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TRAFFIC ACCIDENT RESEARCH UNIT

DEPARTMENT OF MOTOR TRANSPORT N.S.W.

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The Traffic Accident Research Unit was established within the Department of Motor Transport, New South Wales, in May 1969 to provide a scientific approach to the traffic accident problem.

This paper is one of a number which report the results of research work undertaken by the Unit's team of medical, statistical, engineering and other scientists and is published for the information of all those interested in the prevention of traffic accidents and the amelioration of their effects.

Commissioner.

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ABSTRACT

The dynamic performance of devices that are intended to protect baby occupants of crashing automobiles is examined from an engineering point of view.

Dynamic collision simulations were carried out with "baby" dummies restrained by each of three "baby" restraints that were readily available in Sydney. Further simulations were carried out on some experimental restraints.

Strengths and weaknesses of the various restraints are explored and conclusions reached about the crash protection available to babies in New South Wales.

CONTENTS

INTRODUCTION

As with children in child seats and adults in seat belts, crash protection devices for young babies need to satisfy three criteria to be acceptable on safety grounds

- the device must prevent the child being thrown out on to his head
- it must prevent head impact with the car interior and with rigid parts of the restraint itself
- it must distribute crash forces about the child's body in such a manner as to reduce the potential for injury to a minimum.

Similarly, whilst acknowledging that the baby will have to suffer some restriction on movement by being confined to one part of the car and by wearing or lying in the restraint, a well designed device will minimize the degree of inconvenience and discomfort.

Australian Standard E46-1970(1)† specifies the design and performance details that are required for certification of a child restraint by the Standards Association of Australia. Many restraints have been certified for use by children from 9 kg mass upwards (about 1 year of age) but there is at present no device with SAA-approval* for youngsters below this size. While one might expect babies (in this report, children under 1 year of age) to travel less and therefore to be less represented in the population of passengers of crashing vehicles compared with adults, we believe that they nevertheless form a significant group. In 1972 in New South Wales, 18 children under 5 years of age were killed as passengers in motor vehicles, and 779 were reported to have been injured. We do not know how many of these were under 1 year old, but have assumed that some at least were too young to be usefully protected by child seats. Our initial response to the absence of approved protection for this group has been a study of the methods currently being relied upon to restrain baby passengers. This report presents the results of the study.

Parents are transporting many babies in child seats that only have SAA-approval for use with larger children. While they may offer the best crash protection available for babies at the present time, the restraints

† Numbers in parenthesis refer to the bibliography at the end of the paper

* Devices approved by the Standards Association of Australia to AS E46-1970 are referred to as "SAA-approved" in this paper.

are designed to fit larger children and we believe that they should not be relied upon to properly restrain babies. We know of one fatal ejection of a 7 kg baby who was loosely restrained in a seat approved for 9 to 18 kg children. Tight adjustment of the harness is very important, especially around the shoulders of the young child.

Until they are about 6 months old, babies cannot support their heads, and so cannot comfortably sit in a child restraint. The parents of these younger babies usually either keep their babies away from cars, carry them in their arms, or place them in the bassinets or carry-baskets that are available. Where no transmission tunnel prevents the practice, a carry-basket can be wedged between the car seats, on the car floor. This is not often possible so the basket is then carried on the rear seat. Three restraints without SAA-approval are being sold for restraining these various baskets on the car's rear seat. Being unable to obtain significant accident data about their performance, we decided to append them to the program of tests on SAA-approved child restraints which we have recently conducted and reported upon (2,3).

Our report on child restraints(3) discussed much that is relevant to this report, and the reader is recommended to its more detailed description of test equipment and methods.

Basket Restraints

Apart from accommodating the lying down position that parents prefer for babies, bassinet baskets and carry-baskets also have the advantage of accommodating the arbitrary but determined views parents often hold about whether their baby should lie on his front, back or side, and they also allow parents to take their babies into and out of their cars without distubrance to sleep. These advantages have probably influenced manufacturers of baby restraints towards basket restraints and have left the buyer in Australia no other type of restraint for the newly born.

CRASH SIMULATIONS

The same crash simulator, open rig, and deceleration pulse used for testing SAA-approved child restraints(3) were used to expose basket restraints to simulated collisions. The bench seat of the rig was placed head-on for most of the tests to simulate a head-on collision but was also sometimes faced at 45° to simulate decelerations of a front-corner collision.

Two dummies were specially prepared for the tests. They had torso, head, arms and legs of approximately 50th percentile dimensions and masses for a 3 week and a 6 month old child respectively. These dummies were crude, the "3 week" dummy being a flexible doll stuffed with steel pieces and foam, and the "6 month old" dummy being fabricated from general stores in the laboratory. They performed satisfactorily in spite of their simplicity, and were undamaged by tests in which they were restrained against broad surfaces. The doll was badly damaged in two tests where it was sieved through the mesh of widely spaced webbings covering the top of a basket.

Test Program

The three basket restraints readily available in New South Wales late in 1973 were:

- Micklem 701
- Safe-N-Sound Bassinet Restraint SS101
- Safe-N-Sound Basket Carrier.

Other restraints tested were

- Lap/sash through basket handles
- Modified Safe-N-Sound Bassinet Restraint.

Descriptions of each of these restraining systems are given in Appendices A to D.

Each test was made with straps tightened as far as could be done without undue effort or collapse of the basket. Restraints and baskets were re-used for subsequent tests unless a visual inspection revealed significant damage.

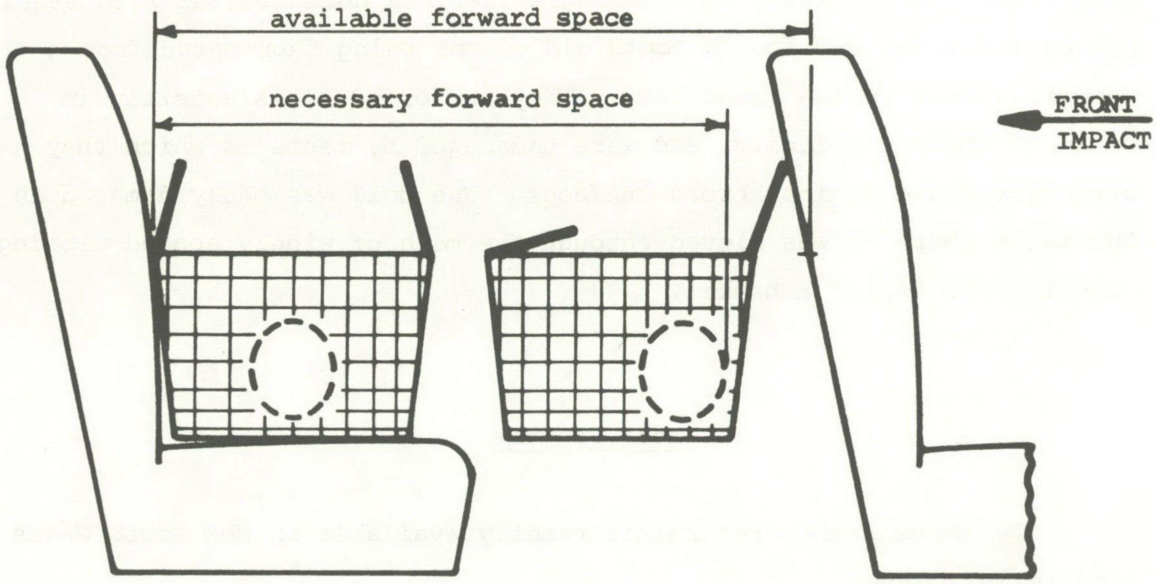


Figure 1a. Forward space

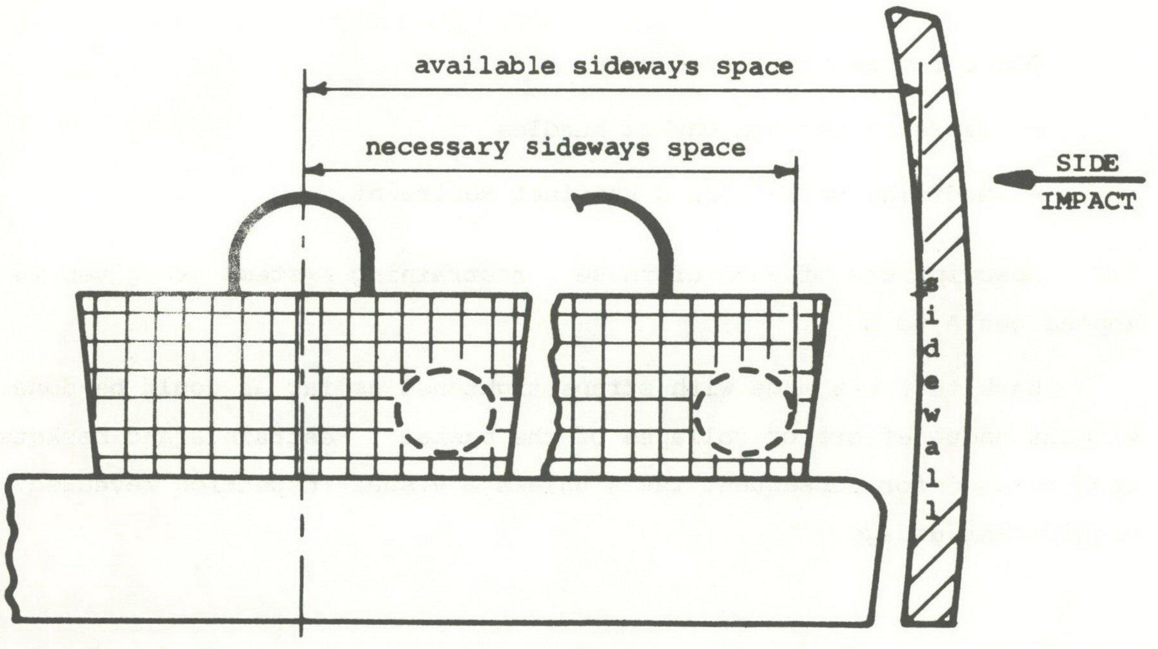


Figure 1b. Sideways space

Test Data

The appendices tabulate the conditions and results of the tests. Dummy movement has been reported in terms of the total space required by the child and his bassinet before and during the collision. The terminology is defined in Figures 1(a) and 1(b). Inspection of the Figures shows that if the necessary space exceeded the available space, the passenger would probably have impacted the interior of the car.

The measurement of space needed during collisions was related to real cars by measuring the space available in the back seat of three car models. The results of these measurements are tabulated in the appendices.

Severe collisions, such as those being simulated in this test program, would not leave many current cars without significant distortion of the passenger compartment. The estimates of "available" space would be optimistic in many such cases.

In head-on simulations, estimates of forwards space requirements were made. No attempt has been made to estimate the need for forwards space during the corner simulations, but estimations of sideways space were made with a camera located so that it faced the bench seat. Compensation was calculated for the component of motion towards the camera during the simulation of front corner collision.

DISCUSSION

In the appendices we discuss features of each of the devices tested for this report. All five of the restraint systems demanded more forwards space than is available in most cars, and hence do not in our opinion protect their passengers against impact (through the unpadded basket wall) with the back of the front seat. The restraint systems all rely upon commercially available baskets, many of which appeared to be of inadequate strength or stiffness, and some of which exposed nails and other sharp protrusions when they were overstressed.

Another unfortunate feature of the three restraints that are readily available was the head-first dive their passenger made into the basket wall when there was a side impact on the head side. Hyperextension of the neck appeared a distinct possibility during some of the corner impacts simulated for this report.

Two of the commercial restraints acted on the basket at car seat level, and consequently tilted and distorted the basket to tip their passenger to the widely spaced straps of the "lid". We believe that the meshes of straps could do serious damage to a young baby. The third of the commercial restraints, the SS101, did not securely attach the bassinet to the car. Having made those criticisms, it must be said that we believe all three restraints contribute something towards keeping their passengers from being ejected out of the car, especially should the car roll. Can anything better be arranged?

Commercial baskets generally, we believe to be too flexible, insufficiently padded and insufficiently strong to provide the crash protection relied upon by the available basket harnesses. A padded and ventilated cocoon with a stiff outer wall can be imagined, however, which would overcome all of the objections discussed above. Ideally it would be connected to the car with a gimbal so that the baby would always press against the cocoon floor. It would also be curved to gently change the attitude of any baby who should slide head first within it. Padding would protect against impact with the car interior.

Our chief objection to the commercial restraints (none of them SAA-approved, it will be recalled) was that they were pivotted at the base of the baskets, with the result that the child dummy was tipped out in our simulated crashes. Baskets should be restrained from their tops, in order to prevent forward rolling. A net is then a useful adjunct to prevent ejection during the much slower rebound phase of any crash.

CONCLUSIONS

Our dynamic tests of the basket restraining system that have been available had led us to believe that passengers of these systems are vulnerable in severe impacts, to trauma from impact with the interior of their cars. We believe that the restraint of the prone baby requires a container which is stiffer, stronger, more gently curved, and better padded than the bassinets and carry baskets that are available in New South Wales. We cannot recommend any of the commercial systems that we have seen.

We are not aware of any device that is suitable for restraining babies in severe crashes. Where possible the child should be placed in a basket which should be jammed between the seats, preferably with a net tied over the tops. If this is impracticable, the basket should be stood on the rear seat and lashed to the floor and parcel shelf, using an existing lap/sash belt where available.

We are carrying out further research in an attempt to develop better approaches to the crash protection of babies, including the possible development of special restraining vests.

REFERENCES

1. Standards Association of Australia, "Child Restraining Devices for Passenger Cars." Australian Standard E46 - 1970.

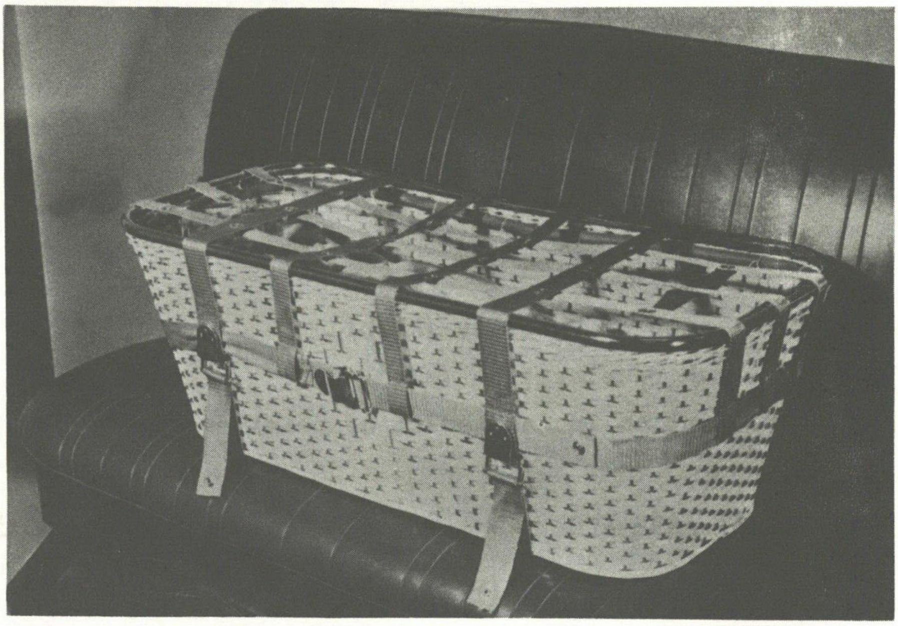
2. David C. Herbert, Brian A. Vazey, James M. Wyllie, Rodney G. Vaughan, Vladimir Leitis, "Evaluation of Australian Child Restraints", Paper 730972, Seventeenth Stapp Car Crash Conference, Oklahoma , 1973.

3. David C. Herbert, Brian A. Vazey, James M. Wyllie, Vladimir Leitis, Rodney G. Vaughan "Child Protection with Adult Belts and Approved Child Restraints", Traffic Accident Research Unit, Department of Motor Transport New South Wales, Draft Report, November 1973.

APPENDIX A

MICKLEM 701 BASSINETTE RESTRAINT

Photograph



TARU Negative 400-13

Description

Basket enclosure constructed of a mesh of webbings that terminate on a steel bar. The bar connects to an adult lap belt.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON BABY RESTRAINT

Restraint Type: Micklem Baby Safe Bassinnette Harness Model 701

Test			
Collision Aspect	Head-on		
Age Represented by Dummy (weeks)	3	26	3
Bassinet (B) or Carry Basket (C)	B	B	C
Test Number	73139	73138	73146
New Restraint Sample?	No	No	No
Sled Deceleration			
Change of Velocity (km/h)	38.3	40.0	38.3
Peak Deceleration (m/s^2)	165	174	165
Duration (ms above 10% of peak)	99	99	100
Space Required	Forwards		
Head and Torso (m)	0.99	1.04	0.90
Space Available (m)			
Morris Mini De-Luxe	No lap belt available		
Volkswagen 1600 Superbug	No lap belt available		
Ford Falcon	0.58		

Comments

The Micklem Baby Safe Bassinette Harness Model 701 is connected to the middle of the rear seat of larger vehicles by an adult lap belt. Whilst called a "Bassinette" restraint, it was illustrated on the package restraining a carry basket, and so tests were performed with both.

The low level of lap belt anchorages, and attachment of the lap belt at the lower edge of the bassinet, allowed the upper part of the bassinet to move further towards the collision than the floor of the bassinet. The floor tilted during collision, the bassinet crumpled to a diamond cross-sectional shape and the passenger spilled towards the mesh of webbing that covers the top of the bassinet. A similar effect was produced with a carry basket.

Whilst total ejection of the passenger was prevented by the mesh, we believe that the random location of loads to the passenger from widely spaced webbings is hazardous. Measurements of the excursions indicated that the passenger would have impacted the back of the front seat in most cars.

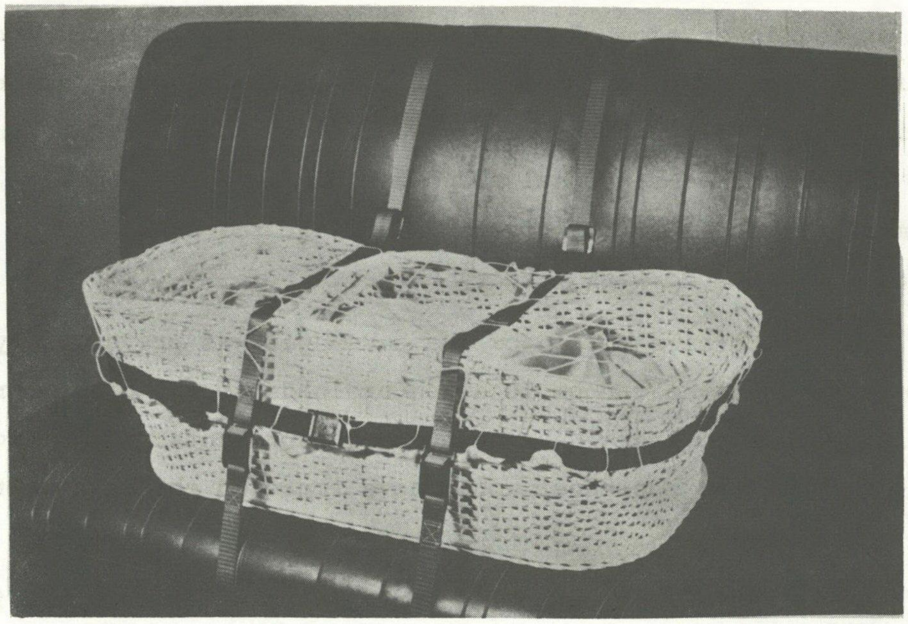
One of the webbings forming the lid of our sample was improperly sewn, and fell apart during installation. Whilst the particular loop was not important during these tests, a need for control of stitching quality is indicated.

Measurements indicated relatively little slip at any of the adjusters.

APPENDIX B

SAFE-N-SOUND BASSINET RESTRAINT SS101

Photograph



TARU Negative 403-4A

Description

Two straps each of which anchors to the car at three points and pass right around a basket. Pram net is an optional extra, but is sometimes sold as part of the system. The horizontal strap shown in the photograph was an addition provided by us for test 73140 only.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON BABY RESTRAINT

Restraint Type: Safe-N-Sound Bassinet Restraint model SS101 and Pram Net.

Test			
Collision Aspect	Head-on		
Age Represented by Dummy (weeks)	3	26	3
Bassinet (B) or Carry Basket (C)	C	C	B
Test Number	73148	73149	73140
New Restraint Sample?	No	No	Yes
Sled Deceleration			
Change of Velocity (km/h)	40.6	39.5	42.8
Peak Deceleration (m/s^2)	175	170	189
Duration (ms above 10% of peak)	99	99	98
Space Required	Forwards		
Head and Torso (m)	0.75	0.86	0.81
Space Available (m)			
Morris Mini De-Luxe		0.54	
Volkswagen 1600 Superbug		0.54	
Ford Falcon		0.58	

Comments

The Safe-N-Sound Bassinet Restraint model SS101 holds a bassinet or carry basket to the vehicle with a pair of straps. Our sample was sold with a pram net which we placed over the top of the baskets of tests 73148 and 73149. For test 73140 we threaded a substantial strap through the perimeter of the pram net to increase its prospects of restraining a passenger if spilled by the bassinet.

Each of the two straps of the restraint starts at an anchorage on the parcel shelf, runs down the back of the seat to the floor behind the seat, runs across the seat to the floor in front of the seat, and then runs up the front of the basket, and across the top of the basket to terminate near the middle of the section which runs down the seat back. The terminations to this strap slipped badly in all tests, 358 mm of slip being noted for the left strap during test 73149. The anchorages on the floor in front of the seat also slipped, and the slippages resulted in the basket and bassinet each moving sufficiently to allow impact of the passenger, through the basket wall, with the back of front seats in most cars.

The passenger remained inside the basket in each of the three tests. The stiff upper frame of the bassinet spread the forces from the straps and presented a flatter side for the baby to crash into.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON BABY RESTRAINT

Restraint Type: Safe-N-Sound Bassinet Restraint modified by us to prevent slippage, with pram net added by us, and secured with strong strap threaded through perimeter.

Test

Collision Aspect	Head-on	Left front corner
Age Represented by Dummy (weeks)	26	3
Bassinet (B) or Carry Basket (C)	B	B
Test Number	73142	73164
New Restraint Sample?	Yes	Yes

Sled Deceleration

Change of Velocity (km/h)	39.1	40.9
Peak Deceleration (m/s^2)	171	177
Duration (ms above 10% of peak)	99	99

Space Required	Forwards	Side
Head and Torso (m)	0.84	0.71

Space Available (m)

Morris Mini De-Luxe	0.54	0.55
Volkswagen 1600 Superbug	0.54	0.64
Ford Falcon	0.58	0.76

Comment

The modified bassinet restraint required much more forwards space than is available in most cars. When tested in the forwards direction, it split the bassinet to expose a menacing row of nails, indicating that bassinet restraints should be kept to suitably constructed bassinets.

The corner collision simulation resulted in the bassinet sliding 340 mm along the seat squab and almost escaping from the right strap. We believe that the passenger would have impacted the car side through the wall of the bassinet in a smaller car.

APPENDIX C

SAFE-N-SOUND BASKET CARRIER

Photograph

TARU Negative 400-37

Description

Plastic tray holding 8 straps that envelope the basket and connect to a plastic peg.

The plastic tray connects to the car floor behind and in front of the seat with two straps.

SUMMARY OF RESULTS OF DYNAMIC TESTS ON BABY RESTRAINT

Restraint Type: Safe-N-Sound Basket Carrier.

Test	
Collision Aspect	Head-on
Age Represented by Dummy (weeks)	3
Bassinet (B) or Carry Basket (C)	C
Test Number	73152
New Restraint Sample?	No
Sled Deceleration	
Change of Velocity (km/h)	39.6
Peak Deceleration (m/s^2)	171
Duration (ms above 10% of peak)	99
Space Required	Forwards
Head and Torso (m)	0.98
Space Available (m)	
Morris Mini De-Luxe	0.51
Volkswagen 1600 Superbug	0.53
Ford Falcon	0.56

Comments

The Safe-N-Sound Basket Carrier could only be used with carry baskets because of the limited size of its moulded base. Connection of the base to the car floor is achieved by two straps through which the base may slide during collision. The floor of the basket is partially held to the base by its edges, but the top of the basket is not restrained against horizontal movement, and so distorted during collision to tip the passenger against the straps that converge at the centre of the top of the basket. We believe that the uncontrolled location of webbing loads from widely separated straps is hazardous and that ejection of the passenger would be possible through the spaces between the straps.

Movements of dummies, as measured from the cinematographs, indicated to us that the passenger could impact the rear of the front seat of most cars.

The locking peg of the restraint tore the webbing to which it was attached, but did not completely separate from it. The largest measure of adjuster slip was 27 mm at the right front floor anchorage.

APPENDIX D

LAP/SASH THROUGH BASKET HANDLES

Photograph

TARU Negative 400-04

Description

An adult lap/sash belt was taken through one of the handles of a carry basket. That handle was slipped through the other handle to keep the basket top "closed".

SUMMARY OF RESULTS OF DYNAMIC TESTS ON BABY RESTRAINT

Restraint Type: Lap/sash threaded through basket handle.

Test		
Collision Aspect	Head-on	Left front corner
Age Represented by Dummy (weeks)	3	3
Bassinet (B) or Carry Basket (C)	C	C
Test Number	73150	73165
New Restraint Sample?	No	No
Sled Deceleration		
Change of Velocity (km/h)	40.2	38.8
Peak Deceleration (m/s^2)	175	166
Duration (ms above 10% of peak)	99	100
Space Required	Forwards	Side
Head and Torso (m)	Not analysed	
Space Available (m)		
Morris Mini De-Luxe	Difficult to fit	
Volkswagen 1600 Superbug	0.47	0.43
Ford Falcon	0.56	0.42

Comment

The use of a lap/sash belt to restrain a basket was an attempt to restrain a child against the floor of his basket during the collision. This was achieved in the head-on simulation, but appeared to use a great deal of space. The corner simulation exceeded the strength of the basket handle and the basket and its passenger flew off the rig.

Significant damage was done to the basket in both tests, indicating a need for a stronger capsule to contain even a 3 weeks old baby.

An attempt to restrain a basket with a lap/sash belt enveloping the basket was abandoned when the belt was found to be too short.