EXPERIMENT ON PASSENGER CAR AND PEDESTRIAN DUMMY COLLISION

1. Introduction

Of the total number of deaths and injuries in motor vehicle traffic accidents in Japan, those of pedestrians account for 35%, bringing into focus the importance which pedestrian motor vehicle traffic accidents have come to assume of late. Owing to many factors involve in this problem, its technical analysis has lagged behind the measures being taken for occupants protection.

With a view to solving this ploblem as much as possible, we have spent several years on it, conducting a series of experiments. In this experimentation, which we are going to revea; here today, medium-sized motor vehicles and dummy pedestrian representing a whole human figure are brought into collision, and the relationships between the vehicle front form and the impact location of the dummy and their corresponding impact location of the vehicle, and the value of the acceleration which occurs in the collision, etc., are preponderantly studied so as to obtain data in the interest of developing a pedestrian-oriented safety vehicle.

2. Experimental Method

The method of experiments is outlined in Fig.1. For the sake of simpler collision conditions for the experimentation, a dummy is standing facing the vehicle center and it is allowed to be hit. Dummy used is 50 percentiles Japanese adult male, which is held suspended under the condition that the mostly part of his own weight is placed on the ground, and whose magnetic retainer is released as soon as the vehicle come within 0.5m--1m from the dummy, and make it free, then allow it to collide with the central part of the vehicle front. Experimental vehicles--weighting 1,000 kg or less and formed as illustrated in Fig.2--come into collision, with their brake apply at a 0.5g constant level. The impact accelerometers built into its head , chest, pelvis and lower leg, and its trajectry trace by high-speed photography.

3. Experimental results

The impact sustain by a pedestrian can be divided into two stages-- the primary impact which occurs when the pedestrian comes into collision with any possible part of the vehicle and the secondary impact which the pedestrian suffers as he or she is brought into collision with the road surface immediately after the primary impact. The following description will be made on the basis of this bipartite division.(see Fig.3)

3.1 Primary Collision

The correspondences between the location of the dummy and

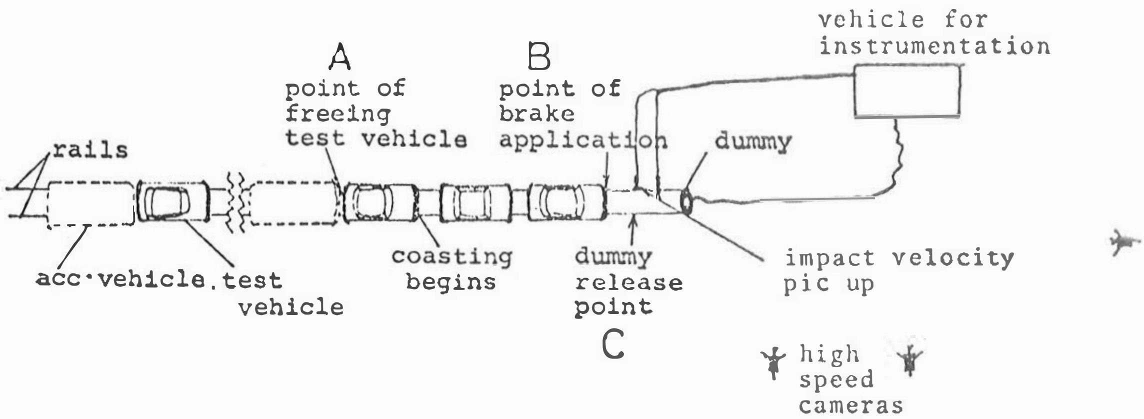

Fig.1 Schematic sketch of the method of expriment

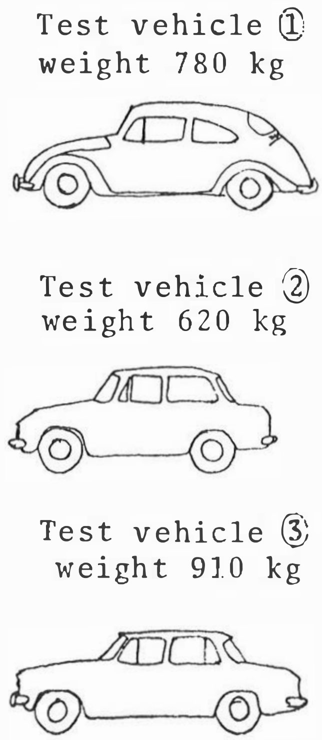

Fig.2 Frontal form of test vehicles

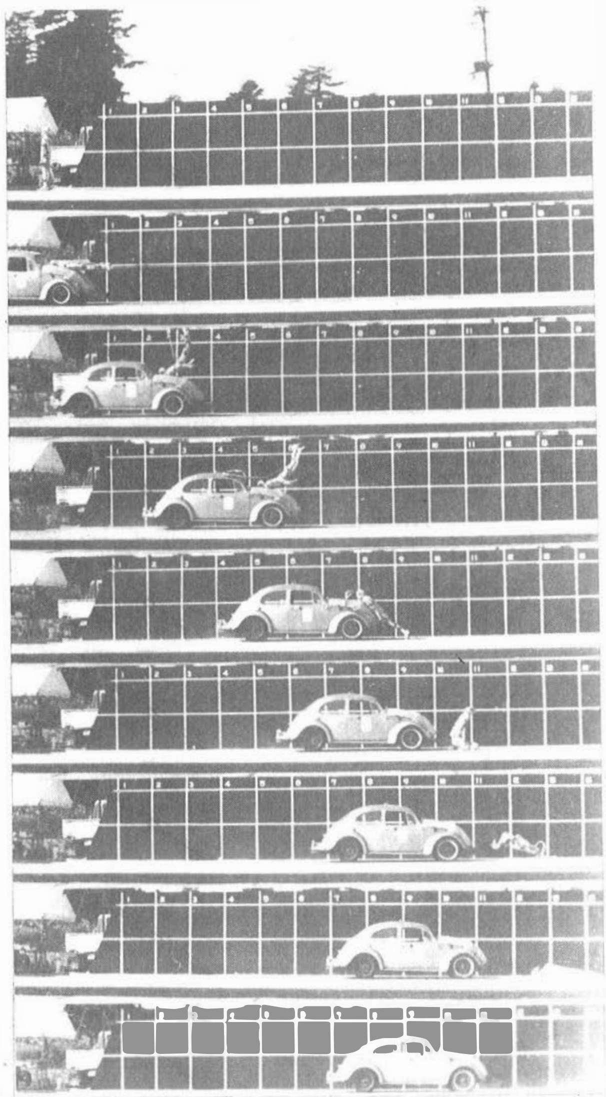

Fig.3 Sequential photo of the dummy behaviour
Test vehicle 1
Impact vel. 41.0km/h

the location of the motor vehicle at the time of a primary collision as obtained in the present experimentation are given in Fig.4. The bonnet has high energy absorption property, and the collision of any area of the dummy body with the bonnet produces low acceleration. For example, at the time of face to face collision, the chest is bound to crush against the bonnet but a peac-G value at this time is 60g or less even if the collision occurs at 40 km/h.(see Fig.5) If this collision takes place against the ventilator region or the windshield glass or other rigid areas of the vehicle, high acceleration is produced. This is by no means lower than the acceleration which results from a secondary collision.(see Fig.6) The head comes into collision not only with the bonnet but occasionally with the ventilator region which results in high peak-G readings. Especialy on smaller vehicle experiments, the head impact almost there.

Therefore, measures against primary collisions are best taken by reducing these rigid regions to a minimum and preventing collision with them as much as possible.

Considering from vehicle front form, the one whose nose region is low (1) has less impact on the human pelvis at the time of a crush, and in relation to impact on the head, too, is more advantageous owing to the head hitting the bonnet in collision at up to 20 km/h. At 30 km/h or more, however the head comesin violent contact with the ventilatorregion, resulting in great impact. Experimentatal vehicle (2) has a generally low and small bonnet, which result in the dummy head dirctly hitting the windowshield glass and sustaining a great impact, bu otherwise is advantageous in shape because of its least impact on the pelvis and little upward kick or fling.

Experimental vehicle (3) is disadvantageous on account of its far larger impact impact on the pelvis than other models, but since the position of the head collision with the vehicle differs little with collision velocity, it is advantageously shaped to enable the establishment of effective countermeasures.

3.2 Secondary Collision

The secondary collision occurs about 700--1200 msec after the primary collision. At this time, the trajectry of the dummy differs according to the impact velocity, the vehicle front form, the mode of brake application and other factors. In this report, forms of falling or dropping are classified into the following four patterns on the basis of the experimental results.

Pattern A: A prone fall in which the leg lands first, with the pelvis, the chest and the head suffering blows. This pattern of falling is called Pattern A.

Pattern B: If the upward kick and the throw-out or hurl are more extensive than in the case of Pattern A, a fall often occurs parallel with the road

	Head	Chest	Pelvis	Lower Leg
Bumper				O 30 ~ 350g
Nose			O 100 ~ 170g	
Bonnet	O 100 ~ 220g	O 25 ~ 75g	O 50 ~ 120g	
Ventilator	O 230 ~ 500g			
Wind Shield	O 200 ~ 400g			

Fig.4 Corresponding impact areas between dummy and vehicle

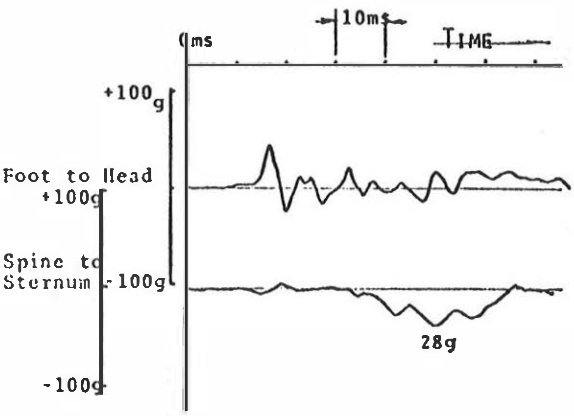

Fig.5

Chest acc. on primary impact
Test vehicle 1
Impact vel. 41.3 km/h

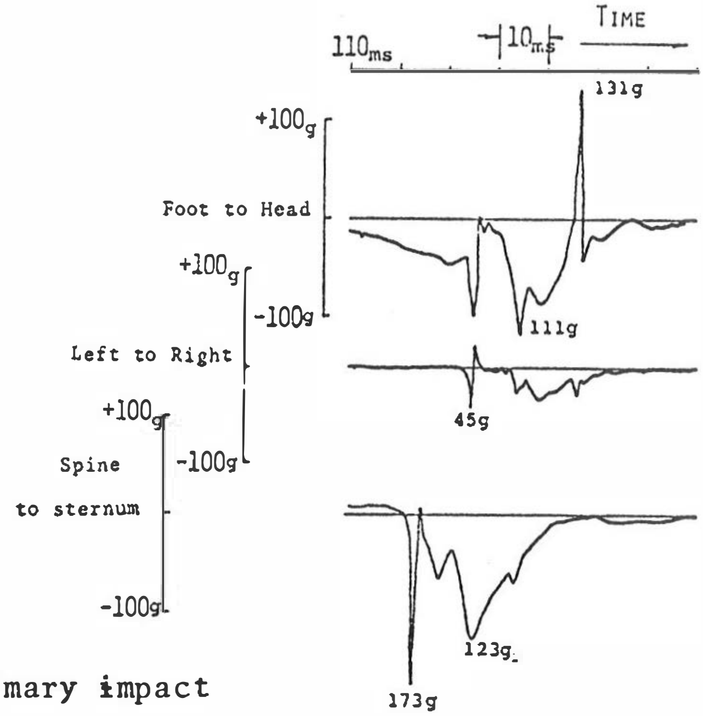

Fig.6 Head acc. on primary impact
Test vehicle 2
Impact vel. 38.1km/h

surface. This is called Pattern B.

Pattern C: Should the upward kick be larger than in the case of Pattern B, a fall occasionally takes place head over heels, with the head landing first. This fall is referred to as Pattern C.

Pattern D: Frequently, a fall is had supinely in a posture the reverse of Pattern A, B and C. This fall is called Pattern D.

The results of the producting vehicles experiments reveal that at a impact velocity at 20 km/h or less, Pattern A results, and at 20--30 km/h, Pattern B is the case, while at 30 km/h or more, the results indicate a trajectory of Pattern C.

Pattern D occurs irrespective of velocities. At 40 km/h, all four Patterns are observed. In this case, the form of a fall on the road surface is identical but the form differ in which the dummy is thrown out or hurled. This we call the Pattern at High Speeds. In order words, the four Pattern of trajectory of a fall are divided into Patterns at Low Speeds and Patterns at High Speeds at the boarderline of about 25 km/h. (Pattern C, however , occurs at speeds higher than 30 km/h and is therefore hard to differentiate.) Fig.7 animates the outline of the patterns of fall.

Secondary collision being a violent contact with a hard road surface, the dummy is likely to sustain large surface pressure at the time of collision, thus making injuries by fall fatal. The acceleration wave form at this time exhibits a sharp rise with short duration time.(see Fig.8 and 9) In primary collisions, the collision locations of the dummy and those of the motor vehicle almost correspond, but in secondary collision, their respective locations of collision differ with each experiment owing to differences in the form of falling.

The most important problem in decreasing injuries is how to decrease the cases of injury on the head. Here consideration is given to the head injuries and forms of falling. In Fig.10, the axis of abscissa represents the maximum acceleration at secondary collision divided by impact velocity as secondary collision coefficient and the axis of ordinate represents frequencies of each patterns. As is clear from this figure, Pattern A is the most advantageous in form of falling. Accordingly, for the sake of cutting injury incidence in secondary collision, it is best to devise a set of conditions in which the form of motor vehicle and the mode of energy absorption, etc.,combine to orient the forms of falling to Pattern A.

Fig.11 illustrates the patterns of falling with respect to each experimental vehicle. Experimental vehicles (1) and (2) assume Pattern A in all of their experiments at 30 km/h or less. With experimental vehicle (3), Patterns B and D are noted. This shows that at 30 km/h or less vehicles (1) and (2) with the nose portion held loely, are more advantageous. To further study this point, experimental vehicle (3) had its front region

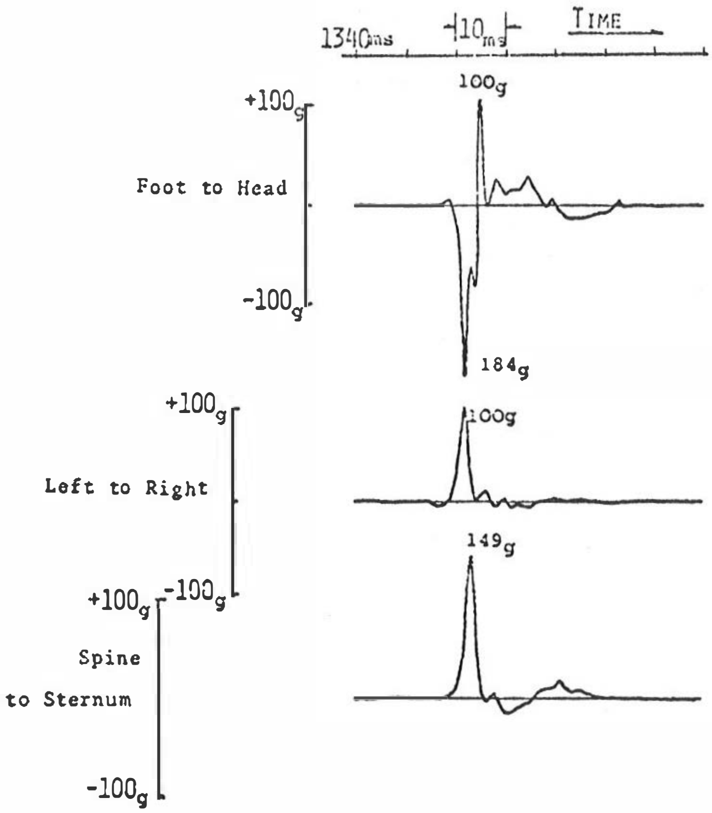

Fig. 8 Head acc. on secondary impact
Test vehicle 3
Impact vel. 13.7 km/h

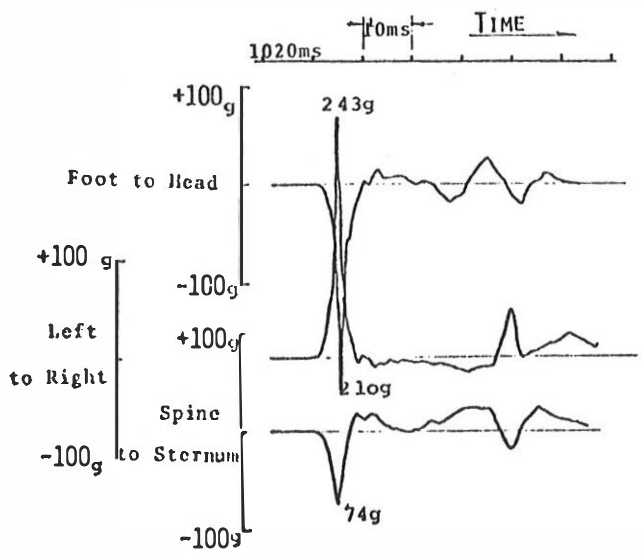

Fig. 9 Head acc. on secondary impact
Test vehicle 2
Impact vel. 36.1 km/h

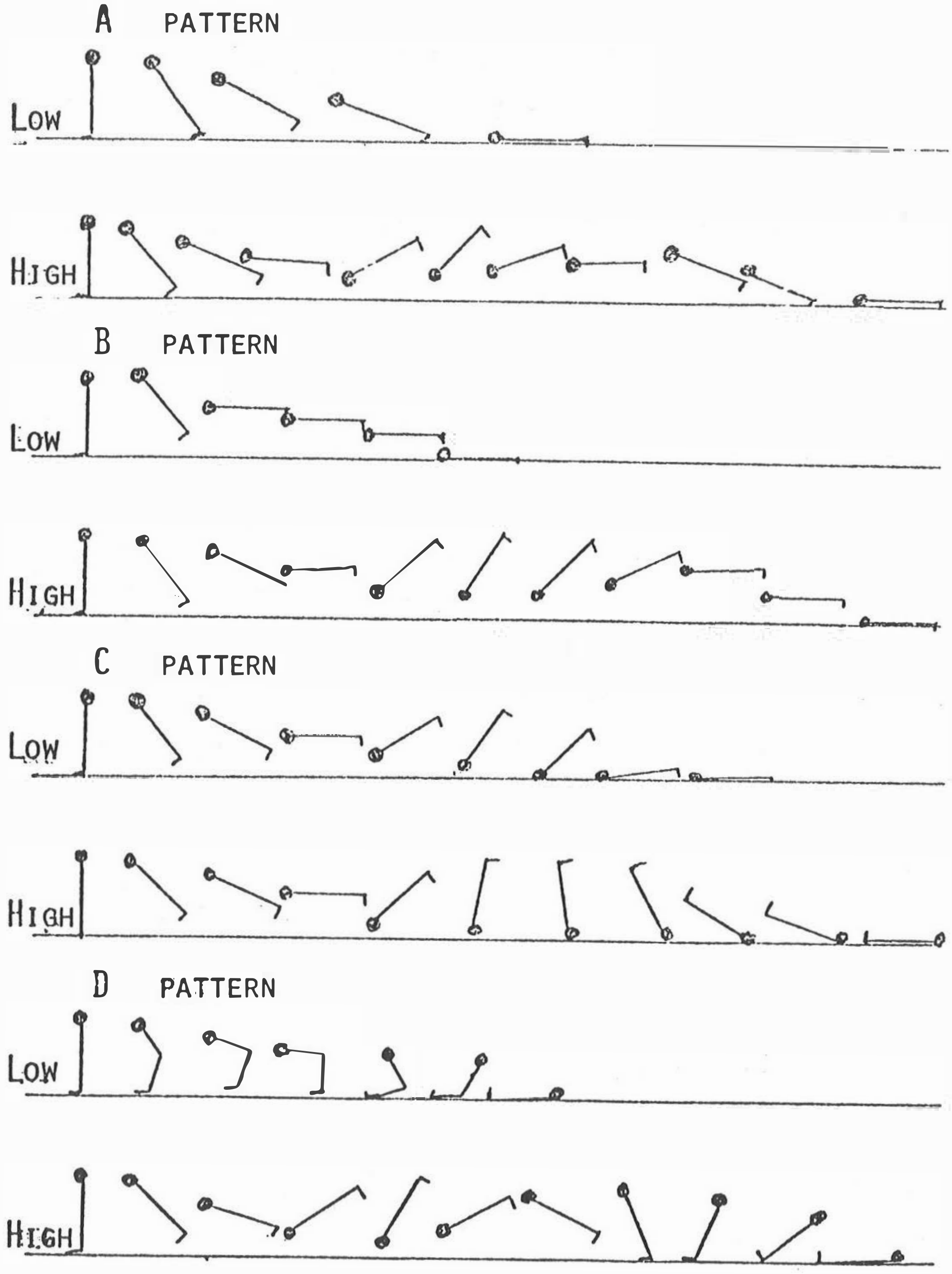

Fig. 7 Sequetial squetch of each pattern

elongated, its nose region lowered to remodeled it to the form of like experimental vehicle (1), and is made into experimental vehicle (3L). As a result, the remodeled vehicle exhibit Pattern A in all of three experiments on it, again demonstrating the preference of low-nosed type (1) of vehicles. At around 40 km/h, there are no significant clear-cut differences between experimental vehicles, and yet Pattern A is occasionally noticed -- a fact indicative of the feasibility of making forms of falling saffer in pattern.

4. Conclusions

Of the impacts sustain by pedestrians, the primary impact and secondary impact can effectively be considered in relation to the collision regions of the vehicle and to the patterns of falling, respectively, in studying vehicle safety factors. For both the primary and secondary impacts, the experimental vehicle (1) with lowly-placed nose is doubtlessly far safer than the other types. For a impact velocity, 25 km/h or so is considered to be a safety limit for the present. Other experimental results are obtained but they are as yet unconvincing, due to the complicated factors which dummy and vehicle have alike. The present series of experiments have hardly covered all of the factors that include vehicular parts dimensions, relative positions, rigidity, impact velocity, degree of brake application and their influences plus dummy rigidity, joint characteristic, its collision attitude and their influences.

These factors shall be duly studied in our future round of experiments, the results of which shall be reviewed in detail to provide data for the development of pedestrian-oriented safety vehicles.

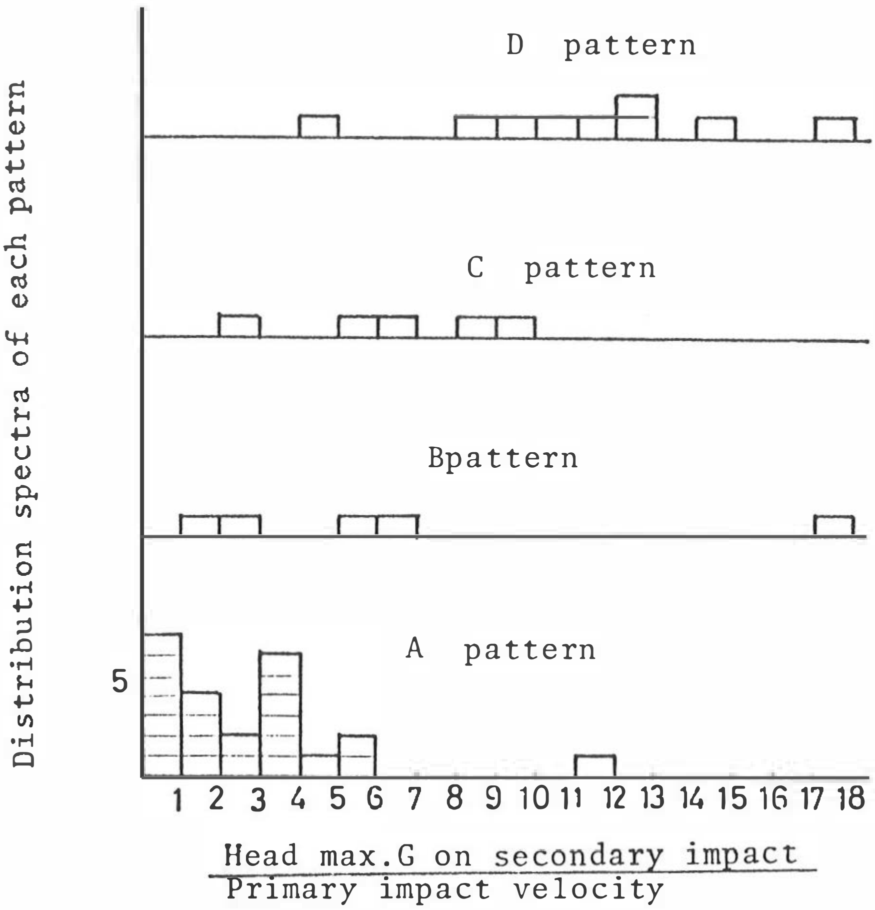

Fig.10 Distribution spectra by Max.G/Impact vel.

Test vehicle 3		D	AA B	B A A C A A D	B D C C
Test vehicle 3L				A A A	
Test vehicle 2			A A	D C D	A
Test vehicle 2L	A	A	A	B A D C D	A
Test vehicle 1		A A A	A	D A A D A	C D D D
Impact vel.	10 km/h	20	30	40	

Fig.11 Pattern distribution of test vehicles