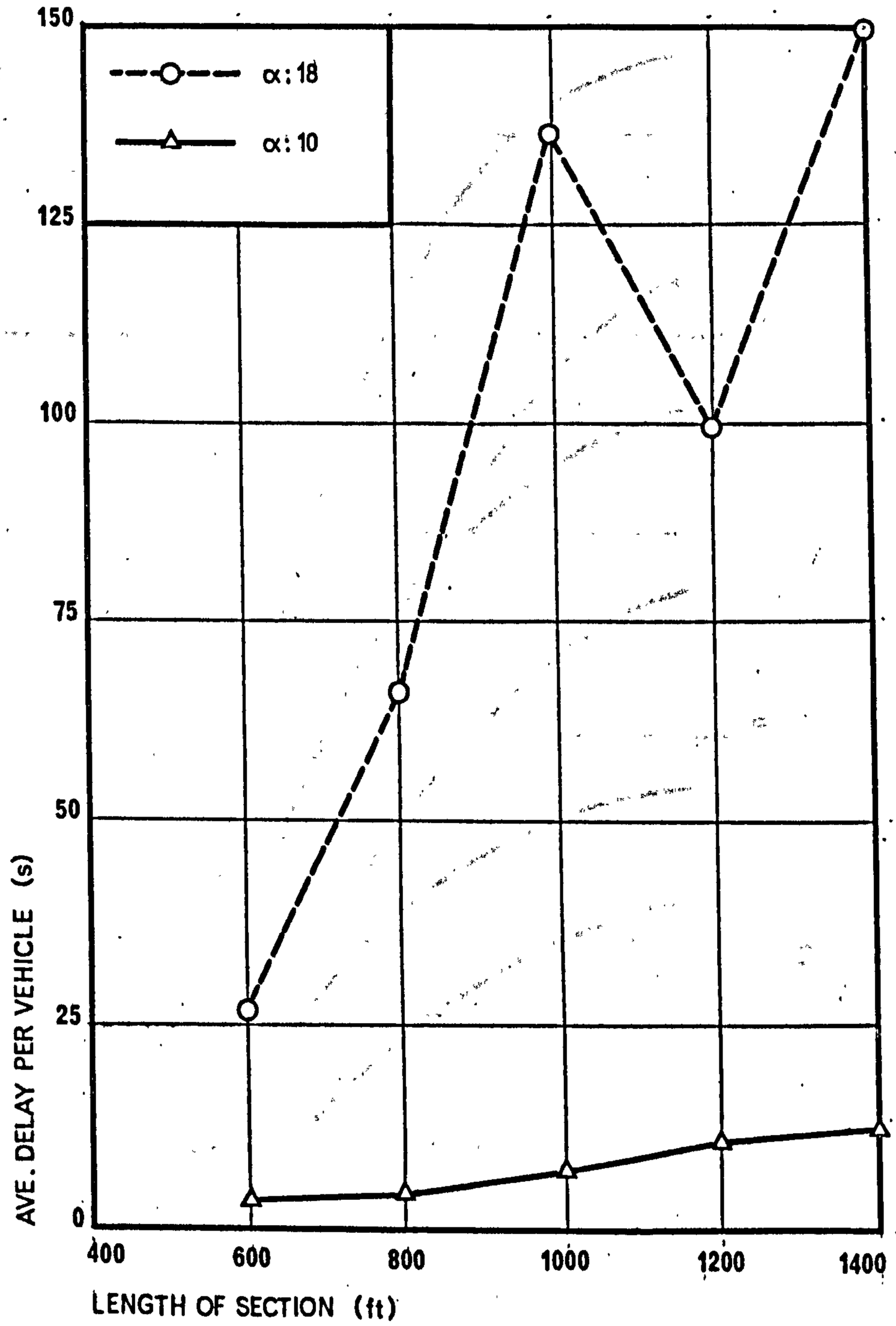


Fig. 3.29 Effect of Length of Section on Delay

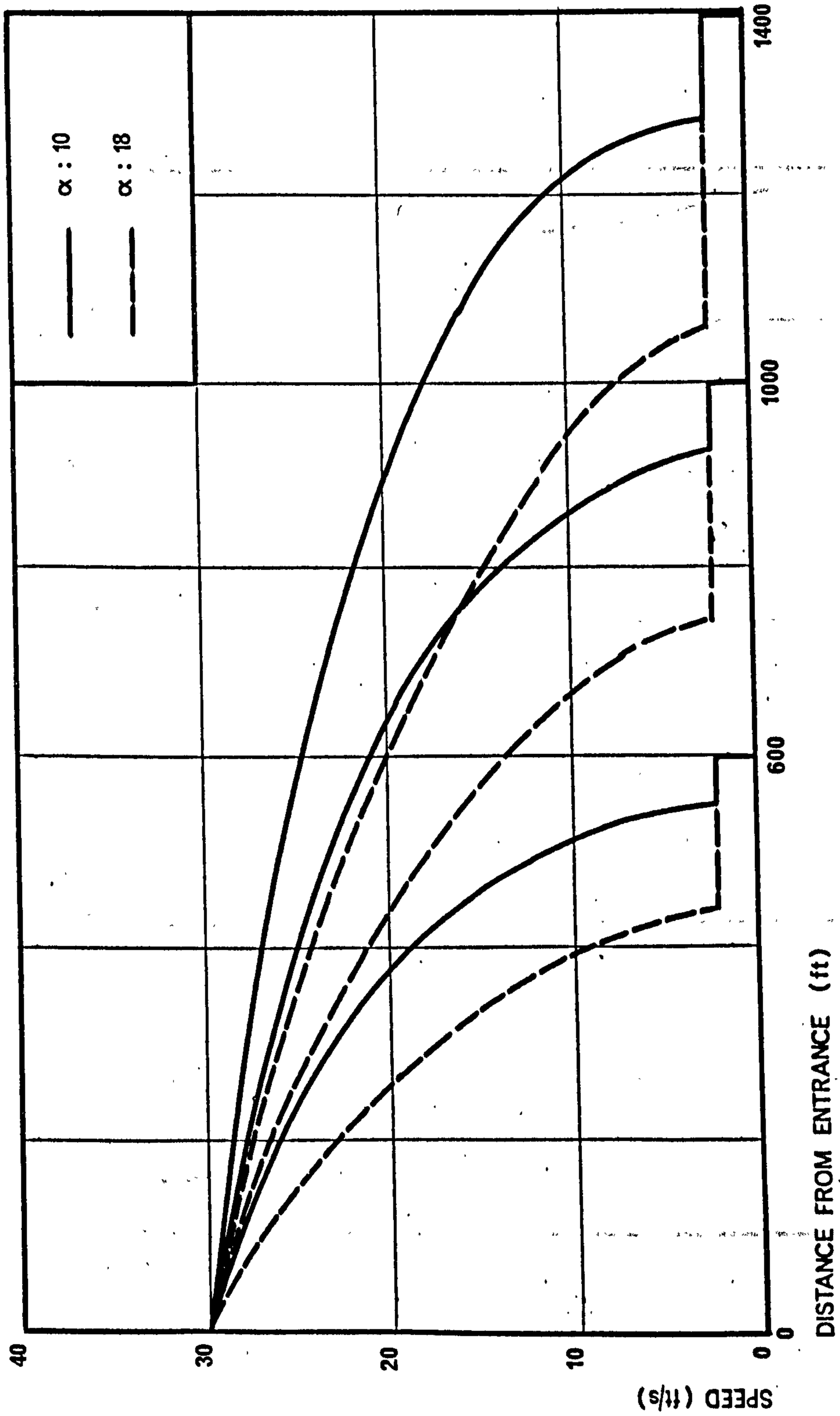


Fig. 3.30 Effect of characteristic speed on progress of a single weaving vehicle unable to weave

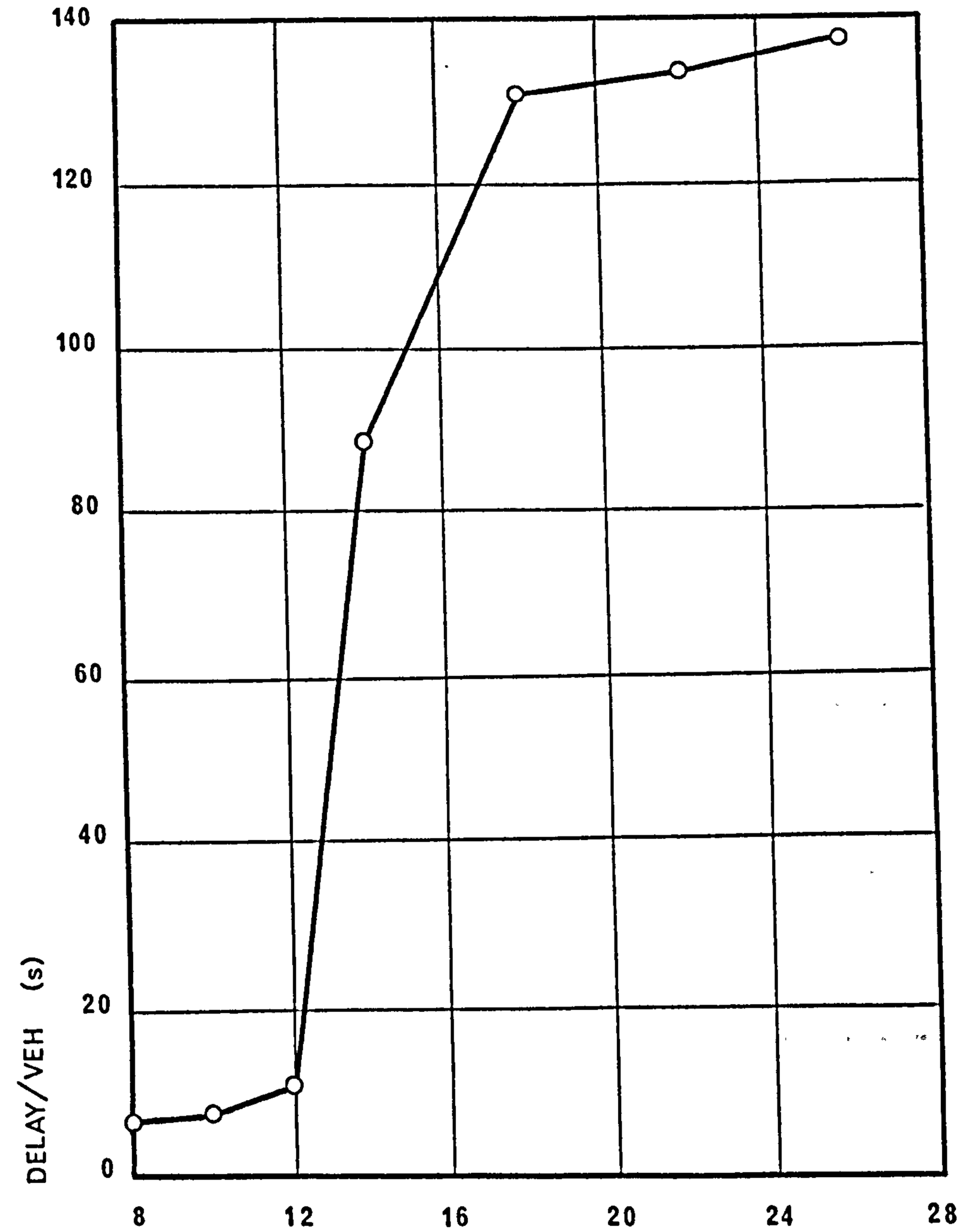


Fig. 3.31 Variation in delay with characteristic speed

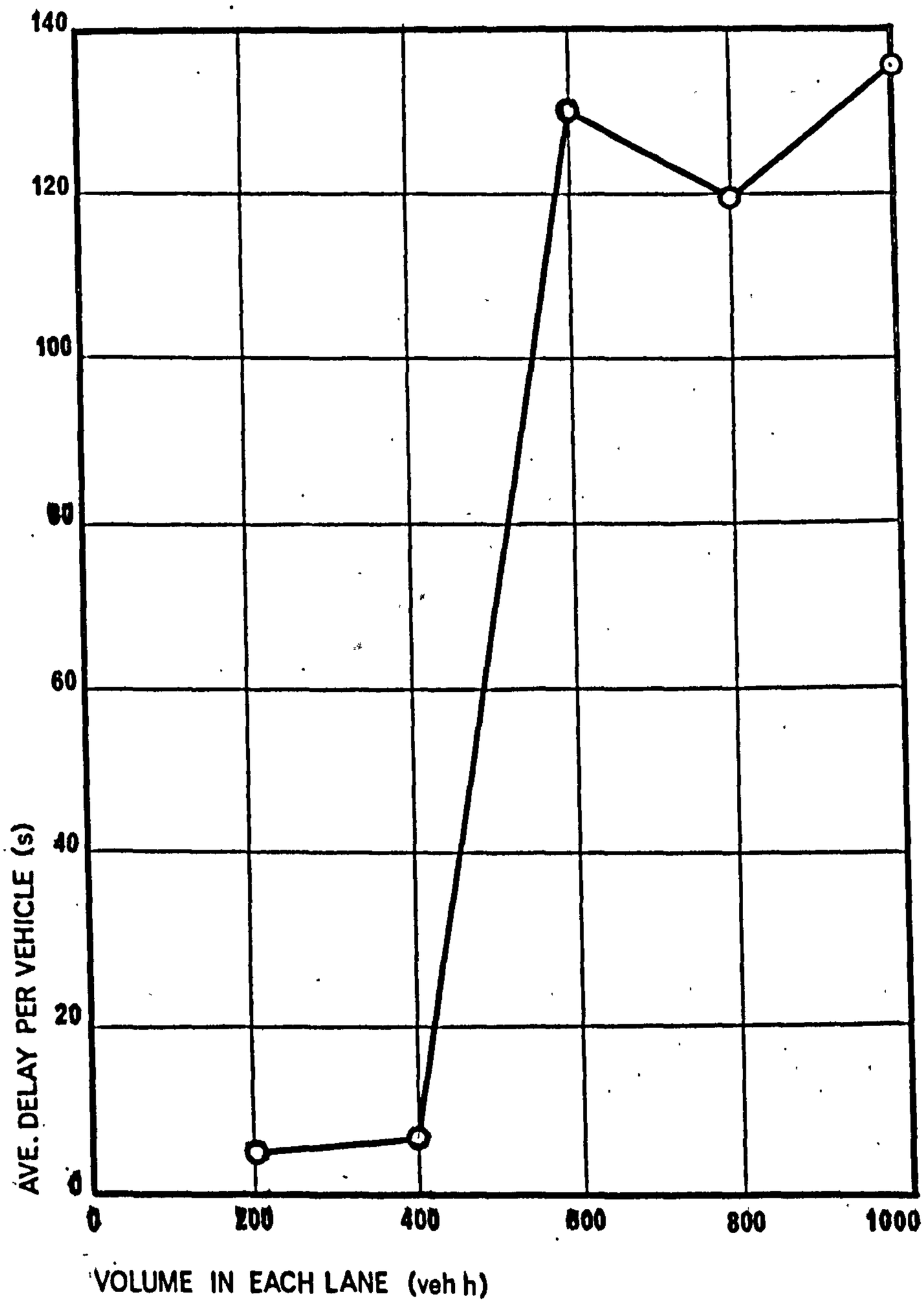


Fig. 3.32 Effect of volume on delay
(characteristic speed = 18 ft/s)

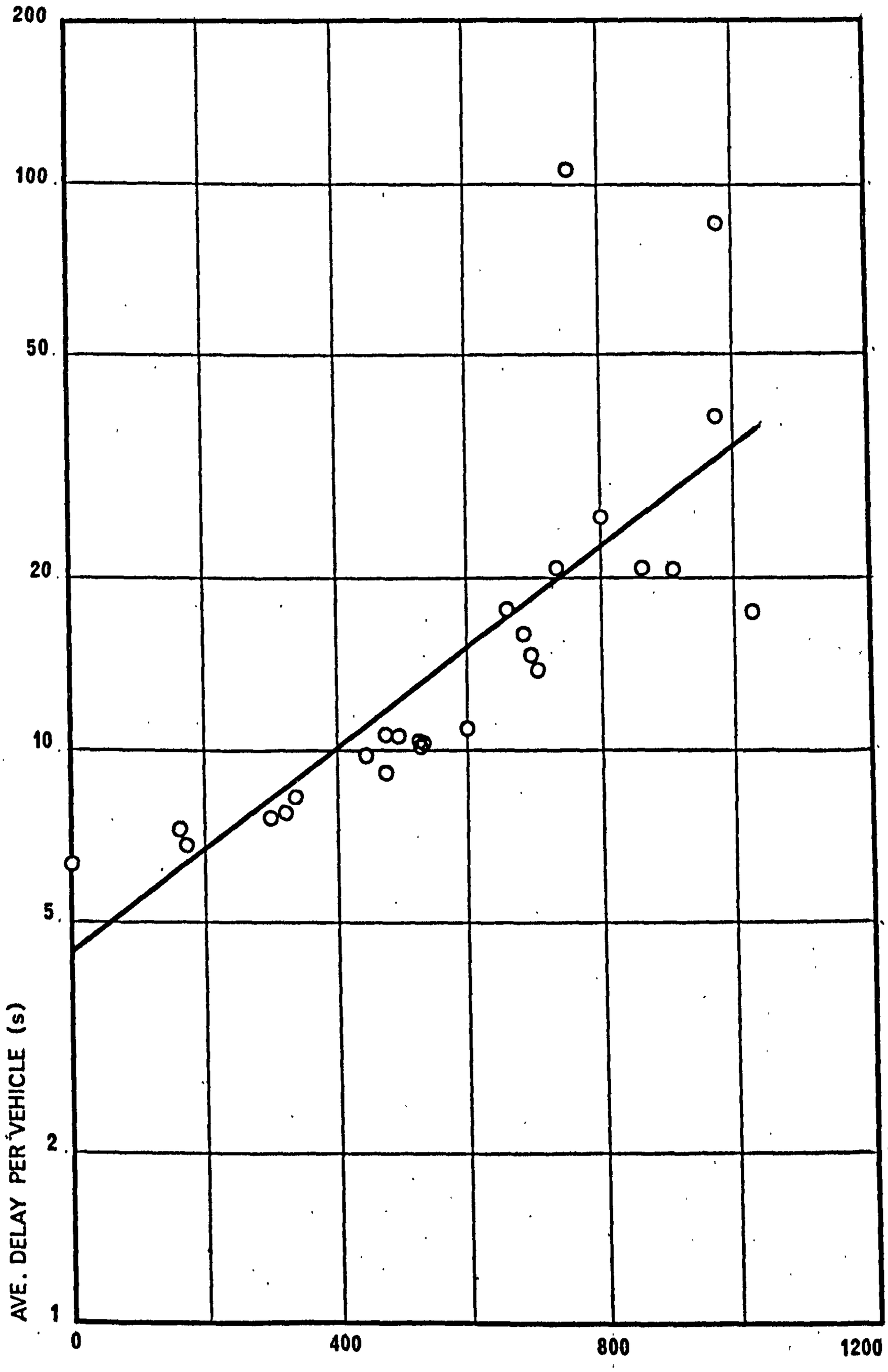


Fig. 3.33 Effect of weaving volume on delay (characteristic speed = 10 ft/s)

fig. 4.1 Camera

fig. 4.3 Electronic intervalometer

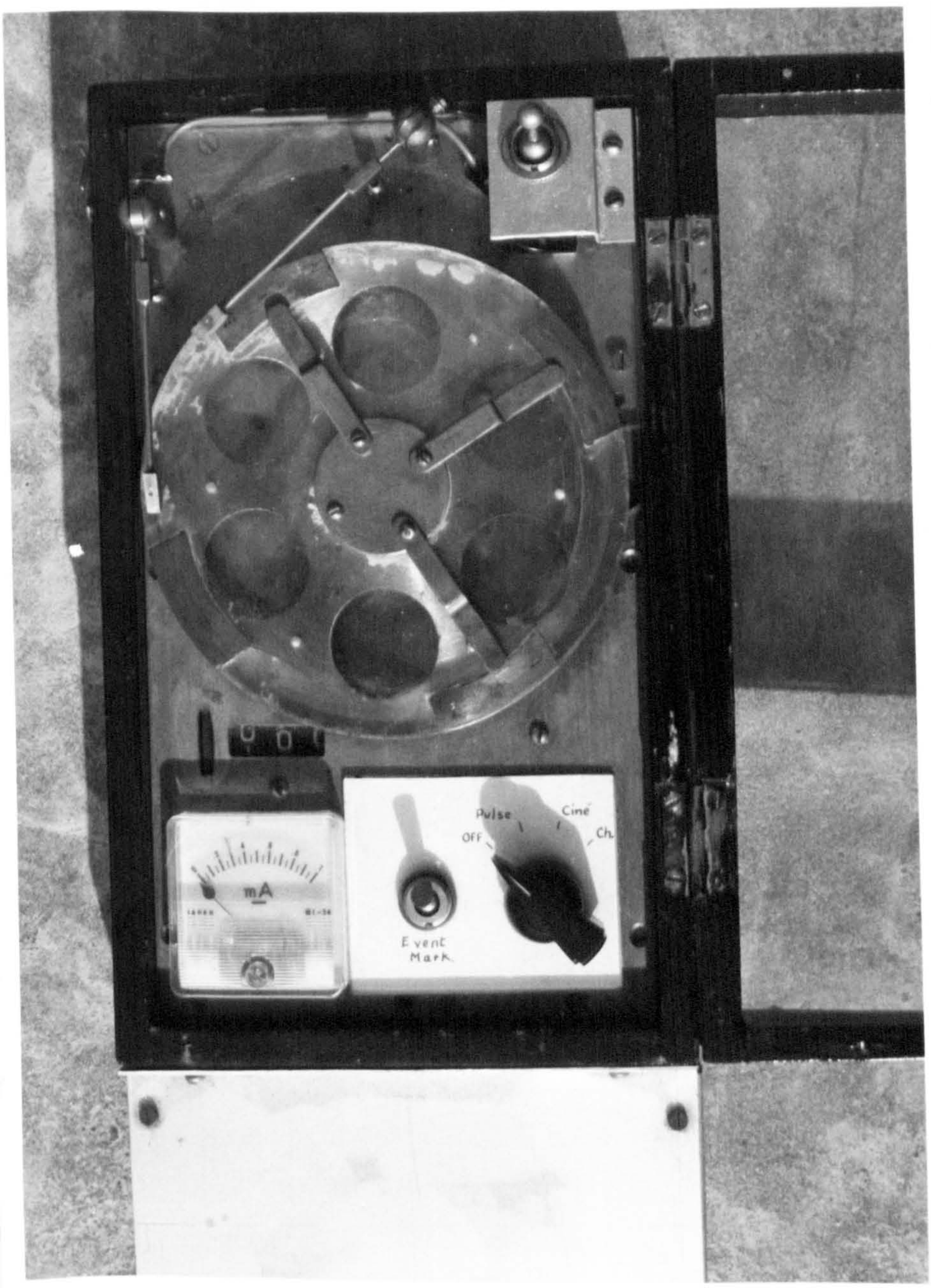
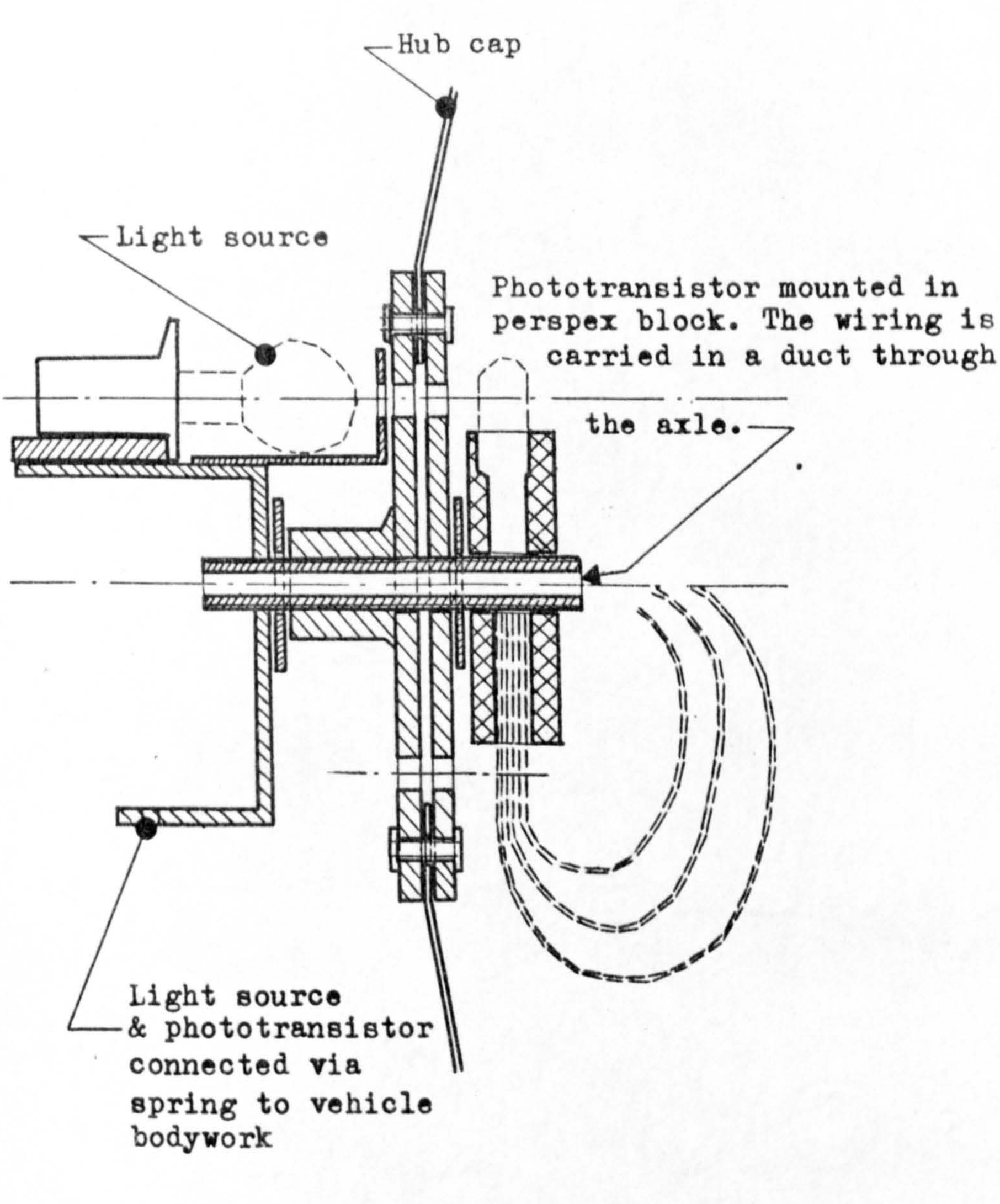


fig. 4.2 Electromechanical intervalometer



SCALE : Actual size

Fig. 4.4 Hub cap pulse generator

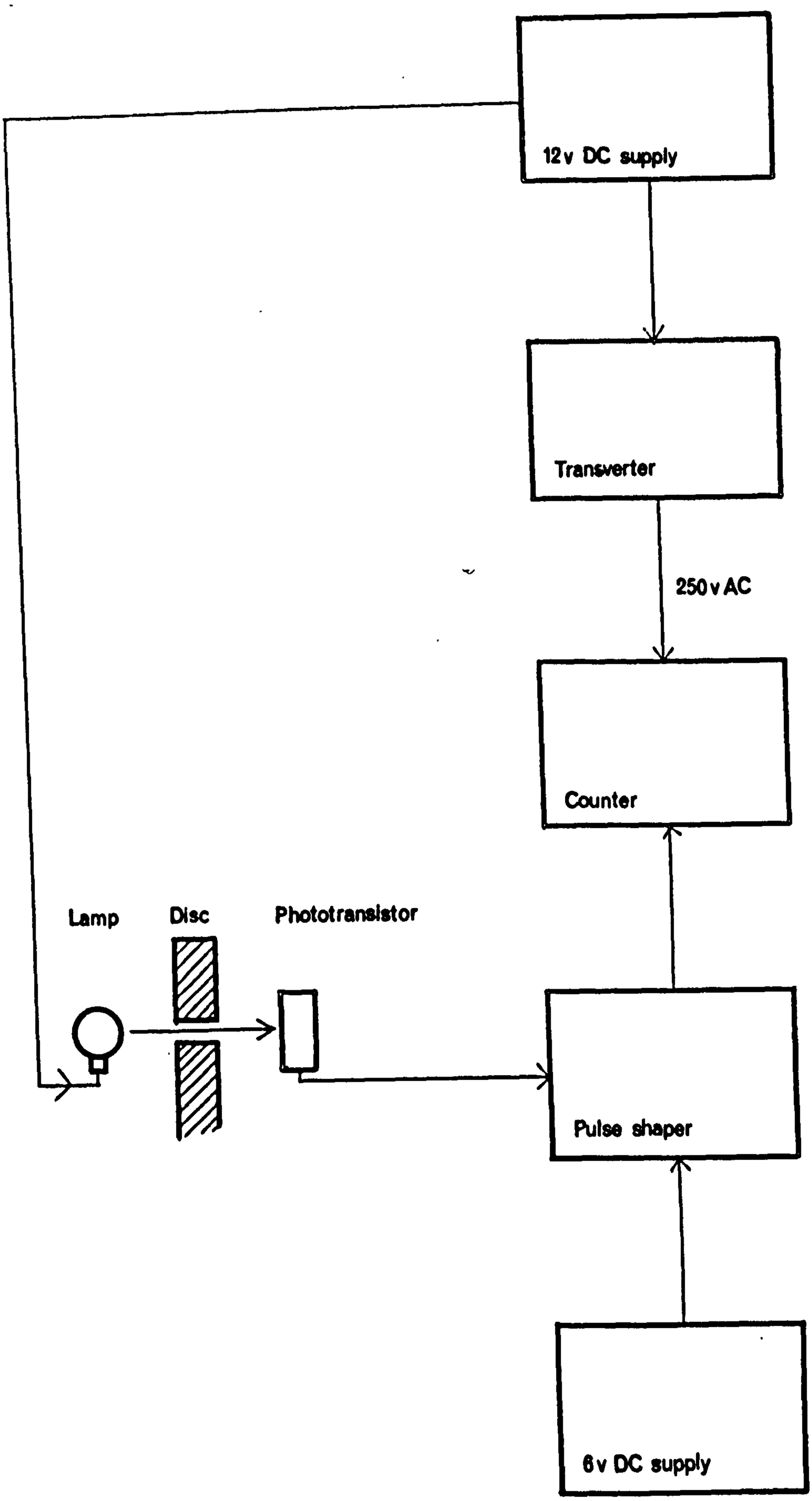


Fig. 4.5 Arrangement of car following equipment

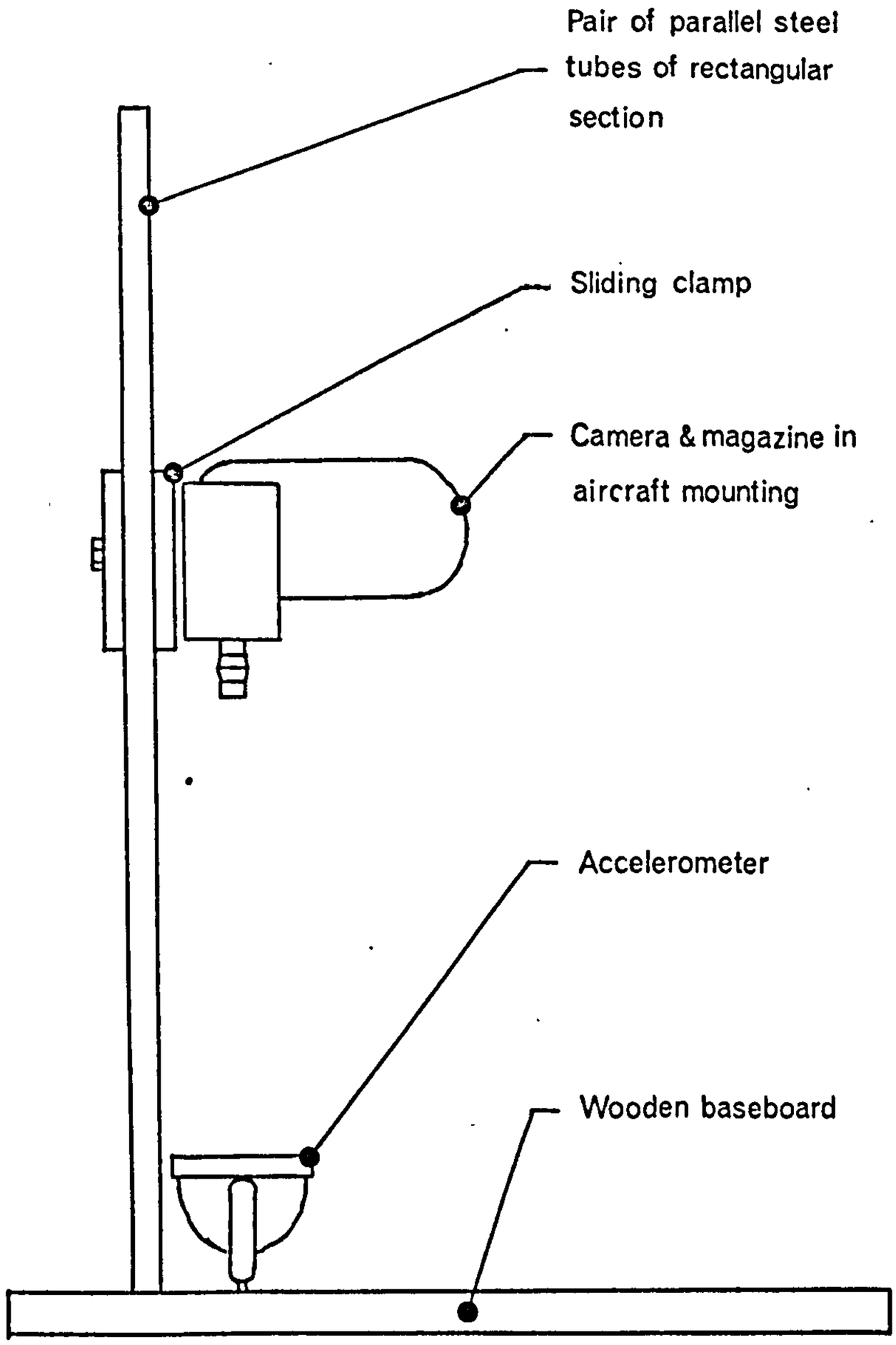


Fig. 4.6 Accelerometer Arrangement

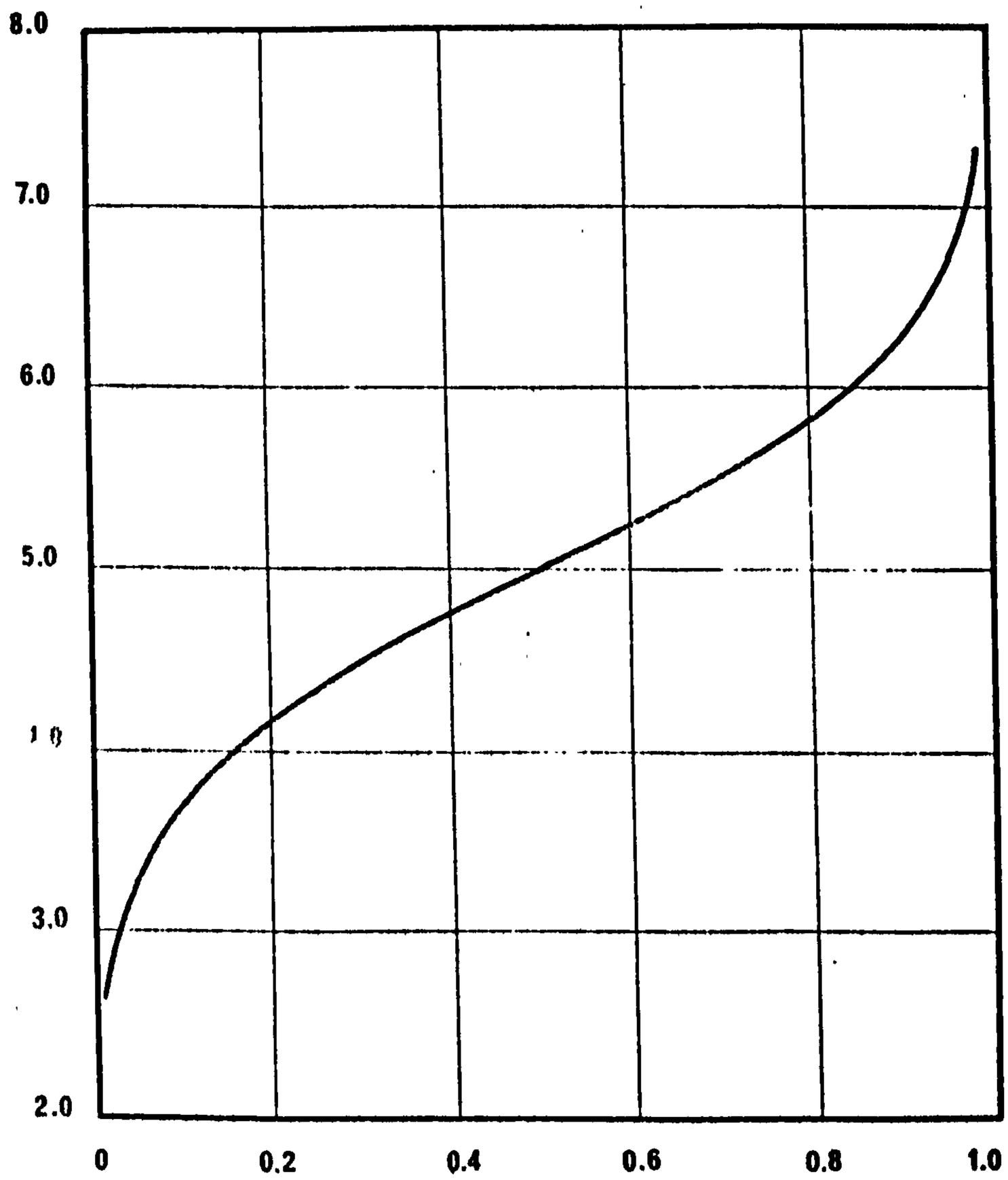


Fig. 1.1 Relationship between probits and proportions

(Source: fig. 6., ref. 2.26)

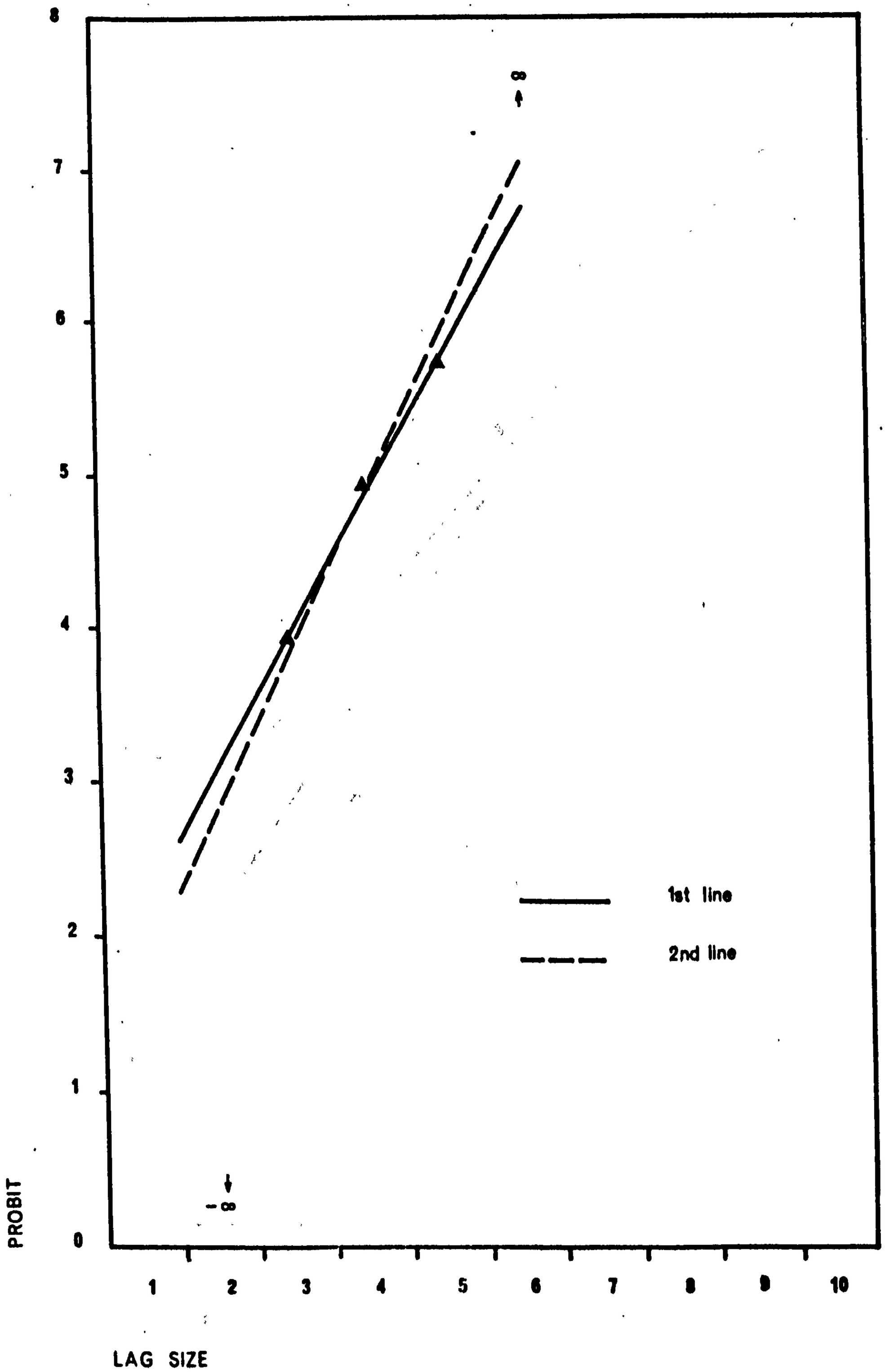


Fig. II.1 Probits for lag acceptance

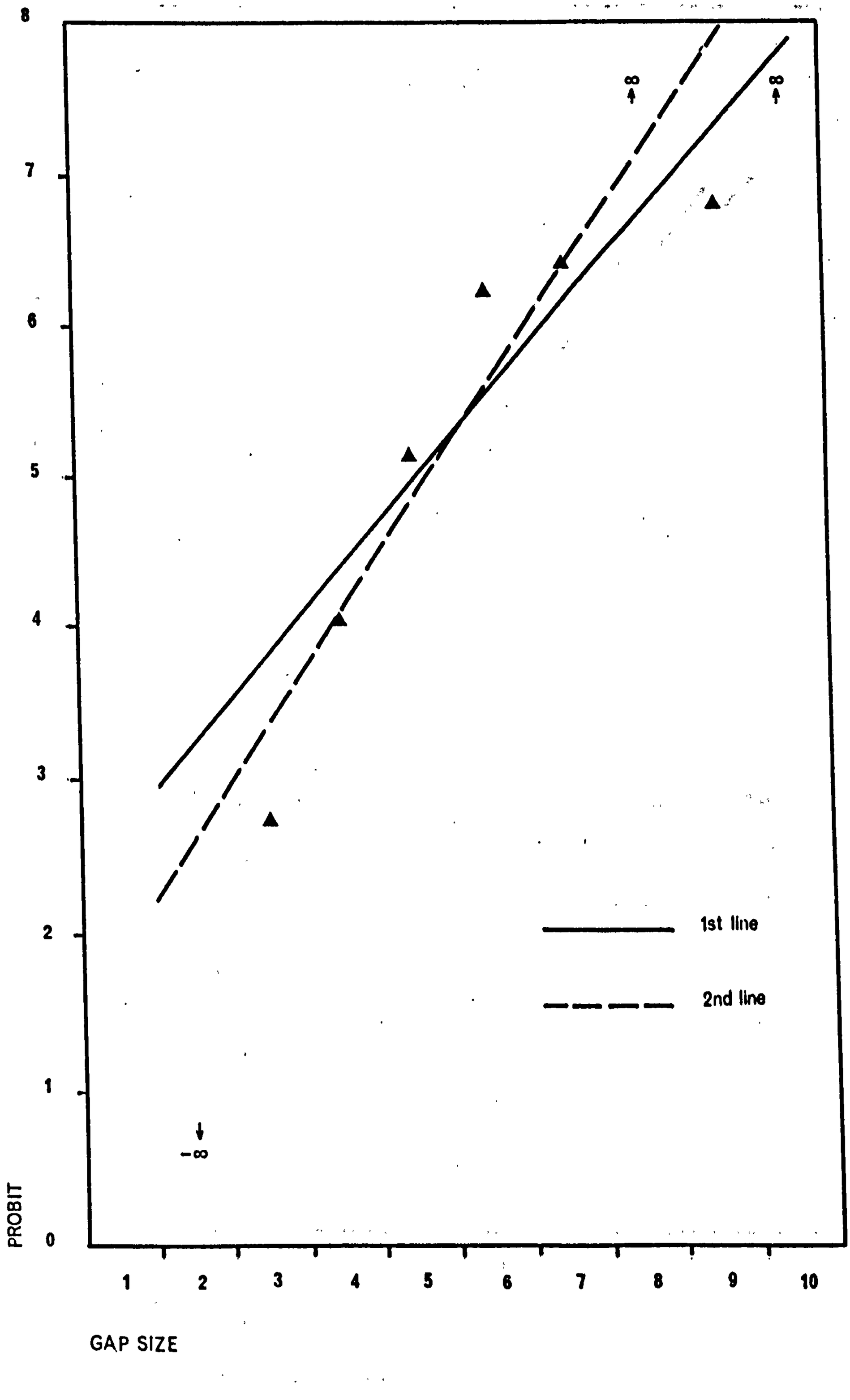


Fig. III.1 Probits for gap acceptance (first gap only)

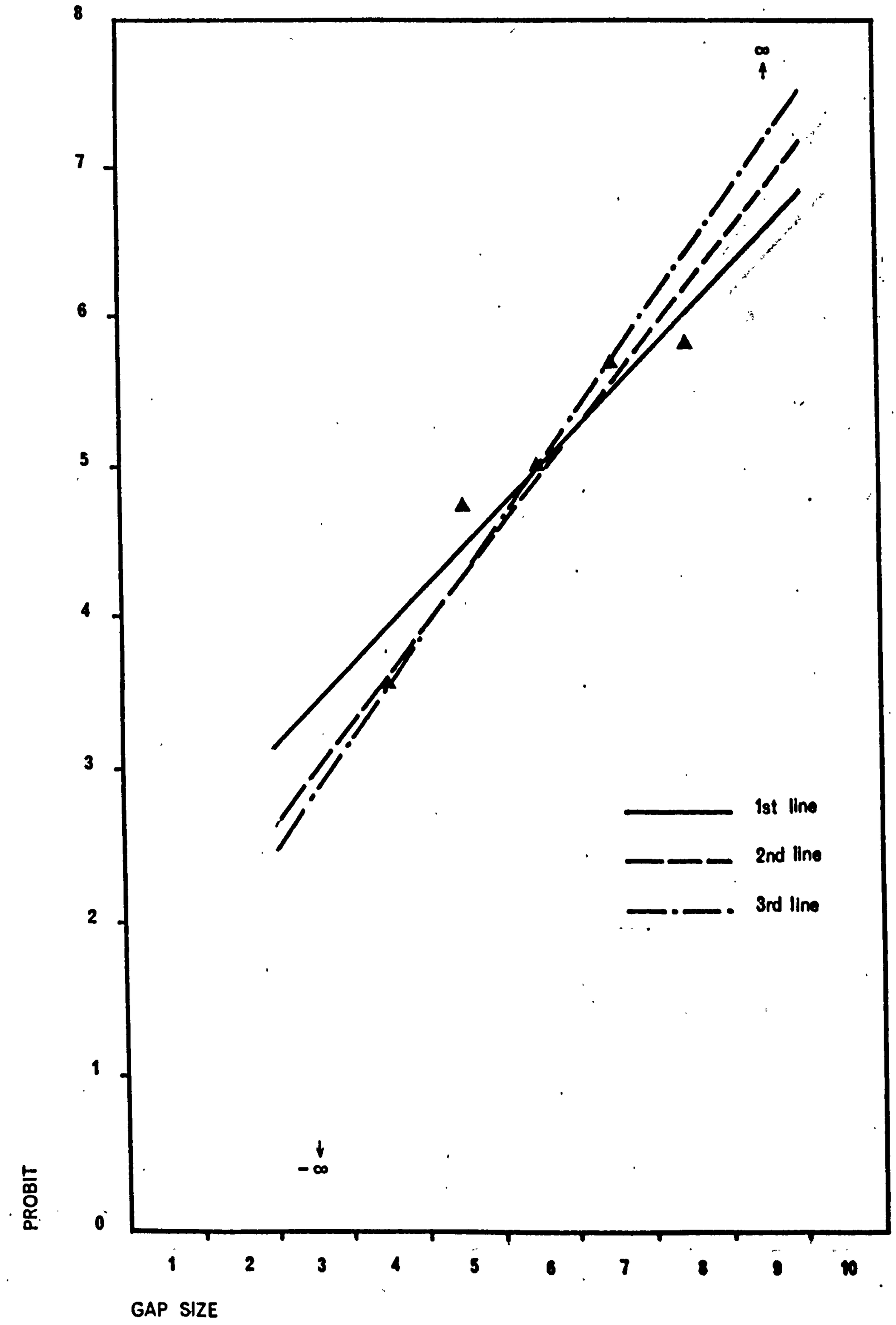


Fig. IV.1 Probits for gap acceptance (all gaps)

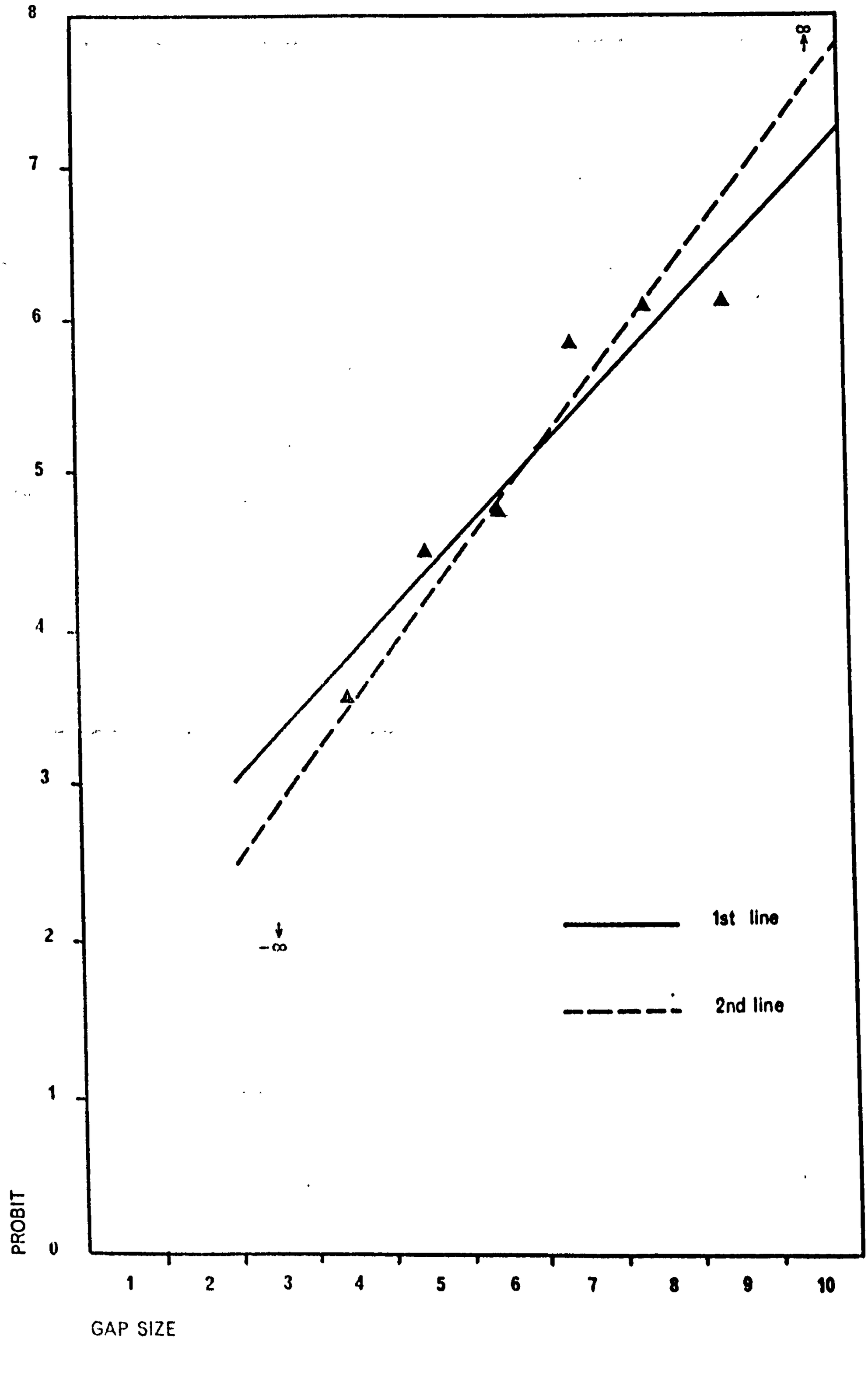


Fig. V.1. Probits for gap acceptance (pairs of vehicles)

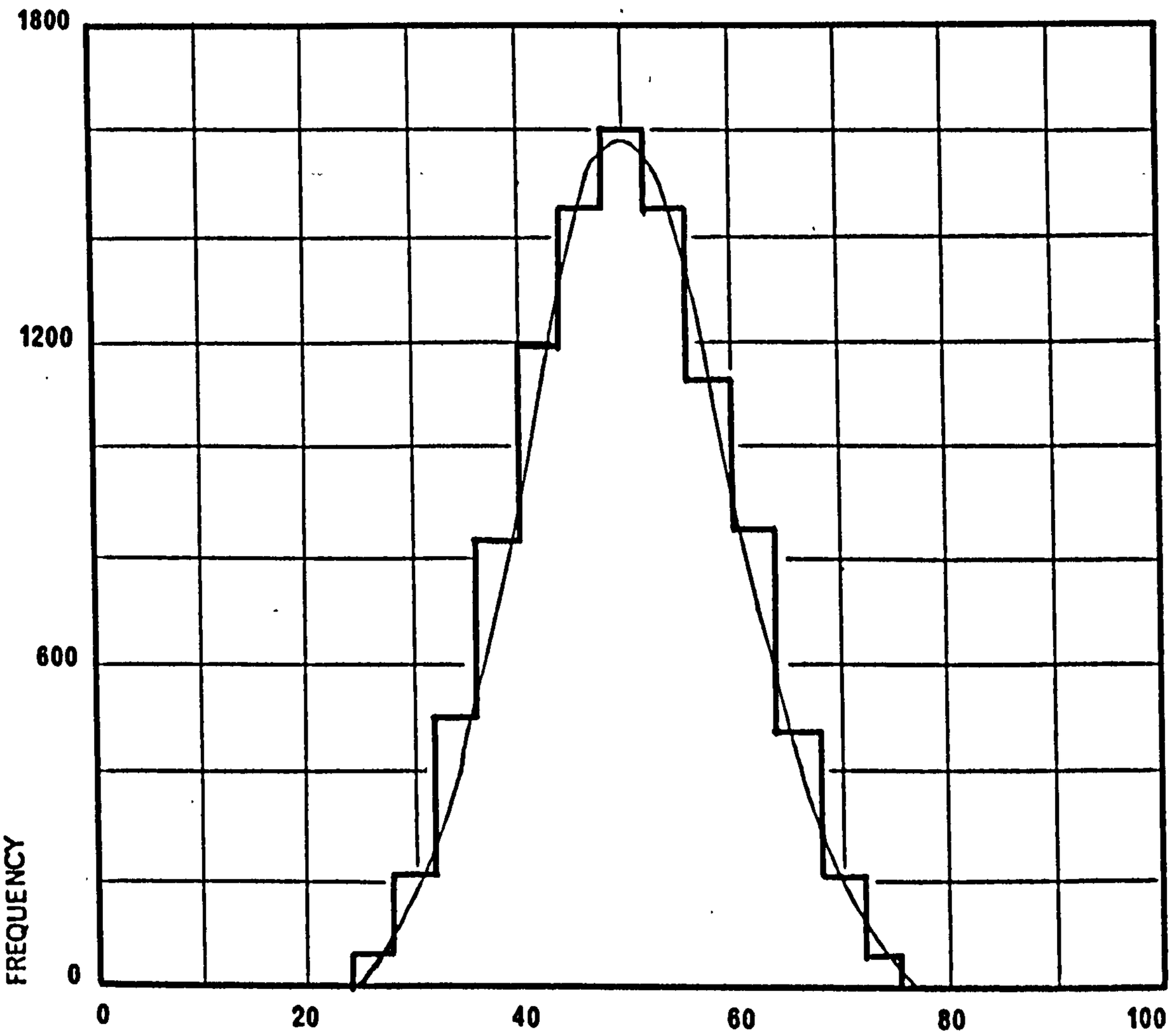


Fig. VIII.1. Generated speed distribution

TABLE 1.1 Verification of Pseudo-Random Number Generator

Investigator	Starting Number	$\leq x/n$	$\leq x^2/n$	n
BEHRENZ	28 395 423 107	0.506 25	0.343 04	500
		0.486 32	0.316 81	1000
		0.503 04	0.334 69	5000
LAUGHLIN	21 348 750 609	0.499 015 7688	0.331 871 7683	500
		0.498 826 9653	0.329 040 1482	1000
POORE	13 543 288 579	0.498 648 0931	0.328 068 1242	500
		0.488 689 6840	0.314 152 0616	1000
		0.499 882 0627	0.332 116 0802	5000
	24 376 589 411	0.497 141 4794	0.329 790 8586	500
		0.499 772 9126	0.332 080 1987	1000
		0.498 838 0784	0.331 994 9178	5000
	34 359 738 367	0.496 240 8228	0.333 921 4303	500
		0.497 483 7457	0.333 572 0239	1000
		0.492 961 2237	0.325 342 1270	5000
	11 324 679 915	0.581 380 8305	0.369 153 9122	500
		0.516 708 3685	0.349 855 8231	1000
		0.504 381 4637	0.338 342 9327	5000
Expected		0.500 000 0000	0.333 333 3333	-

TABLE 1.2 Simulation as a Modelling Technique.

CRITERION	ANALYSIS	SIMULATION	TRIAL
Cost	Least	Medium	Most
Time	Least	Medium	Most
Reproducibility	Most	Medium	Least
Realism	Least	Medium	Most
Generality of Results	Most	Medium	Least

Table 1.3 : Speed Distributions on Five Categories of Road

Category	Mean Speed (mile/h)	Lowest Speed	Highest Speed	Speed Range
A	16	8	28	20
B	24	8	40	32
C	35	19	51	32
D	45	27	69	42
E	59	28	94	66

TABLE 2.1 Films used in Gap Acceptance Data Collection

Film code	Dates	Times	Film Type	Approx. Footage	Camera Speed
A1/CR 1	Tuesday 30.3.65	1640-1705 1755-1852	Kodak Tri-X	200	1 frame/s
	Wednesday 31.3.65	1651-1745			
A1/CR 2	Thursday 3.6.65	1600-1800	Kodak Tri-X	200	1 frame/s
A1/CR 3	Tuesday 29.6.65	1600-1800 Intermittent	Kodak Tri-X	180	1 frame/s
	Wednesday 30.6.65	do.			
	Thursday 1.7.65	do.			
	Friday 2.7.65	do.			

TABLE 2.2 Pooled Median Acceptance Times as Determined by Different Methods

Investigator	Combined Gaps and Lags (s) for:-		
	Right Turns	Left Turns	Through Movements
SOLBERG	7.36	7.82	7.18
RAFF	7.45	7.85	7.35
BISSELL	7.35	7.65	7.10

TABLE 2.3 Lag Acceptance Data

Gap Size (s)	Number Rejected	Number Accepted	Total	Proportion Accepted
0 - 1.5	18	0	18	0
1.5- 2.5	36	0	36	0.000
2.5- 3.5	28	5	33	0.152
3.5- 4.5	12	11	23	0.478
4.5- 5.5	8	26	34	0.765
5.5- 6.5	0	28	28	1.000
6.5- 7.5	0	22	22	1
7.5- 8.5	0	11	11	1
8.5- 9.5	0	12	12	1
> 9.5	0	5	5	1

TABLE 2.4 Gap Acceptance Data

Gap Size (s)	Number Rejected	Number Accepted	Total	Proportion Accepted
0 - 1.5	81	0	81	0
1.5- 2.5	72	0	72	0.000
2.5- 3.5	71	1	72	0.014
3.5- 4.5	37	8	45	0.178
4.5- 5.5	21	25	46	0.543
5.5- 6.5	3	23	26	0.885
6.5- 7.5	2	22	24	0.917
7.5- 8.5	0	26	26	1.000
8.5- 9.5	1	24	25	0.960
9.5-10.5	0	8	8	1.000
10.5-11.5	0	8	8	1
11.5-12.5	0	0	0	-
>12.5	0	3	3	1

TABLE 2.5 Gap Acceptance Data (All gaps)

Gap Size (s)	Number Rejected	Number Accepted	Total	Proportion Accepted
0 - 1.5	414	0	414	0
1.5- 2.5	441	0	441	0
2.5- 3.5	206	0	206	0.000
3.5- 4.5	79	7	86	0.081
4.5- 5.5	32	21	53	0.396
5.5- 6.5	17	18	35	0.514
6.5- 7.5	6	19	25	0.760
7.5- 8.5	4	16	20	0.800
8.5- 9.5	0	12	12	1.000
9.5-10.5	0	11	11	1
10.5-11.5	0	8	8	1
11.5-12.5	0	2	2	1
12.5-13.5	0	4	4	1
>13.5	0	4	4	1

TABLE 2.6 Summary of Gap Acceptance Data

Analysis of:	Stopped Vehicles (All gaps, with correction)	Stopped Vehicles (First gap only)	Moving Vehicles
Mean (s)	5.5450	5.1352	4.1208
Standard deviation (s)	1.5225	1.3330	0.9855
Significance of Chi-Squared fit of line to observed data	N.S.	80 percent	90 percent
Number of tests	437	436	154

TABLE 2.7 Arrival Distribution Data

Gap Size(s)	Observed Frequency (48 min)	(60 min)	Predicted Frequency (Exp.)	(Trunc.Exp.)
0.00- 0.24	8	10	91.6	0
0.25- 0.49	33	41	85.1	0
0.50- 0.74	25	31	76.5	0
0.75- 0.99	52	65	70.9	0
1.00- 1.24	53	66	65.3	121.2
1.25- 1.49	77	96	60.8	108.4
1.50- 1.74	72	90	54.6	95.3
1.75- 1.99	80	100	50.6	85.0
2.00- 2.24	65	81	46.7	76.5
2.25- 2.49	48	60	42.8	68.1
2.50- 2.74	46	58	38.8	61.2
2.75- 2.99	24	30	36.6	55.1
3.00- 3.49	58	73	63.0	91.4
3.50- 3.99	49	61	54.4	74.2
4.00- 4.49	27	34	45.4	60.6
4.50- 4.99	20	25	38.8	46.2
5.00- 5.49	22	27	32.0	37.2
5.50- 5.99	17	21	28.6	29.2
6.00- 6.49	15	19	22.4	21.4
6.50- 6.99	13	16	19.2	18.4
7.00- 7.49	9	11	16.2	15.2
7.50- 7.99	11	14	15.0	12.2
8.00- 8.49	10	12	11.2	9.2
8.50- 8.99	6	8	9.6	7.6
9.00- 9.49	7	9	8.6	5.8
9.50- 9.99	3	4	-	-
10.00-10.99	7	9	-	-
11.00-11.99	7	9	-	-
12.00-12.99	5	6	-	-
13.00-13.99	6	7	-	-
14.00-14.99	7	9	-	-
15.00-15.99	4	5	-	-
16.00-16.99	4	5	-	-
17.00-17.99	1	1	-	-
18.00-18.99	1	1	-	-
19.00-19.99	1	1	-	-
>20.00	8	11		
Total	901	1126		

TABLE 2.8 Gap Acceptance Data (Pairs of vehicles)				
Gap Size (s)	Number Rejected	Number Accepted	Total	Proportion Accepted
0.0- 1.5	0	0	0	-
1.5- 2.5	0	0	0	-
2.5- 3.5	0	0	0	0.000
3.5- 4.5	12	1	13	0.077
4.5- 5.5	18	8	26	0.308
5.5- 6.5	14	10	24	0.417
6.5- 7.5	6	26	32	0.813
7.5- 8.5	4	23	27	0.852
8.5- 9.5	2	13	15	0.867
9.5-10.5	0	15	15	1.000
10.5-11.5	0	10	10	1

TABLE 2.9 Output saturation flows (no right turning vehicles). Input saturation flow = 3200 veh/h

Run number	Output saturation flow (veh/h)
9	3229
17	3207
124	3301
125	3296
126	3280
127	3271
128	3293
Mean	3268

Chi-Squared = 12.624 (NS at 5 percent level)

TABLE 2.10 Output saturation flows

Run no.	Saturation flow veh/h	Run no.	Saturation flow veh/h	Run no.	Saturation flow veh/h
18	3180	34	3139	50	3022
19	3139	35	3066	51	3097
20	3128	36	3148	52	3159
21	3166	37	3253	53	3311
22	3241	38	3317	54	3335
23	3286	39	3320	55	3312
24	3264	40	3410	56	3342
25	3270	41	3284	57	3330
26	3165	42	3107	58	3038
27	3107	43	3119	59	3045
28	3115	44	3190	60	3203
29	3211	45	3294	61	3318
30	3272	46	3322	62	3338
31	3277	47	3295	63	3448
32	3296	48	3371	64	3362
33	3249	49	3401	65	3420

Mean : 3233.06

TABLE 2.11 Output saturation flows (only right turning vehicles in the right hand lane, no opposing flow. Input saturation flow = 3200 veh/h

Run number	Output saturation flow (veh/h)
10	3201
134	3229
135	3227
137	3211
138	3227
139	3211
140	3201
141	3221
142	3200
143	3202
Mean	3213

Chi-Squared = 0.934 (NS at 5 percent level)

TABLE 2.12 Input data for calibration checks

Date:	28.2.66		10.3.66					16.5.67
Time:	1700 1730	1730 1800	1645 1700	1700 1715	1715 1730	1730 1745	1745 1800	1700 1800
Run number:	2	3	4	5	6	7	8	913
Signal timings:								
Cycle	74	56	69	70	70	54	56	95
Red	39	24	36	33	36	28	26	38
Amber	3	3	3	3	3	3	3	3
Green	32	29	30	34	31	23	27	52
Lost	-4	-3	-4	-2	-1	-3	-2	+3
Approach volume: (veh/h)	1230	1222	1048	1428	1232	1320	1516	1544
Opposing volume:	906	882	1004	1272	944	852	880	536
Proportion of right turns:	0.099	0.102	0.115	0.109	0.097	0.067	0.113	0.071
Proportion of straight ahead vehicles in right hand lane:	0.135	0.170	0.107	0.132	0.152	0.273	0.214	0.369
Straight ahead saturation flow: (veh/h)	3200	3200	3200	3200	3200	3200	3200	3410

TABLE 2.13 Comparison between observed and simulated saturation flows

Run number	Simulation time (h)	Saturation Flow (veh/h)	
		Simulated	Observed
2	0.50	1959	
	0.75	1990	
	1.00	2028	
	1.25	2017	
	1.50	2051	2082
3	0.50	2167	
	0.75	2194	
	1.00	2180	
	1.25	2169	
	1.50	2157	2334
4	0.50	1939	
	0.75	1987	
	1.00	1968	
	1.25	1952	
	1.50	1935	2022
5	0.50	1805	
	0.75	1803	
	1.00	1839	
	1.25	1851	
	1.50	1859	2004
6	0.50	2129	
	0.75	2180	
	1.00	2152	
	1.25	2127	
	1.50	2106	2064
7	0.50	2462	
	0.75	2453	
	1.00	2447	
	1.25	2418	
	1.50	2430	2220
8	0.50	2341	
	0.75	2378	
	1.00	2401	
	1.25	2383	
	1.50	2361	2040
913	0.50	2907	
	0.75	2923	
	1.00	2837	
	1.25	2851	
	1.50	2816	3000

TABLE 2.14 Starting random numbers

Number	Run number	Number	Run number
16 766 227 665	5, 65, 128	11 056 509 687	33, 95
12 568 992 695	6, 66, 129	26 786 306 551	34, 96
16 227 794 393	7, 67, 130	12 419 496 263	35, 97
18 180 792 463	8, 68, 131	10 474 845 881	36, 98
26 623 389 775	2, 69, 132	27 073 607 511	37, 99
23 424 064 747	3, 70, 133	13 553 858 597	38, 100
16 081 504 723	4, 71, 134	21 763 350 257	39, 101
31 169 332 435	9, 72, 135	12 867 358 073	40, 102
27 423 786 533	10, 73, 136	15 510 013 429	41, 103
29 949 894 245	11, 74, 137	20 148 588 451	42, 104
16 908 266 597	12, 75, 138	17 763 713 041	43, 105
11 279 475 059	13, 76, 139	12 720 743 459	44, 106
31 962 591 479	14, 77, 140	13 581 824 761	45, 107
14 908 445 117	15, 78, 141	10 456 504 261	46, 108
20 467 873 909	16, 79, 142	16 925 356 159	47, 109
26 996 165 535	17, 80, 143	22 981 222 079	48, 110
14 655 268 757	18, 81	32 175 585 749	49, 111
17 537 758 717	19, 82	13 082 701 501	50, 112
16 955 567 199	20, 83	15 545 595 521	51, 113
15 061 593 199	21, 22, 84	24 301 248 601	52, 114
22 358 515 139	23, 85	24 517 989 735	53, 115
23 522 333 129	24, 86	23 830 130 309	54, 116
31 044 969 961	25, 87	10 937 288 715	55, 117
31 997 368 683	26, 88	15 545 595 521	56, 118
22 957 754 249	27, 89	11 049 966 723	57, 119
31 624 309 899	28, 90	27 552 689 625	58, 120
17 379 323 787	29, 91	15 293 939 437	59, 121
13 895 103 741	30, 92	25 993 270 233	60, 122
16 643 616 001	31, 93	18 991 072 341	61, 123
20 153 700 495	32, 94	16 046 167 871	62, 124
		22 662 215 861	63, 125
		31 739 161 195	64, 126
		12 345 678 911	1, 127

TABLE 2.15 Effect of simulation time and starting random number on simulated saturation flows

Run	Time h	Satn flows		Run	Time h	Satn flows	
		Two lane veh/h	Single lane veh/h			Two lane veh/h	Single lane veh/h
12	1	3251	2069	14	7	3278	2039
	2	3247	2068		8	3280	2046
	3	3261	2065		9	3285	2057
	4	3262	2066		10	3285	2053
	5	3260	2052		11	3281	2058
	6	3248	2053		12	3283	2062
	7	3249	2052				
	8	3246	2059	15	1	3293	1931
	9	3247	2056		2	3304	1981
	10	3254	2047		3	3297	1968
	11	3253	2043		4	3276	1994
	12	3250	2047		5	3283	1992
					6	3262	1991
13	1	3186	2003		7	3260	1998
	2	3190	2004		8	3264	2005
	3	3207	2025		9	3262	2002
	4	3227	2022		10	3252	2005
	5	3238	2032		11	3255	2002
	6	3233	2026		12	3250	2003
	7	3244	2035				
	8	3242	2039	16	1	3252	2132
	9	3240	2038		2	3281	2029
	10	3247	2040		3	3283	2036
	11	3256	2032		4	3274	2037
	12	3256	2027		5	3266	2038
					6	3253	2038
14	1	3169	1992		7	3253	2054
	2	3247	2019		8	3240	2065
	3	3268	2029		9	3240	2064
	4	3270	2039		10	3233	2065
	5	3266	2024		11	3228	2060
	6	3266	2023		12	3234	2059

TABLE 2.16 Confidence limits for mean simulated saturation flows after five hours simulation

Confidence limits (percent)		Saturation flow (veh/h)	
		both lanes	single lanes
95	upper	3283	2055
	lower	3243	2000
99	upper	3297	2074
	lower	3228	2074
99.9	upper	3326	2114
	lower	3198	1940
Mean		3263	2028

TABLE 2.17 Right turning vehicle factors

Proportion of right turns (percent)	Opposing flow (veh/h)	No special phase		Early cut off	
		Run	Right turn factor	Run	Right turn factor
5	1	18	1.15	66	1.21
	200	19	2.86	67	2.46
	400	20	4.12	68	4.72
	600	21	7.89	69	9.51
	800	22	12.48	70	14.22
	1000	23	30.06	71	19.15
	1100	24	39.38	72	37.44
	1200	25	101.68	73	96.18
10	1	26	1.13	74	1.19
	200	27	2.73	75	2.59
	400	28	4.27	76	3.97
	600	29	6.54	77	6.87
	800	30	12.86	78	10.15
	1000	31	30.18	79	19.85
	1100	32	37.77	80	26.44
	1200	33	109.39	81	35.56
15	1	34	1.13	82	1.15
	200	35	2.45	83	2.35
	400	36	3.96	84	4.29
	600	37	5.73	85	6.01
	800	38	11.45	86	7.93
	1000	39	21.59	87	15.48
	1100	40	32.74	88	25.27
	1200	41	85.32	89	32.74

continued→

TABLE 2.17 concluded

Proportion of right turns (percent)	Opposing flow (veh/h)	No special phase		Early cut off	
		Run	Right turn factor	Run	Right turn factor
20	1	42	1.15	90	1.16
	200	43	2.20	91	2.25
	400	44	3.23	92	3.44
	600	45	4.94	93	4.62
	800	46	10.13	94	8.72
	1000	47	24.71	95	20.11
	1100	48	35.17	96	26.15
	1200	49	168.18	97	39.18
25	1	50	1.20	98	1.16
	200	51	2.09	99	2.16
	400	52	3.02	100	3.25
	600	53	5.25	101	4.44
	800	54	9.04	102	8.40
	1000	55	30.77	103	18.66
	1100	56	52.45	104	24.06
	1200	57	115.32	105	36.90
30	1	58	1.16	106	1.16
	200	59	2.09	107	2.10
	400	60	2.80	108	2.97
	600	61	4.80	109	4.07
	800	62	8.86	110	7.30
	1000	63	22.60	111	16.10
	1100	64	34.33	112	19.24
	1200	65	149.94	113	26.79

TABLE 2.18 Regression constants

Runs	Ppn. of right turns, percent	a	b	r	F
18- 25	5	+0.130	0.00337	0.99	227.2
26- 33	10	+0.078	0.00312	0.98	185.4
34- 41	15	+0.058	0.00323	0.98	178.5
42- 49	20	-0.162	0.00362	0.96	69.3
50- 57	25	-0.168	0.00365	0.98	115.7
58- 65	30	-0.202	0.00358	0.96	67.3
18- 65	5-30	-0.044	0.00348	0.97	773.8
66- 73	5	+0.302	0.00279	0.93	39.9
74- 81	10	+0.270	0.00272	0.99	1245.7
82- 89	15	+0.232	0.00267	0.99	358.2
90- 97	20	+0.091	0.00285	0.99	380.1
98-105	25	+0.070	0.00281	0.99	391.0
106-113	30	+0.089	0.00258	0.99	415.3
66-113	5-30	+0.175	0.00273	0.98	952.9

TABLE 2.19 Analysis of variance for runs 18-65 (simulated right turning vehicle factors when no special right turning phase is provided)

Source of variation	Sum of squares	Degrees of freedom	Mean square
Between treatments	11 798.8227	5	2 359.7645
Between blocks	43 959.1669	7	6 279.8810
Residual	19 200.8268	35	548.5950
Total	74 958.8614	47	-

F (between treatments) = 2 359.76 / 548.59 = 4.3015(5,35) **

F (between blocks) = 6 279.88 / 548.59 =11.4472(7,35) ***

TABLE 2.20 Effect of starting random number on simulated right turning vehicle factors

Run number	Right turning vehicle factor
114	5.47
115	5.76
116	5.15
117	5.66
118	5.82
119	5.72
120	5.75
121	5.54
122	5.39
123	5.11
Mean	5.537

TABLE 2.21 Confidence limits for mean right turning vehicle factor (derived from Table 2.20)

Confidence level (percent)		Confidence limit
95	upper	5.719
	lower	5.355
99	upper	5.804
	lower	5.260
99.9	upper	5.921
	lower	5.153

TABLE 2.22 Saturation flows (no special right turning phase). Runs 18-65

Opposing flow (veh/h)	Proportion of right turning vehicles (percent)					
	5	10	15	20	25	30
1	3169	3139	3109	3055	2963	2967
200	2854	2641	2537	2488	2440	2353
400	2738	2406	2260	2221	2194	2167
600	2484	2239	2104	2057	1951	1934
800	2223	1947	1861	1832	1807	1781
1000	1908	1808	1745	1702	1666	1670
1100	1929	1750	1691	1676	1641	1647
1200	1759	1676	1638	1621	1620	1611

TABLE 2.23 Saturation flows (9s early cut off). Runs 66-113

Opposing flow (veh/h)	Proportion of right turning vehicles (percent)					
	5	10	15	20	25	30
1	3156	3102	3087	3035	3011	2972
200	2933	2680	2536	2477	2419	2349
400	2702	2460	2238	2208	2164	2131
600	2415	2191	2110	2076	2016	1992
800	2285	2054	1982	1880	1834	1819
1000	2154	1845	1811	1752	1714	1699
1100	1944	1829	1775	1705	1691	1683
1200	1769	1781	1729	1675	1662	1660

TABLE 2.24 Degrees of saturation (no special right turning phase). Runs 18-65

Opposing flow (veh/h)	Proportion of right turns (percent) 5	10	15	20	25	30
1	0.57	0.57	0.57	0.58	0.59	0.59
200	0.61	0.66	0.68	0.70	0.72	0.75
400	0.65	0.75	0.81	0.81	0.85	0.87
600	0.76	0.87	0.96	1.01	1.16	1.20
800	0.89	1.23	1.44	1.59	1.69	1.89
1000	1.38	2.20	2.30	3.23	4.75	4.26
1100	1.64	2.63	3.24	4.41	7.80	6.19
1200	3.39	6.66	7.68	19.37	16.64	25.70
(1.75)	0.58	0.60	0.63	0.65	0.67	0.69

TABLE 2.25 Degrees of saturation (9s early cut off). Runs 66-113

Opposing flow (veh/h)	Proportion of right turns (percent) 5	10	15	20	25	30
1	0.57	0.57	0.58	0.58	0.58	0.59
200	0.60	0.65	0.68	0.70	0.73	0.75
400	0.67	0.73	0.84	0.84	0.88	0.89
600	0.80	0.89	0.99	0.97	1.05	1.08
800	0.93	1.08	1.15	1.43	1.60	1.63
1000	1.07	1.62	1.78	2.71	3.05	3.11
1100	1.59	1.99	2.61	3.39	3.80	3.64
1200	3.24	2.51	3.24	4.86	5.61	4.91
(1.75)	0.58	0.60	0.63	0.65	0.67	0.69

TABLE 2.26 Opposing volume at which saturation occurs

Proportion of right turns (percent)	Opposing volume (veh/h)	
	No special phase	Early cut off
5	835	880
10	700	750
15	600	600
20	560	560
25	500	510
30	460	500

TABLE 2.27 Delays : 15 percent right turning vehicles (all delays in seconds)

Opposing flow (veh/h)	No special phase (runs 34-41)				Early cut off (runs 82-89)			
	Approach arm only		Approach and opposing arm	Per delayed vehicle	Approach arm only		Approach and opposing arm	Per delayed vehicle
	simulated	RRL			simulated	RRL		
1	17.0	11.41	17.0	21.3	14.8	11.55	14.8	18.9
200	15.7	13.09	14.6	18.8	15.0	13.61	14.2	18.4
400	21.6	17.18	18.1	24.9	18.6	19.13	17.2	22.0
600	91.3	53.76	58.4	103.4	37.3	187.58	27.9	42.5
800	1083.1	-	577.2	1214.8	224.9	-	126.5	253.2
1000	1819.9	-	862.7	2010.6	1310.4	-	634.1	1447.0
1100	1998.3	-	891.4	2278.1	1608.6	-	735.9	1811.7
1200	2123.3	-	904.6	2379.2	1749.3	-	1031.6	1958.6

TABLE 2.28 Variation in delay per arrived vehicle on the approach arm with starting random number

Run number	Delay (s)
114	83.88
115	122.37
116	57.79
117	84.78
118	140.90
119	92.17
120	86.32
121	89.29
122	65.89
123	64.67
Mean	88.82

TABLE 2.29 Confidence limits for delay/arrived vehicle (derived from Table 2.28)

Confidence level (percent)	Upper (s)	Lower (s)
95	107.24	70.40
99	115.29	62.35
99.9	127.76	49.87

TABLE 2.30 Delay/veh on approach and opposing arms at saturation

Proportion of right turns (percent)	Delays (s)		
	No special phase	Early cut off	Difference
5	45	26	19
10	84	56	28
15	58	28	20
20	93	29	64
25	84	38	46
30	52	30	22

TABLE 2.31 Comparison of optimum settings computed by different methods

	Cycle time(s)	Effective green N-S	Effective green E-W
RRL recommended method	46	26	4
Using simulated results	71	50	5

TABLE 3.1 Calculation of Car-Following Parameters

Correlation Coefficient	Characteristic Speed	Reaction Time	Observation Time	Weighting Coefficient
	ft/s	s	s	
r	a	T	t	t x r = w
0.87	15.5	0.50	30.00	26.10
0.78	24.8	0.75	8.25	6.43
0.93	33.6	0.50	11.25	10.46
0.89	28.5	0.75	29.00	25.81
0.81	20.0	0.50	21.25	17.21
0.80	16.7	1.00	36.75	29.40
0.83	17.5	0.50	27.50	22.82
0.70	14.3	0.75	65.00	45.50
0.89	18.0	1.00	15.00	13.35
0.76	17.1	0.25	12.00	9.12
0.91	27.6	1.00	6.00	5.46
0.84	17.4	1.00	71.00	59.64
0.78	17.8	0.50	101.50	79.17

Sum of aw = 6374.16

Sum of Tw = 246.2900

Sum of w = 350.47

Average a = 18.18 ft/s

Average T = 0.7027s.

TABLE 3.2 Effective Lengths of Vehicles Queueing at Traffic Signals

Vehicle Type	Effective length (ft.)	Sample Size
Private Car	19.0	160
Commercial Vehicles	36.2	9
Buses	34.4	11
Overall	20.8	180

Table 3.3: Observed Speed Distributions

Site:	Bull Ring	St. Martins Circus
No. of vehicles observed	287	209
Mean speed (ft/s)	4.27	11.89
Standard deviation (ft/s)	1.74	2.67
Coefficient of variation	0.41	0.22
Hourly volume	818	777

TABLE 3.4 Starting Random Numbers Used In Production Runs

Starting Number	Used In Run No.	Starting Number	Used In Run No.
11 279 475 059	101, 140	16 643 616 001	154
31 962 591 479	102, 141	20 153 700 495	155
14 908 445 117	103, 139	11 056 509 687	156
20 467 873 909	104, 143	26 786 306 551	157
26 996 165 535	105, 144	12 419 496 263	158
14 655 268 757	106	10 474 845 881	159
17 537 758 717	107	27 073 607 511	160
16 955 567 199	108	13 553 858 597	161
15 061 593 199	109	21 763 350 257	162
22 981 222 079	135	12 867 358 073	163
32 175 585 749	136	15 510 013 429	164
13 082 701 501	137	20 148 588 451	165
22 358 515 139	145	17 763 713 041	166
23 522 333 129	146	12 720 743 459	167
31 044 969 961	147	13 581 824 761	168
31 997 368 683	148	10 456 504 261	169
22 957 754 249	149	16 925 356 159	170
31 624 309 899	150	24 301 248 601	171
17 379 323 787	151	13 414 389 209	172
13 895 103 741	152	24 517 989 735	153

TABLE 3.5 Effect of Length on Delay (alpha = 18ft/s)

Length of Section (ft)	Run Number	Ave. Delay Per Veh.(s)
600	101	27.40
800	102	66.73
1000	103	130.67
1200	104	99.80
1400	105	149.83

TABLE 3.6 Effect of Length on Delay (alpha = 10ft/s)

Length of Section (ft)	Run Number	Ave. Delay Per Veh.(s)
600	140	3.35
800	141	4.49
1000	139	7.47
1200	143	11.19
1400	144	12.91

TABLE 3.7 Delay Incurred by a Single Vehicle Unable to Weave (Delay in Seconds)

Section Length (ft)	Characteristic Speed (ft/s)	
	10	18
600	18.0	37.8
1000	31.1	62.2
1400	43.2	86.4

TABLE 3.8 Variation in Delay with Characteristic Speed

Run Number	Characteristic Speed (ft/s)	Ave. Delay/ Veh. (s)
171	8	6.25
139	10	7.47
172	12	10.78
135	14	88.90
103	18	130.67
136	22	133.24
137	26	137.85

TABLE 3.9 Variation in Average Delay/Veh. with Volume

Run Number	Volume Per Lane (Veh/h)	Weaving Volume Per Lane (Veh/h)	Average Delay Per Vehicle (s)
106	200	60	5.22
107	400	120	6.92
103	600	180	130.67
108	800	240	118.79
109	1000	300	135.59

TABLE 3.10 Effect of Weaving Volume on Delay. Characteristic Speed = 10ft/s

Run Number	Proportion of Weaving Vehs.		Total Weaving Volume (Veh/h)		Delay Per Veh (s)
	Left Hand	Right Hand	Nominal	Actual	
145	0	0	0	0	6.36
146		0.3	180	166	7.62
147		0.6	360	322	7.73
148		0.9	540	477	10.58
149		1.0	600	523	10.54
150	0.3	0	180	175	6.72
139		0.3	360	302	7.47
151		0.6	540	448	9.66
152		0.9	720	597	10.78
153		1.0	780	695	14.39
154	0.6	0	360	340	8.22
155		0.3	540	475	9.19
156		0.6	720	655	13.55
157		0.9	900	756	106.72
158		1.0	960	803	25.13
159	0.9	0	540	491	10.58
160		0.3	720	660	17.27
161		0.6	900	737	20.96
162		0.9	1080	907	20.26
163		1.0	1140	978	85.76
164	1.0	0	600	525	10.06
165		0.3	780	681	13.39
166		0.6	960	866	20.55
167		0.9	1140	977	38.77
168		1.0	1200	1062	17.29

TABLE II.1 Probits from observed data		
Nominal Lag Size (s)	Proportion Accepted	Probit
2	0.000	-
3	0.152	3.97
4	0.478	4.94
5	0.765	5.72
6	1.000	-

TABLE II.2 Calculations for fit of second line

p	x	y	y-P/Z	1/Z	y^1=y-P/Z+p/Z	w	n	wn
0.000	2	3.127	2.687	14.402	2.687	0.1618	36	5.825
0.152	3	4.002	3.344	4.133	3.972	0.4386	33	14.474
0.478	4	4.877	3.738	2.525	4.945	0.6333	23	14 566
0.765	5	5.752	3.182	3.321	5.722	0.5174	34	17.592
1.000	6	6.627	7.118	-	7.118	0.2284	28	6.395

TABLE II.3 Chi-Squared Test for Fit of Second Line					
x:	2	3	4	5	6
y^1:	2.8487	3.8626	4.8773	5.8920	6.9067
p(e):	0.016	0.127	0.452	0.813	0.972
n(e):	0.576	4.191	10.396	27.642	27.216
n(o):	0	5	11	26	28
					Chi-Squared = 1.0525 (4 d.f.)

TABLE III.1 Probits from observed data

Nominal Gap Size (s)	Proportion Accepted	Probit
2	0.000	-
3	0.014	2.78
4	0.178	4.07
5	0.543	5.11
6	0.885	6.20
7	0.917	6.39
8	1.000	-
9	0.960	6.75
10	1.000	-

TABLE III.2 Calculations for fit of second line

p	x	y	y-P/Z	1/Z	y^{1}=y-P/Z+p/Z	w	n	wn
0.000	2	3.050	2.621	16.881	2.621	0.1427	72	10.2744
0.014	3	3.641	3.091	6.333	3.179	0.3158	72	22.7376
0.178	4	4.232	3.487	3.372	4.087	0.5118	45	23.0310
0.543	5	4.823	3.728	2.549	5.112	0.6289	46	28.9294
0.885	6	5.414	3.609	2.733	6.027	0.5192	26	13.4992
0.917	7	6.004	2.507	4.151	6.313	0.4373	24	10.4952
1.000	8	6.595	-1.860	8.950	7.090	0.2391	26	6.2166
0.960	9	7.186	-19.845	27.433	6.490	0.0944	25	2.3600
1.000	10	7.777	8.102	-	8.102	0.0262	8	0.2096

TABLE III.3 Chi-Squared Test for Fit of Second Line				
x	y'	p(e)	n(e)	n(o)
2	2.6433	0.01	0.72	0
3	3.3949	0.05	3.60	1
4	4.1465	0.20	9.00	8
5	4.8981	0.46	21.16	25
6	5.6497	0.74	19.24	23
7	6.4013	0.92	22.08	22
8	7.1529	0.985	25.61	26
9	7.9045	1.00	25.00	24
10	8.6561	1.00	8.00	8
Chi-Squared = 4.1865 (8 d.f.)				

TABLE IV.1 Probits from observed data		
Nominal Gap Size (s)	Proportion Accepted	Probit
3	0.000	-
4	0.081	3.60
5	0.396	4.74
6	0.514	5.04
7	0.760	5.71
8	0.800	5.84
9	1.000	-

TABLE IV.2 Calculations for fit of second line

p	x	y	y-P/Z	1/Z	y'=y-P/Z+p/Z	w	n	wn
0.000	3	3.351	2.867	9.808	2.867	0.223	206	45.938
0.081	4	3.896	3.274	4.613	3.647	0.403	86	34.658
0.396	5	4.441	3.582	2.935	4.744	0.580	53	30.740
0.514	6	4.986	3.746	2.508	4.765	0.636	35	22.260
0.760	7	5.531	3.501	2.890	5.697	0.574	25	14.350
0.800	8	6.076	2.226	4.480	5.810	0.415	20	8.300

TABLE IV.3 Chi-Squared Test for Fit of Second Line				
x	y^l	p(e)	n(e)	n(o)
3	2.998	0.020	4.12	0
4	3.655	0.090	7.74	7
5	4.312	0.245	12.99	21
6	4.969	0.490	17.15	18
7	5.626	0.735	18.38	19
8	6.282	0.900	18.00	16
9	6.939	0.980	11.76	12
Chi-Squared = 9.4196 (6 d.f.)				

TABLE IV.4 Calculations for fit of third line

p	x	y'	$y'-P/Z$	$1/Z$	$y''=y'-P/Z+p/Z$	w	n	wn
0.000	3	2.998	2.579	-	2.579	0.1311	206	27.007
0.081	4	3.655	3.106	6.152	3.604	0.3222	86	27.709
0.396	5	4.312	3.531	3.180	4.790	0.5343	53	28.318
0.514	6	4.969	3.746	2.508	5.035	0.6364	35	22.274
0.760	7	5.626	3.395	3.038	5.703	0.5529	25	13.823
0.800	8	6.282	1.164	5.687	5.713	0.3428	20	6.856
1.000	9	6.939	7.371	-	7.371	0.1448	12	1.738

TABLE IV.5 Chi-Squared Test for Fit of Third Line				
x	y''	p(e)	n(e)	n(o)
3	2.877	0.017	3.502	0
4	3.596	0.081	9.696	7
5	4.316	0.248	13.144	21
6	5.035	0.516	18.060	18
7	5.754	0.773	19.325	19
8	6.474	0.929	18.580	16
9	7.193	0.986	11.832	12
Chi-Squared = 9.311 (6 d.f.)				

TABLE V.1 Probits from observed data		
Nominal Gap Size (s)	Proportion Accepted	Probit
3	0.000	-
4	0.077	3.56
5	0.308	4.50
6	0.417	4.79
7	0.813	5.89
8	0.852	6.05
9	0.867	6.11
10	1.000	-

TABLE V.2 Calculations for fit of second line

p	x	y	y-P/Z	1/Z	y'=y-P/Z+p/Z	w	n	wn
0.000	3	3.300	2.826	10.633	2.826	0.208	0	0.000
0.077	4	3.829	3.229	4.970	3.611	0.381	13	4.949
0.308	5	4.357	3.557	3.076	4.504	0.548	26	14.240
0.417	6	4.886	3.737	2.528	4.791	0.633	24	15.185
0.813	7	5.414	3.613	2.726	5.829	0.559	32	19.158
0.852	8	5.943	2.718	3.899	6.039	0.458	27	12.379
0.867	9	6.471	6.993	7.384	6.993	0.279	15	4.182
1.000	10	7.000	7.421	-	7.421	0.131	15	1.967

TABLE V.3 Chi-Squared Test for Fit of Second Line				
x	y'	p(e)	n(e)	n(o)
3	2.846	0.016	-	-
4	3.533	0.071	0.923	1
5	4.220	0.218	5.668	8
6	4.907	0.464	11.136	10
7	5.594	0.722	23.104	26
8	6.280	0.900	24.300	23
9	6.967	0.976	14.640	13
10	7.654	0.996	14.940	15
Chi-Squared = 1.768 (7 d.f.)				

TABLE VI.1 Details of hypothetical traffic signal controlled intersection				
Arm:	North	South	East	West
Stopline width (ft)	20	20	15	12
Straight ahead saturation flow (veh/h)	3200	3200	2250	1900
Flow (veh/h)	600	900	120	100
Proportion of right turners (percent)	3	15	5	5
(No left turning vehicles. All vehicles are cars.)				

TABLE VI.2 Comparison of optimum settings by different methods			
	Cycle time(s)	Effective green N-S	Effective green E-W
RRL recommended method	46	26	4
Using simulated results	71	50	5

TABLE VII.1 Purpose of various input conditions	
Run number	Purpose
2-8, 913	To test simulated results against results obtained at test sites
9,17, 124-133	To check on simulated straight ahead saturation flow when no right turns are allowed
10, 134-143	To check the output saturation flow when right turns only are allowed in the right hand lane, with no opposing flow
11	To check the behaviour of the program with an impenetrable opposing flow
12-16	To observe the effect of simulation time on simulated results
17-65	Production runs for the condition where no special right turning phase is provided
66-113	Production runs for the condition where a special right turning phase is provided
114-123	To investigate the effect of varying the starting random number on sim--ulated right turning vehicle factors and delays

TABLE VII.2 Turning proportions		
Run number	Proportion of right turns	Proportion of straight ahead vehicles in the right hand lane
2-8, 913	See Table 2.12	
9	0	0.5
10	0.5	0
11	0.15	0.15
12-16	0.15	0.15
17	0	0.3
18-113	See Table 2.18	
114-123	0.15	0.15
124-133	0	0.3
134-143	0	0.5

TABLE VII.3 Opposing volumes	
Run number	Opposing volume (veh/h)
2-8, 913	See Table 2.12
9	1000
10	1
11	1600
12-16	600
17	1000
18-113	See Table 2.17
114-123	600
124-133	1000
134-143	1000

TABLE VIII.1 Results of investigations into speed generation procedure

Input				Output		
Mean	(Range)	Starting random number	Number of speeds generated	Mean	Standard deviation	Coefficient of variation
30	13	12 345 678 911	10 000	29.94	4.944	0.165
	14			29.94	5.324	0.177
	15			29.93	5.704	0.190
	16			29.93	6.084	0.203
40	19			39.91	7.225	0.180
	20			39.91	7.605	0.190
	20	23 456 789 111		39.98	7.562	0.189
	21	12 345 678 911		39.90	7.986	0.199
50	24			49.89	9.127	0.183
	25			49.89	9.507	0.190
	26			49.98	9.887	0.198
60	29			59.87	11.027	0.184
	30			59.86	11.408	0.190
	31			59.86	11.788	0.197