METHODOLOGY OF RECONSTITUTION OF ACTUAL ACCIDENTS ON TEST TRACKS

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I. DEFINITION OF TEST PARAMETERS

There are only three parameters which may be used to reconstruct an accident : velocities, angles of impact and points of impact.

Parameters are defined by the methods developed for detailed analysis of accidents (1 and 2) :

- Velocity variation (ΔV) by use of the energy dissipated during a collision by the vehicle or vehicles with the obstacle or obstacles.
- Impaction of vehicles and closeness of centres of gravity are determined by distortion of vehicles and obstacles after the impact.

Once the basic data are retained, test parameters are selected by strictly respecting approach velocities and angles for frontal impacts, for the important factor is to obtain the same velocity variations as during the actual accident. For all impacts in which two velocity vectors at an angle are compounded, the important factor is to obtain the correct resulting vector in order to ensure that the trajectory followed by the occupants of the impacted vehicle inside their compartment is faithful.

II. PRACTICAL ACHIEVEMENT OF TEST (3)

1) General layout

Tests are carried out on the test and collision track of the Lardy Technical Centre, which is designed to meet all present and future standards but also to reproduce any type of accident.

This last requirement is the reason for a layout composed of two distinct zones (fig. 1).

The first zone (A) with an impact wall of 60 m3 of reinforced concrete, i.e. 150 tonnes, is the traditional section where all tests are carried out against an infinitely rigid obstacle. This may be the wall itself with or without a dynamometric buffer, but it may also be an inclinable wall which may vary through the whole range of 0 to 45° (mainly 30°) to the left or to the right, a dynamometric pole or any other form of obstacle required to reconstitute an actual accident.

The second zone (B) is located at the intersection of the main 350 m track with a 100 m track. This latter cuts the first at right angles at a distance of 200 m from the impact wall and provides a number of forms of collisions : frontal, lateral, from behind, tests of roll-over, etc. A third oblique track allows for impacts at various angles over a quarter of a circle of radius 50 m from the point of crossing of main tracks. Each track, of width 7 m of particular section (two 1 % gradients), converges towards the centre of a hangar of area 1500 m2 (50 m x 30 m) which provides freedom from the effects of bad weather. In this place, also, tests are carried out with pedestrians and cyclists.

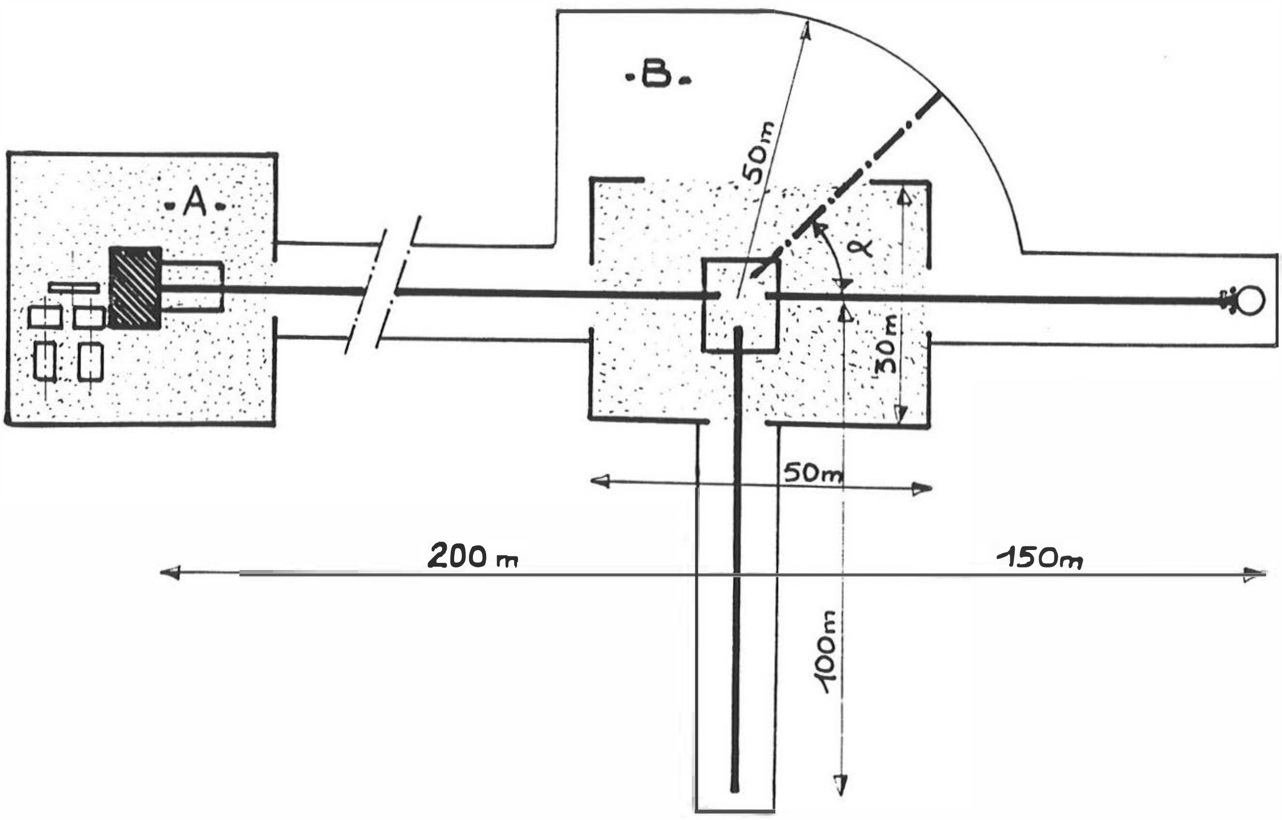


Fig. 1 - Overall view of collision test tracks

Both zones are fitted with equipment to provide best utilisation of tests carried out on them. A wide bridge is placed in front of the wall and also at the intersection to facilitate overhead photography and a wide pit is provided for low level photography.

The bridges also accommodate all the lighting systems so that there can be no impediment of any sort to the movement of the vehicles after impact. The two pits are fitted with projectors built into recesses to provide the widest possible field of vision for cameras filming the undersides of vehicles. Furthermore, in order to improve the quality of photographs which are particularly interesting in relation to deformation of structures the pits are covered by thick laminated glass sheets resting on a wide mesh metal lattice (600 mm x 200 mm) ; this enable the pits to be completely closed and provides a surface on which vehicles may move almost normally.

The winch :

Vehicles are drawn at speed by a winch which comprises a set of two 300 CV IC engines which may be used separately or simultaneously. A thick cable (dia 18 mm), runs unterruptedly along the centre of the main track. It transmits the drive force by means of a carriage which can be attached to it as required at any point of the track by means of a special gripper (fig. 2).

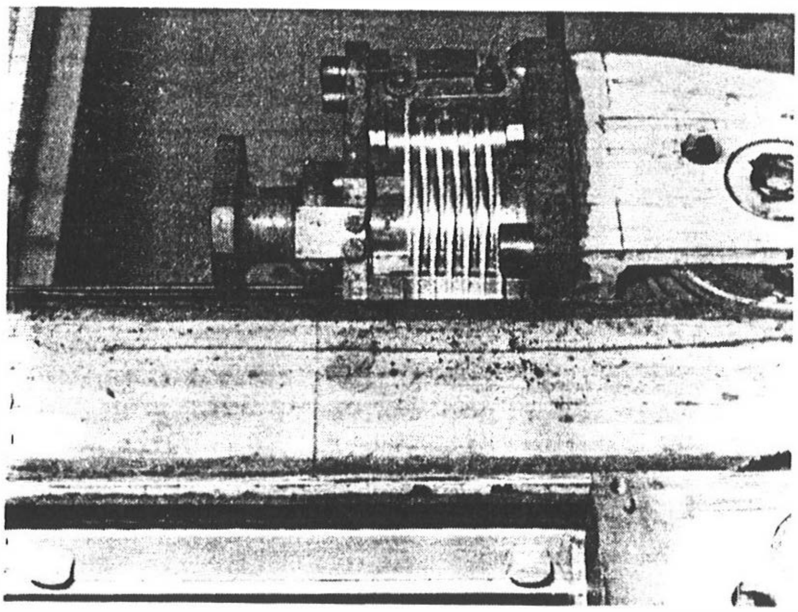


Figure 2.

Accuracy of trajectory :

Though the vehicles are accelerated by two IC engines each fitted with an automatic gear box with three forward speeds and one reverse speed, velocity at the point of impact is regulated electrically by means of a Foucault current, Telma-type truck brake. Data on the vehicle velocity is supplied to a mini-computer by a tachymetric dynamo which is directly connected to the cable and varies the intensity of the current transmitted to the braking mechanism so that the braking mechanism cancels excess power of the engines to establish an equilibrium when the desired velocity is attained (fig. 3). The two IC engines are controlled by prior setting of their carburetors.

This method has two advantages :

- errors of impact velocity are less than 1 %,
- force of traction on the vehicle is always positive because it is at least the load necessary to preserve the velocity acquired ; this latter advantage is essential for good fidelity of vehicle trajectory.

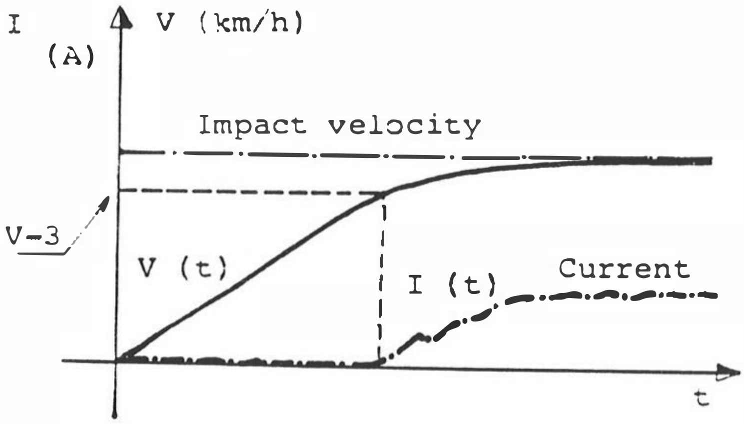


Figure 3.

Though a continual positive traction force is a necessary condition to provide accuracy of trajectory, the following precautions must nevertheless be taken :

- state of track must be impecable : the 1 % half gradients which converge towards the rail facilitate flow of rain water,
- the front wheel assembly of the vehicle must be completely set on a VISUALINER bench and tyres must be checked,
- the connection between vehicle and carriage provided by a V cable the loop of which marks the centre line of the vehicle,
- measurement cables are balanced on either side of the vehicle.

When these precautions are taken, vehicle trajectories are respected with a tolerance of ± 5 cm. They are, of course checked on a film and also immediately after each run by examining the marks of the tyres on a line of talc in comparison with the ideal trajectory.

The attitudes of vehicles which form part of the test parameters are set either by replacing the shock absorbers by threaded rods if the vehicles is immobile or by modifying the suspension springs if the vehicle is mobile, in order not to disturb its trajectory.

Measurement equipment :

Tests are carried out alternately on one or other of the test tracks and the method of a mobile measurement laboratory has been selected. This is a bus which is specially equipped for the quite special function of recording all the parameters of an impact. A technique of multiplexing provides a means of obtaining more than 100 parameters of each crash.

Complete utilisation also depends on wide cinematograph coverage with twelve ultra-rapid cine-cameras and two reporter's cameras.

Operation of the recorders and start of the cine-cameras form an integral part of the run sequence for reasons of safety.

2) Equipment specific to accident reconstitutions

The installations at the technical centre at Lardy are the necessary basis for reconstruction of all forms of actual accidents. However, supplementary equipment specific to each case has had to be created for some of these reconstitutions.

a. System of pulley blocks designed for providing different speeds between two vehicles.

A system of pulley blocks combined with the possibilities offered by these launching tracks provides a means of reconstituting all possible accident configurations between two vehicles such as that illustrated in fig. 4.

Figure 4 shows diagramatically the preparation of a collision between two vehicles, X and Y, of which the trajectories form an angle of 45° and of which the velocity ratio is ½.

Accuracy of impact point is ensured because the vehicles are finally connected to the same main cable in every case, even if auxiliary cables and carriages are used as in figure 4.

New auxiliary cables of smaller diameter are used for every test and we have been able to verify that their elongation is negligible during the last phase, the regulation phase, of the trajectory during which the traction force is limited to preservation of velocity.

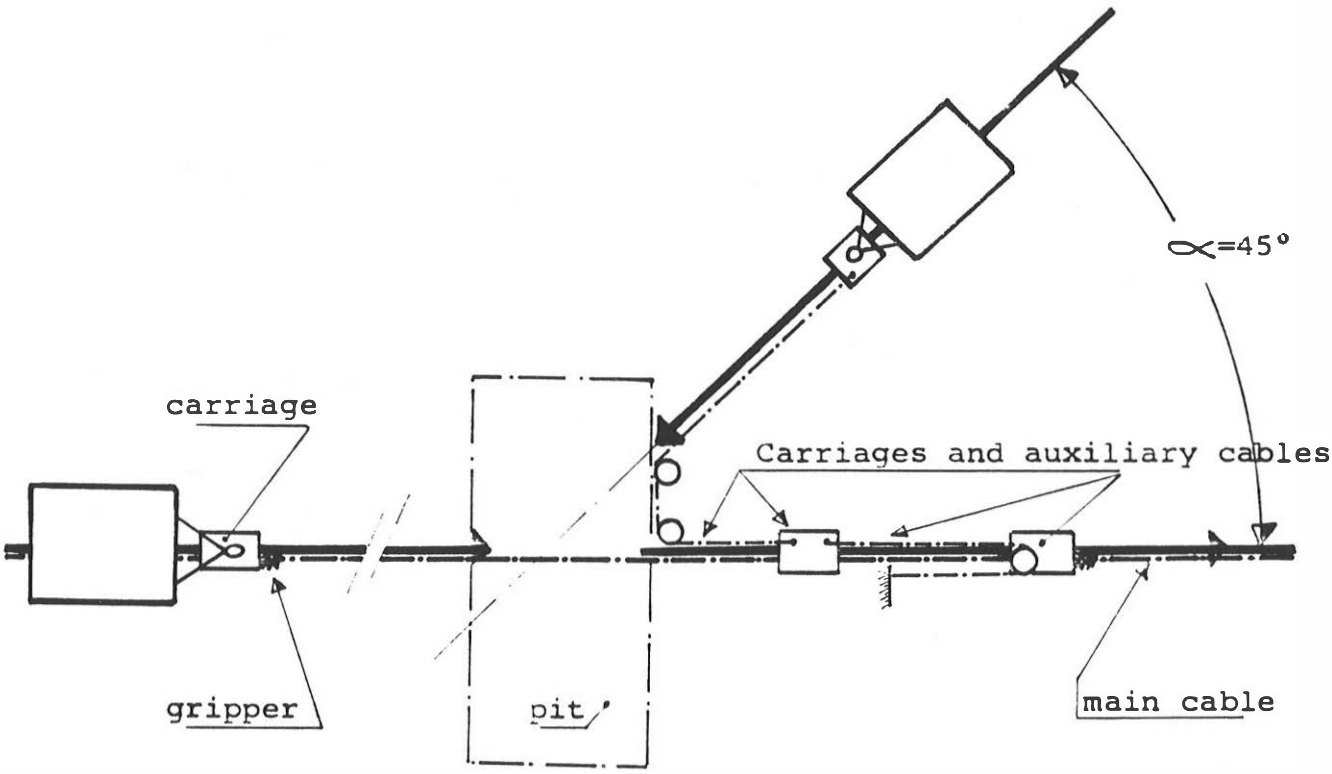


Figure 4.

b. Propulsion of pedestrians and cyclists

A harness/electro-magnet/winch assembly maintains the pedestrian in the desired configuration while respecting position of the various centres of gravity of the subject with respect to the vehicle. A contact actuated by the vehicles controls release of the pedestrian. This contact is positioned allowing for the response time of the electro-magnet and the velocity of the vehicle so that the pedestrian is released a few milli-seconds before the impact.

The propulsion of a cyclist (figure 5) is a more difficult operation because this is a moving body with a very unstable equilibrium. Its own velocity has, furthermore, a primordal influence on the trajectory of the subject during impact, mainly in lateral impacts which are the most frequent in this field.

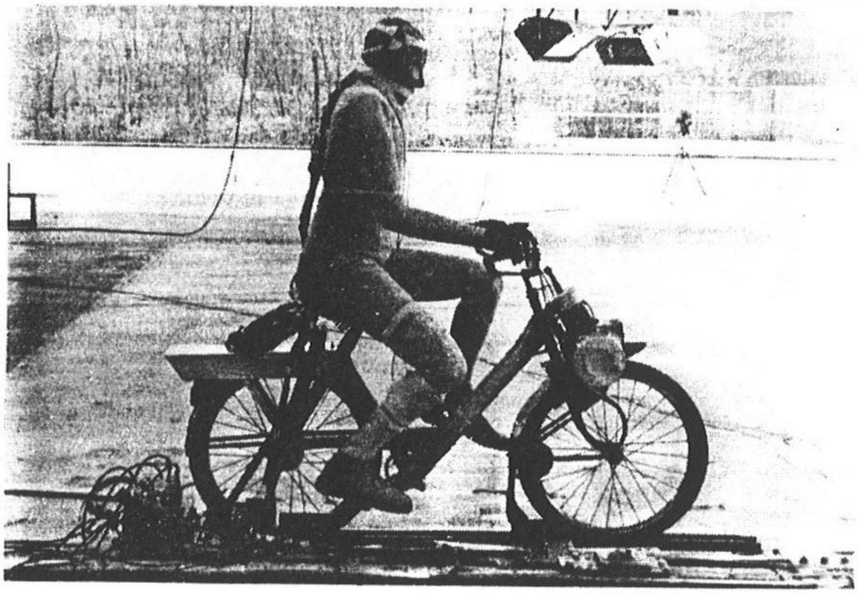


Figure 5.

The two wheels of the bicycle are guided in a steel section in the shape of an omega Ω. A third securing point is selected at the parcel holder or the sadle and its function is to stabilise the cyclist during the first acceleration phase. The whole assembly is fitted on a carriage which runs on the main rail of the track and which is stopped 2 to 3 metres before the point of impact : the cyclist continues on his impetus without any noticeable modification of his equilibrium.

c. Roll-over carriage

A traditional system of roll-over reproduces one phase normally called the perfect roll-over of which the rotational axis is the same as the longitudinal axis of the vehicle, which rarely occurs in reality. We have designed a carriage which comprises a large flat area, 4.5 m x 4.5 m, inclined to 20°, on which the vehicle may be set in any position (fig. 6). Thus it is possible to reproduce any form of roll-over which affect different parts of the structure.

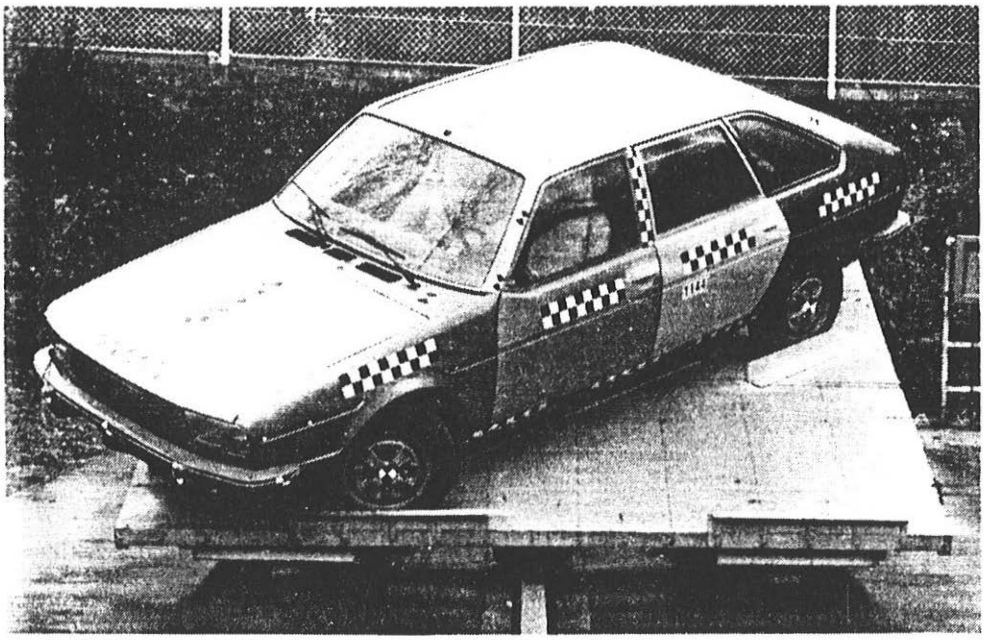


Figure 6.

d. Platform for lateral impacts against static obstacle

This is a very flat and perfectly smooth platform which carries a vehicle which may be oriented in any direction with respect to the dynamometric pole, so that the collision against this type of obstacle is no more exclusively a frontal one. The carriage is braked at the moment of impact by distortion of two metal tubes set in the wall. The vehicle, the friction of which is lowered by the presence of a lubricante, may strike the pole laterally at any point and at any angle without any exterior interference (figure 7).

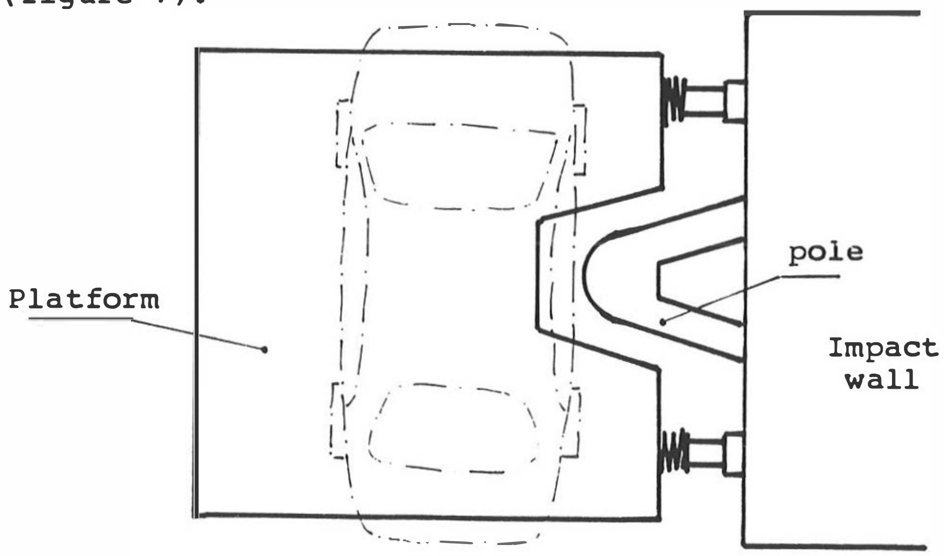
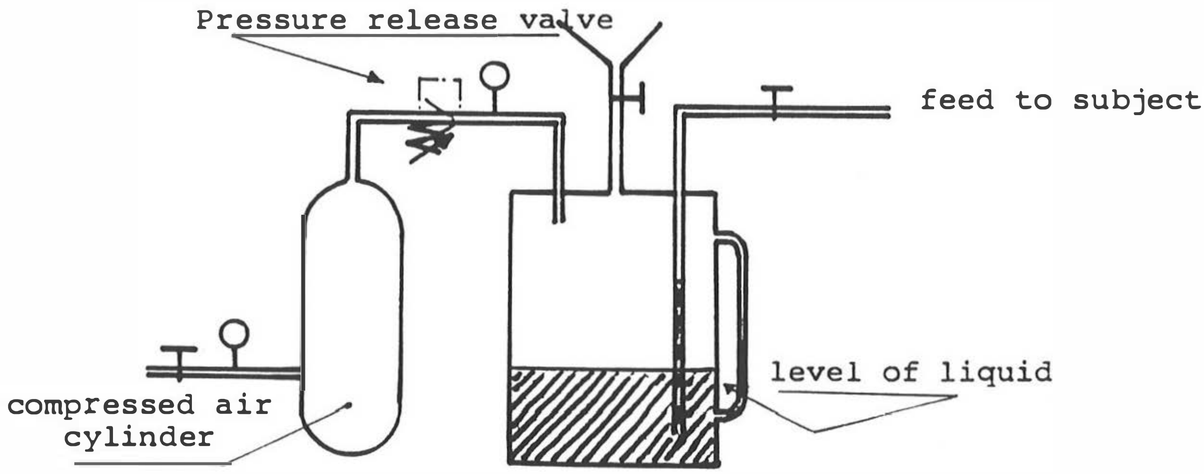


Fig. 7 - View of platform from above

e. Injection system for recreating arterial pressure

(fig. 8) The medical authorities rapidly realised the necessity for simulation of arterial pressure in order to reveal cerebral injuries and other haemorrhages, during reconstitutions of accidents with cadavers. A mixture of water, formal and china ink was selected for its good diffusion and fixation of carbon particles allows the detection of vessel ruptures. We have developed in collaboration with IRO (Institut de Recherche Orthopedique) a system that provides a means of infusing the subject just before the test and of maintaining constant pressure during the impact and a few seconds after.



Note : This system is designed to be carried on the vehicle tested.

Figure 5.

CONCLUSION

Experience acquired by more than fifty reconstitutions of actual accidents which have been carried out up to this day on the RENAULT test tracks has enabled the following conclusions to be drawn :

- If all the precautions given in detail above are taken, error of velocity is less than 1 % of the value laid down and error of point of impact is less than ± 5 cm.

- The other parameters which provide fidelity of the reconstitution are :

a) Accuracy of analysis of angles of impact of the true accident, which is a function of the complexity of the accident. This leads us today to prefer accidents which configurations are fairly pure.

b) Accuracy of attitudes of the vehicles and, in particular, the attitude during braking of a vehicle when colliding in the case of frontal impact, collisions with pedestrians or bicycles, and lateral collisions, or the attitude at impact time of a vehicle struck during the same lateral collisions.

All these extra precautions ensure that the deformations of vehicles are reproduced to within less than 3 cm mainly in the resistant zones of the structure.

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