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CONTROL OF BODY NOISE FROM COMMERCIAL VEHICLES

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1. INTRODUCTION

Body noise from commercial vehicles arises when impacts occur between parts of the body, suspension and chassis. The forces in the vehicle structure causing the impacts occur principally when these vehicles travel over uneven road surfaces. The Department of Environment, Transport and the Regions (DETR) receives many complaints from members of the public disturbed by high levels of body noise from single vehicles.

A possible method of control is to ensure that the road surface is in a good condition with an even longitudinal profile. The dynamic forces generated through the axles of vehicles running on the surfaces would then be minimised. Such an approach would help to alleviate the problem but the maintenance of all roads to a good and safe standard is already a principal objective of all highway authorities. Consequently, with finite resources, it is not possible to entirely eradicate small irregularities on road surfaces. It is important therefore to consider what can be done to the vehicles themselves to help reduce the incidence of vehicle body noise in the community.

In response to this, the DETR commissioned the Transport Research Laboratory (TRL) to carry out a programme of research to investigate the sources and control of vehicle body noise. In 1996 an advisory group was set up with a remit of developing a guide to the best practice for controlling this type of noise nuisance. The group comprised representatives from the vehicle and body manufacturers, operators associations, and operating engineers. The group was chaired by the TRL, who were responsible for producing the Guide. A consultation draft has now been produced which will be circulated to groups within the vehicle industry trade associations and other interested organisations for comment.

Once published, the Guide is intended to provide advice on the control of vehicle body noise for all those responsible for the design, manufacture, maintenance and use of commercial vehicles. This Paper summarises the main sources of body noise and briefly outlines *some* of the noise control measures described in the Guide relating to the design and maintenance of commercial vehicles. Aspects of vehicle operation relating to body noise generation are also discussed in the Guide, but are not included in this Paper.

2. SUMMARY OF BACKGROUND RESEARCH

The development of the Guide was based on studies of vehicle body noise carried out by TRL between 1993 and 1995. Measurements of body noise were mainly taken on the TRL test track although measurements of noise were also made at a roadside location where body noise had been a cause of complaint by a local resident.

To establish the typical sources of body noise, 14 different vehicles were tested as individual case studies. The sample included a range of body types and suspension designs some of which were thought likely to cause body noise. Each vehicle was driven at various speeds over different test surfaces on the TRL test track. The surfaces used included road sections where an irregularity had been deliberately constructed. The irregularities used were a trench and a ramp; the profile dimensions are shown in Figure 1. The dimensions of these road surface irregularities were based on survey data from previous TRL studies [1,2]. The surfaces were intended to be representative of irregularities that might be encountered on public roads. A section of track with a smooth longitudinal profile was also used for comparison to provide baseline noise levels. For each drive-by, a time history of the A-weighted noise level was recorded at a reference distance of 7.5m from the centre of the vehicle. The likely sources of body noise were observed at the track-side and noted.

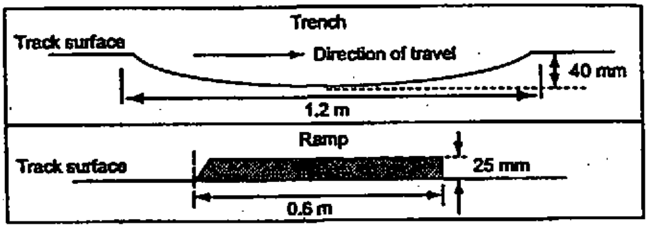

Fig. 1 Dimensions of test profiles

Maximum levels of body noise generated by the vehicles travelling over the uneven surfaces were found to be greater, by between 5 to 25 dB(A), than the corresponding noise levels generated over the smooth, reference surface. In several of the cases examined the overall levels of body noise measured at the track-side were between 100 and 110 dB(A)[1]. Clearly, at the highest levels encountered these noise levels would be painful to the listener and, if occurring in practice, could startle and cause severe disturbance to pedestrians, residents etc.

To aid the identification of the noise sources a specially developed set of drum rollers was also used. Each vehicle was operated statically with its drive axle mounted on the rollers. Profiled battens attached to the rollers simulated undulations on a road surface causing vertical forces to act through the vehicle suspension, chassis and body. With the drive wheels rotating slowly causing repeated generation of body noise, it was possible to locate the various sources of the noise. Where possible, remedial treatments were applied to each noise source individually followed by repeat measurements of drive-by noise on the test track to monitor the effect. In this way, the relative contribution to overall body noise from each source was established.

From the vehicle case studies, the most commonly occurring causes of body noise were categorised into separate source groups. The following list of typical body noise sources is arranged in approximate rank order of most significant to least significant contributor to body noise generation (i.e. noisiest to quietest).

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[1] Measured using fast response time weighting.

- Suspension noise generated by metal-to-metal impacts
- Impact noise associated with the movement of tipper bodies (or demountable containers and bodies).
- Rattles caused by poorly fitting doors and locking mechanisms.
- Impact noise caused by movement of lifting gear mechanisms, hydraulic rams etc.
- Rattles caused by loose fittings and fastenings.
- Rattles produced by unsecured chains, equipment, tools etc.
- Vibration of body panels.

The highest levels of body noise generally occurred when the vehicles passed over the uneven test surfaces unladen. This was most noticeable for commercial vehicles fitted with steel leaf suspensions. However, loading was also found to affect other mechanisms of body noise generation such as movement of tipper bodies.

3. CONTROLLING COMMERCIAL VEHICLE BODY NOISE

The following sections briefly summarise some of the vehicle design and maintenance recommendations given in the Guide to minimise the generation of body noise.

Suspension systems

Figure 2 shows a typical steel leaf suspension system used on many commercial vehicles. The areas where noise is generated are numbered in order of their relative contribution to overall body noise. Impact noise caused by movement of the spring ends (sources 1 and 2) is by far the most significant noise generating mechanism associated with this type of suspension system.

The use of steel leaf suspension with large clearances between the rear of the main springs and their slipper seats will inevitably give rise to impact noise, especially when the vehicle is unladen. If the vertical load on the main springs is briefly removed, such as when the vehicle traverses an uneven section of road, the spring ends may momentarily lose contact with the slipper seats. If, during this movement, the axle drops a sufficient distance relative to the chassis, the spring ends may strike against the retaining pins causing impact noise. An instant later when the vehicle weight descends onto the suspension, the spring ends will re-connect with the slipper seats generating impact noise. If the vehicle passes over a series of discontinuities in the road surface this can lead to a rapid succession of impacts as the suspension is excited through cycles of deflection. The noise problem is exacerbated if the vehicle has a number of axles fitted with this type of suspension.

The helper springs act to stiffen the suspension when the vehicle is heavily laden. Under lighter loads the helper springs are not in contact with their brackets. When sufficiently large deflections of the main suspension occur, impact noise is generated when the helper spring ends strike the brackets.

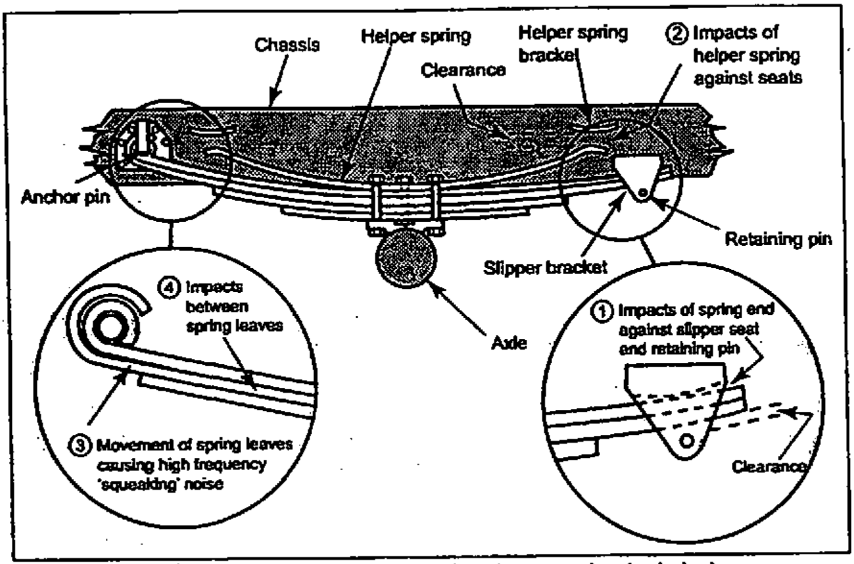

Fig. 2 Noise from typical steel leaf suspension (unladen)

Figure 3 shows an example of an alternative steel leaf suspension design that avoids many of the problems associated with the conventional design. A swinging shackle at the rear mounting of the leaf spring eliminates the metal-to-metal impacts that occur with the slipper seating. The helper spring, which bears against the main spring, is fitted with compliant blocks isolating the metal surfaces during large deflections of the suspension.

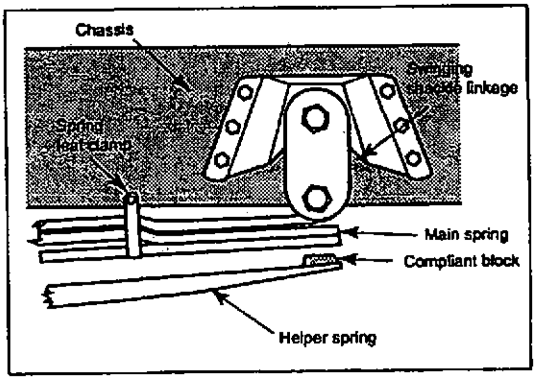

Fig. 3 Example of helper spring fitted with compliant block to control impact noise

Air and rubber suspension systems are not prone to the noise generation problems associated with many designs of steel leaf suspension. Also, the dynamic forces transmitted to the vehicle body via air suspension are generally less than is the case with equivalent steel leaf suspension, especially when the vehicle is unladen. Consequently, sources of body noise are not excited to the same extent.

Tipper bodies

Figure 4 indicates the main sources of body noise characteristic of tipper bodies. The main causes of body noise are associated with movement of the tipper body relative to the vehicle chassis. This results in impacts between the underside of the body and the chassis rails. If the tipper pivot bar is worn, impacts will also occur within the tipper hinge. Other sources of body noise caused by movement of the tipper lift gear and rear doors will be discussed as part of other sections in this Paper.

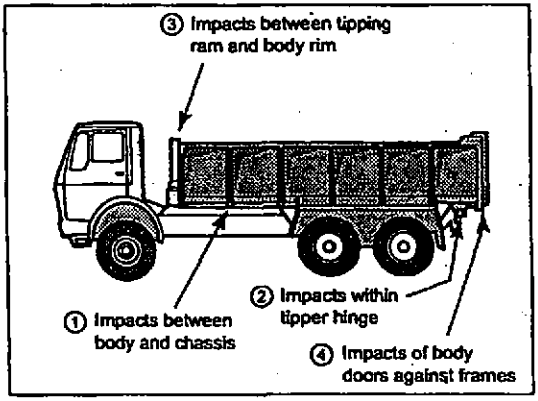

Fig. 4 Tipper body noise sources

To avoid high levels of impact noise caused by movement of the unladen tipper body it is essential that a hard-wearing compliant material is attached to the body or chassis rails to prevent metal-to-metal contact. If lateral guides are fitted to centralise the body as it comes to rest on the chassis, metal-to-metal contact between the guides and the body should also be avoided. Some builders of tipper bodies now attach rubber isolating pads as standard to control impact noise. For vehicles already in-service, missing or damaged materials intended to absorb such impacts should be replaced.

Vertical movement of the tipper body can be reduced by clamping the body to the chassis which will decrease the impact forces when the vehicle is driven over an uneven road surface. Proprietary devices are available which firmly clamp the tipper body onto the chassis when the body is lowered. Such clamps automatically release when the tipping gear is operated to raise the tipper body. Restraining the tipper body can also be expected to reduce wear of the tipping hinge and other components. Installation costs are significantly reduced if clamps are attached when the body is initially fitted to the vehicle, although clamping devices can also be retro-fitted to some vehicles.

Impact noise generated by the tipping hinge occurs as a result of clearances between the pivot bar and its associated bushes. This problem increases as the components wear. Pivot hinges should ideally be designed in such a way as to minimise wear. This may require the use of hardened bearing materials or more effective lubrication systems (e.g. grease seals to retain lubricant in the bushes). The use of suitable metal/rubber bushes may also be considered as a means of absorbing the forces in the hinge which cause wear when the vehicle is in motion.

Doors and fastenings

Various causes of body noise from doors and fastenings are shown in Figure 5.

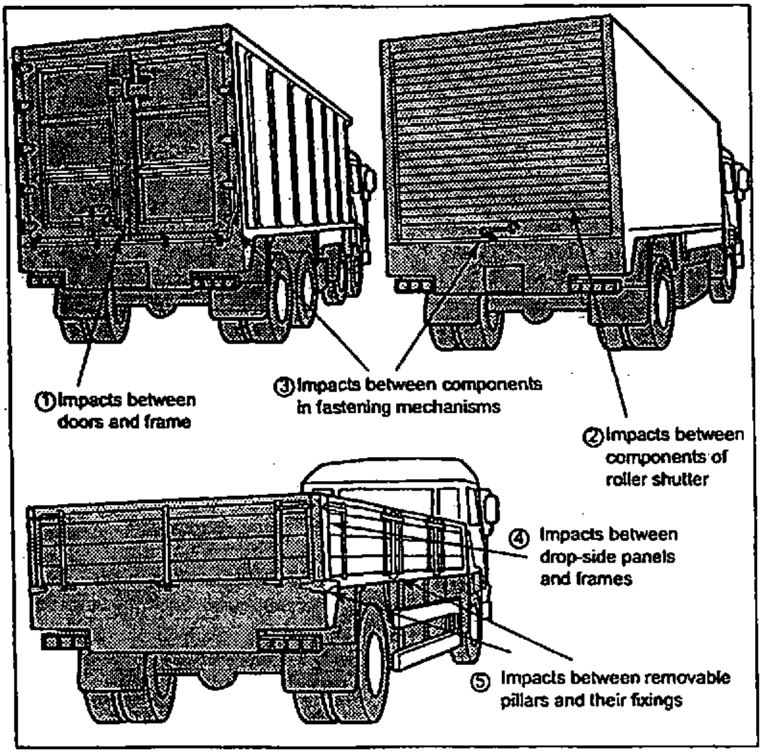

Fig. 5 Noise from doors and fastenings

Where possible, compliant material should be fixed between the contact faces of doors and frames to minimise any clearances and prevent movement of the doors when closed. Should any movement of a closed door occur, perhaps as a result of damage to the fastening mechanism or distortion of the door, the material will absorb some of the impact force. These measures will be particularly effective if the compliant material prevents metal-to-metal contact between rigid metal doors (or drop-side panels) and their frames.

Door fastenings should operate not only to secure the door but to prevent any movement of the door against the frame despite any wear of the components. In the case of tipper bodies, an additional screw thread fastening can be fitted to metal tailgates to tighten the door firmly against the frame.

Lifting gear

Lifting gear, such as tipping rams, tail lifts and cranes, should be firmly restrained when the vehicle is in motion. This is particularly important when the components become worn. The greater the mobility of the stowed gear, the larger the impact forces will be between components. Wear of the mechanism caused by the motion of the vehicle will also be minimised if the lifting gear is immobilised. Where impacts are likely to occur, metal-to-metal contact should be prevented by using a compliant material to isolate the components. As an example, Figure 6 indicates potential areas of noise generation from a front end tipping gear mechanism.

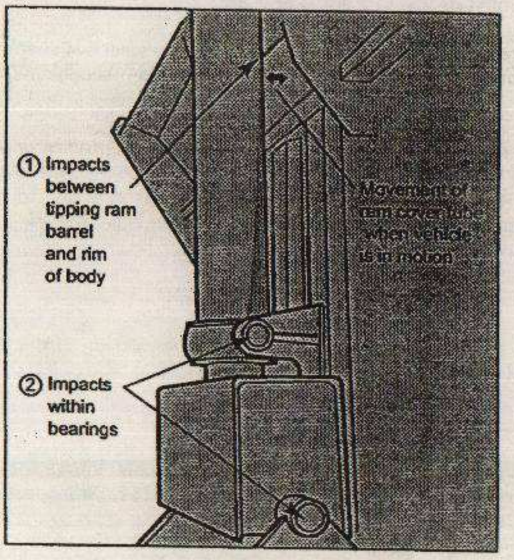

Fig. 6 Tipping gear noise sources

The clearance between the tipping ram cover tube and the tipper body should be sufficient to avoid any contact between the two when the vehicle is in motion. The backward and forward movement of the tipping ram will become greater as the various bearing components wear. Movement of the cover tube can be controlled by fitting a compliant ring around the base of the cylinder to seat the tube on the cylinder when the tipping ram is lowered. As a temporary measure to reduce noise from worn, front end tipping gear, a compliant material might be attached either to the tipping ram cover tube or the front of the tipping body to prevent metal-to-metal contact.

Loose fittings

Loose equipment should be restrained sufficiently firmly to prevent any movement of the items against their fixings that may cause impact noise. For certain fittings or accessories, (e.g. folding or sliding metal ramps on car transporters) it may not be feasible to entirely eliminate all movement of the components when the vehicle is travelling. It may, however, be possible to prevent metal-to-metal impacts by fitting compliant material to isolate the contacting surfaces.

4. CONCLUSIONS

1. Tests carried out at the TRL test track and at the roadside showed that when the road surface has an uneven profile vehicle body noise can contribute significantly to overall levels from commercial vehicles.

2. In the worst cases examined, body noise raised the overall levels by 25 dB(A) with total noise then reaching nearly 110 dB(A) at 7.5m.

3. The main sources of body noise were associated with steel leaf suspensions, tipper bodies, poorly fitting doors and locking mechanisms, lifting gear mechanisms, and loose fittings and fastenings.

4. A consultation draft of a guide to best practice for the control of commercial vehicle body noise has been produced. The Guide was developed by TRL with the support of a vehicle industry advisory group. Once published, the Guide is intended to provide advice on the control of vehicle body noise for all those responsible for the design, manufacture, maintenance and use of commercial vehicles.

5. ACKNOWLEDGMENTS

The work described in this Paper is reproduced with the permission of the Vehicle Standards and Engineering Division of the DETR.

6. REFERENCES

1. G.R. Watts, 'Case Studies of the Effects of Traffic Induced Vibrations on heritage buildings', Transport Research Laboratory Research Report RR156. Transport Research Laboratory, Crowthorne, UK, (1988).

2. G.R. Watts, 'The Effects of Traffic Induced Vibrations on heritage buildings - Further Case Studies', Transport Research Laboratory Research Report RR207. Transport Research Laboratory, Crowthorne, UK, (1989).

7. DISCLAIMER

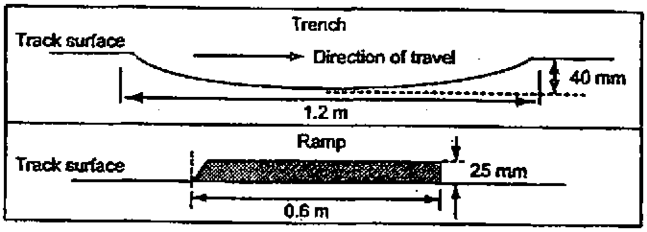

Fig. 1 Dimensions of test profiles

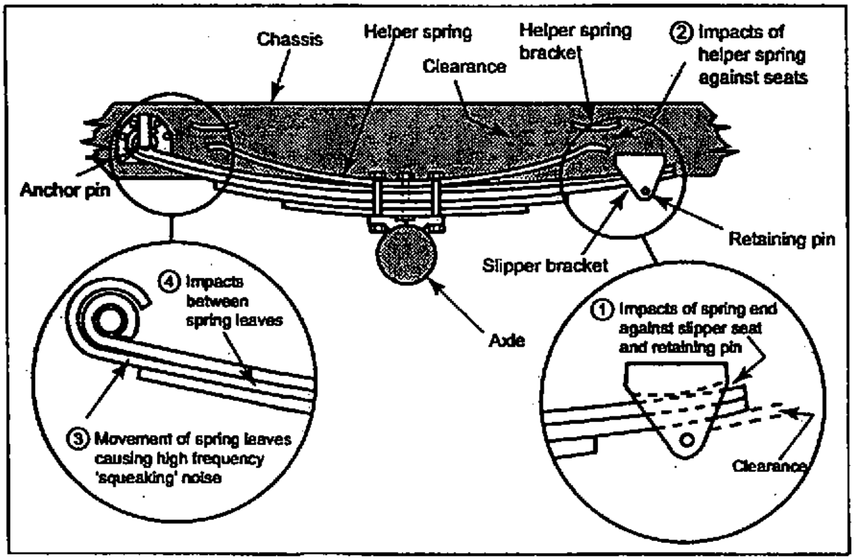

Fig. 2 Noise from typical steel leaf suspension (unladen)

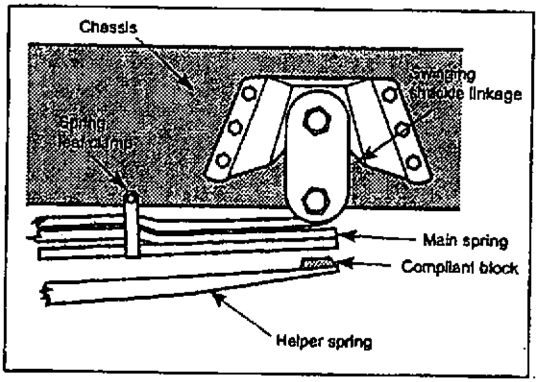

Fig. 3 Example of helper spring fitted with compliant block to control impact noise

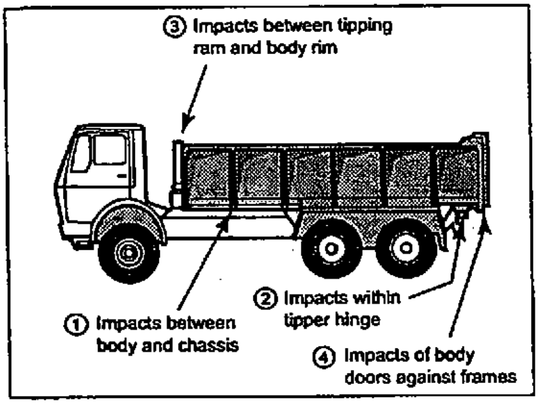

Fig. 4 Tipper body noise sources

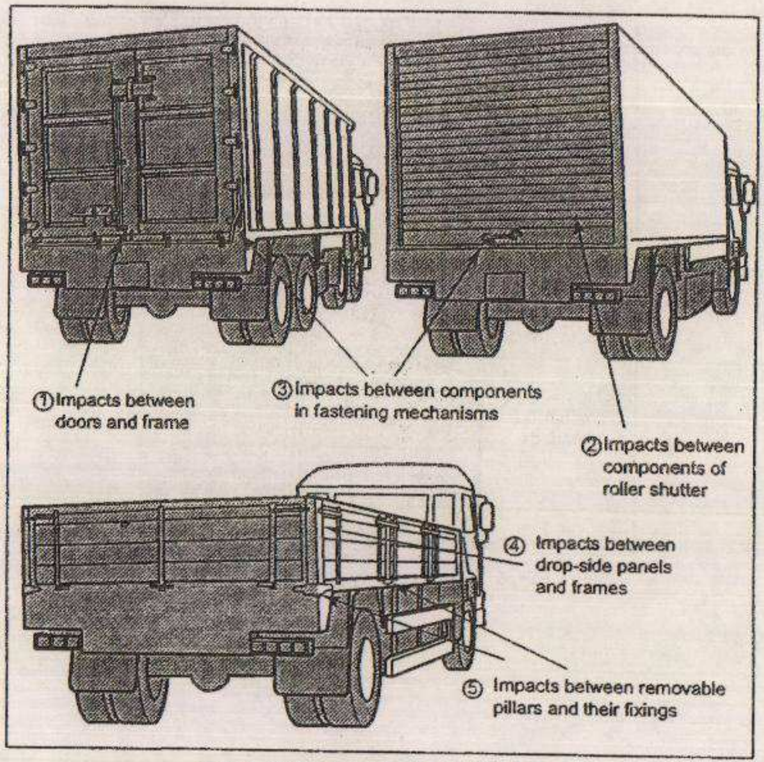

Fig. 5 Noise from doors and fastenings

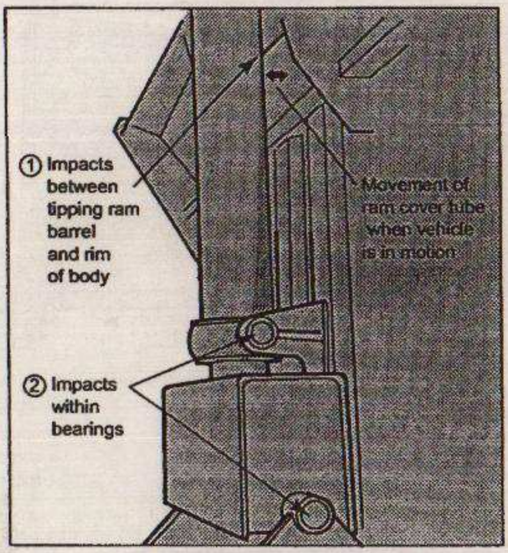

Fig. 6 Tipping gear noise sources