EXPERIMENTAL STUDY OF INJURIES OBSERVED ON PEDESTRIANS

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The improvement of the protection of the occupants of a vehicle necessitated a bidisciplinary collaboration between:

- On the one hand S.A. CITROEN and O.N.S.E.R.

- On the other hand O.N.S.E.R. and the Center of Highway Traumatology.

This collaboration comprises the exchanges of information (biomechanical, measurement and application of the data, mathematical model building), as well as studies undertaken together (accidentology, reconstitution of the accident, improvement of safety systems, utilization of mathematical models).

Parallel to these programs, an experimental study of the shocks between vehicles and pedestrians had been planned because of the importance of this phenomenon (frequency, seriousness of the injuries).

A tridisciplinary team was created, by associating:

- the safety group of an automobile manufacturer (S.A. CITROEN)
- a biomechanical team from a research laboratory (O.N.S.E.R.)
- a research team from a Medical Faculty (Center of Highway Traumatology and Anatomical Laboratory).

The experimental study undertaken at Marseille, makes possible the analysis of the kinematic of the pedestrian during the shock, as well as the means of diminishing the aggressiveness of the form or the architecture of the front sections of the vehicles of the touring type.

The experimentation is carried out by using anthropomorphical dummies and anatomical subjects, and will be reinforced by mathematical models.

The objectives sought are:
- the determination of the mechanisms in the emergence of the injuries
- the quantitative and qualitative analysis of lesional agents
- the influence of the parameters of the vehicle (form, rigidity, speed)
- the comparison of the comportment of the dummy and the anatomical subject
- the determination of the biodynamic criteria
- the perfecting of the mathematic model-building.

EXPERIMENTATION STRUCTURE

In order to realize the shocks between the touring type vehicle, moving at speeds between 5km/h and 40km/h, and a subject, erect, free of movement, an experimentation structure was realized in Marseille during the second semester of 1978 (Laboratory of Biomechanical Impact Studies).

The test installations

The vehicle ramp

This is an inclined ramp on which the vehicle reaches the desired speed by gravity.

The testing area

It consists of a metal building the soil of which is covered with a bituminous surface identical to that of roadways.

The lighting of the shock zone

It is done with three fixtures each comprising five lamps of 5.000 W.

Elements of control and servo-control

Measurement of vehicle speed at the moment of shock is performed with the aid of a photo-electric cell. Two parameters are directly servo-controlled thanks to the cut-off of a photo-electric barrier controlling timed relays. These are the braking of the vehicle and the releasing of the subject.

The cinematographic coverage

High-speed cinematography is actually the principal means of study.

Four rapid cameras, the shutter speed of which is 500 images per second, are used for the kinematic coverage of the subject:

- a vertical view directed at the point of shock
- two lateral views furnishing a total analysis of the trajectory of the pedestrian, with particular attention to the level of the initial vehicle-pedestrian contact (front shield/lower limbs)
- a 3/4 view from the front following the fall of the subject to the ground.

The tests are shot in color and a shot at normal speed covers the environment before and after the test, and permits the realization of cinematography at the real shock speed.

Still photographs complete this cinematic coverage.

The test material

The vehicle

It is a small CITROEN VISA four-door sedan, taken from stock, in its original configuration permitting the consideration the real kinematics of the pedestrian during the shock. The vehicle is positionned in such a way that, taking into consideration its characteristics, its braking is 0,7g, this being realized by the servo-control of the original elements of the vehicle in order to obtain a beginning of deceleration at the moment of shock.

A second mock-up of an automobile is available on the site, allowing the variation of numerous parameters of form and structure.

The utilization of the inclined plane allows the reduction of the speed and insures a large reproducibility of the selected speed.

The subject

Two types of tests are realized in identical configurations, one with an anthropomorphic dummy, the other with an anatomical subject. The dummy utilized is the O.N.S.E.R. dummy,

50th centile, male. This dummy, developed by the O.N.S.E.R., is a subject at normal erect position. Tested and used by the O.N.S.E.R., either as an automobile passenger or as a pedestrian, has given satisfactory results at the level of the reproducibility of the kinematic. Moreover, its geometric characteristics and the values of the masses of the corporal segments as well as their inertias are perfectly known.
The anatomical subjects are fresh cadavers delivered at the laboratory by the Body Donations. They must correspond to a pre-established morphological standard, as well as to certain criteria of completeness. The anatomical preparation consists of an incomplete reheating as well as a movableness giving satisfactory biodynamic results.
Two shock configurations have been retained, one facing the axis of the vehicle, the other in profile on the right side of the axis of the vehicle. The subjects are maintained in the erect position with the possibility of adjusting their contact with the ground and they are freed at the moment of shock.

CARRYING OUT OF THE TESTS

During the first semester of 1978, ten periods of testing were undertaken, using successively shock speeds of 10 km/h, 20 km/h and 25 km/h. Each test configuration is systematically doubled.

The vehicle

The utilization of the inclined plane permits the reduction of adjustement of the vehicle speed. Moreover, the reproducibility and reliability of this procedure are very satisfactory.
The architecture and rigidity of the elements of the vehicle being perfectly known by the manufacturer, the data gathered on the vehicle, are limited to the speed at the moment of shock, the characteristics of the braking, the points of impact by the subject, and the importance of the deformations of each impacted zone.
After each test, the front elements of the vehicle are removed and replaced by new elements (wind-shield, hood, front shield, bumper beam,...)

Schedule of tests with dummies

Two dummies are available in Marseille.

Manipulations before test

- preparation and adjustement of the dummy
- positioning of cinematographic references
- placing in position of the subject at the shock point.

Manipulations after test

- diagramming of ground position of dummy
- research of impacts on the subject
- verification of the completeness of the dummy
- repairs if necessary.

Schedule of tests with anatomical subjects

The subjects are received by tha Anatomical Laboratory about 48 hours before the test. Every effort is made for the preparation of the bodies to respect a comparable plasticity to a normal muscular tonicity of a living and relaxed subject. This is done by an incomplete reheating and a movableness of the limbs in order to give free play to the articulations which are not immobilized by the cadaveric rigidity.

Manipulations before test

- non-blocking packing of the rhinopharangeal orifices and minimum enveloping bandaging.
- clinical examination of the teguments
- radiological pre-impact evaluation of detection, and interpretation
- placement of cinematographic references on the selected anatomical points
- positioning of shock point.

Manipulations after test

- diagram of subject's position on the ground
- clinical evaluation
- radiological post-impact evaluation and interpretation
- embalming and conservation (Winckler liquid and cold)
- necropsy.

The radiologic evaluations comprise a dozen systematic X-rays (cranium, cervical rachis, thorax, pelvis, limbs). This standard evaluation is often completed, especially in post-impact, at the request of the medical personnel.

The necropsy comprises the following operations:

Cranium and face: removal of the head
congelation at -22°C.
sagital sawing
analysis of encephalon and meninges
bone examination

Viscera : anterior thoracic panel
abdominal panel

evisceration if necessary for verification of rachis

Limbs : oriented dissection

Fragmentation by segments:

head and neck

trunk

limbs (autopode, zygopode, acropode)

This fragmentation in segments is destined to serve for the mathematical model building of the shock.

Evaluation of experimentation

The report of the test comprises a cinematographic document which is actually the principal document allowing the production of these tests. The high-speed cinematography, thanks to these easily exploitable films, leads to a perfect comprehension of the kinematics of the pedestrian. The dimensions of the vehicle and the subjects being known and referenced (positioning of the sighting marks) it is possible to formulate hypotheses on the modifications of the kinematics starting from the evolutions of certain parameters such as the morphology of the subject, its weight, its attitude at the moment of shock, the speed, form, or rigidity of the front structures of the vehicle.

For each test a series of photographs taken from the films (cameras in lateral positions) is selected and permits the definition of certain elements of the kinematics, as well as an easy comparison between two subjects by juxtaposing the instantaneous still photos.

This analysis is completed by a study of the technical documents (deformations of the vehicle, impacted zones) and medical (X-rays, clinical examinations, autopsy) enabling the establishment of the association between the impacts and the injuries quantitatively and qualitatively as well.

The measurement of complementary parameters (efforts of the subject on the ground during the shock, effort activated at impact, acceleration of the subject....) is only envisaged for a future study, and in consideration of the observed.

Preliminary experimental results are illustrated by following figures.

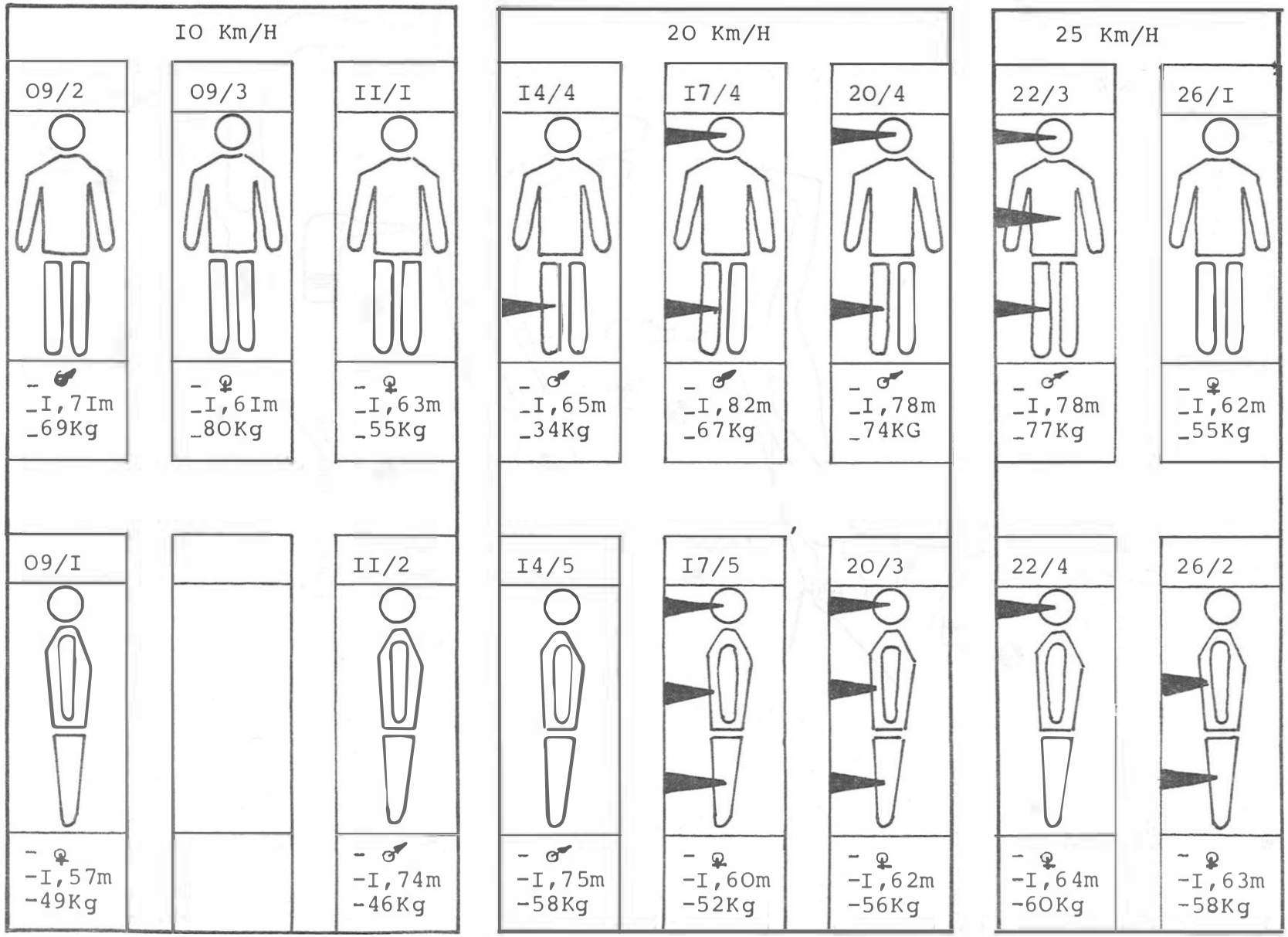


Fig. N° I: Crashes with Anatomical Subjects: Injuried body segments

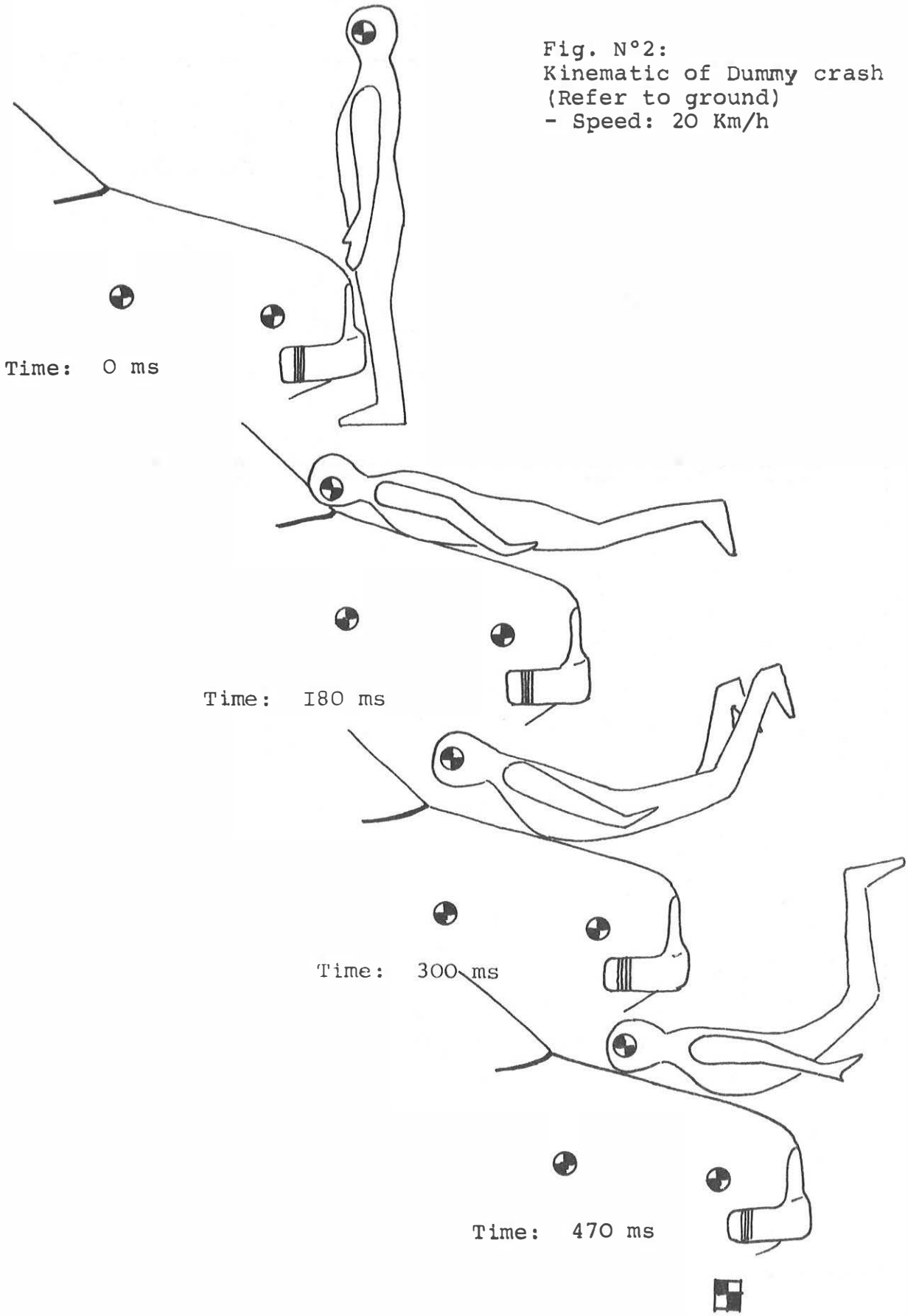


Fig. N°2:
Kinematic of Dummy crash
(Refer to ground)
- Speed: 20 Km/h

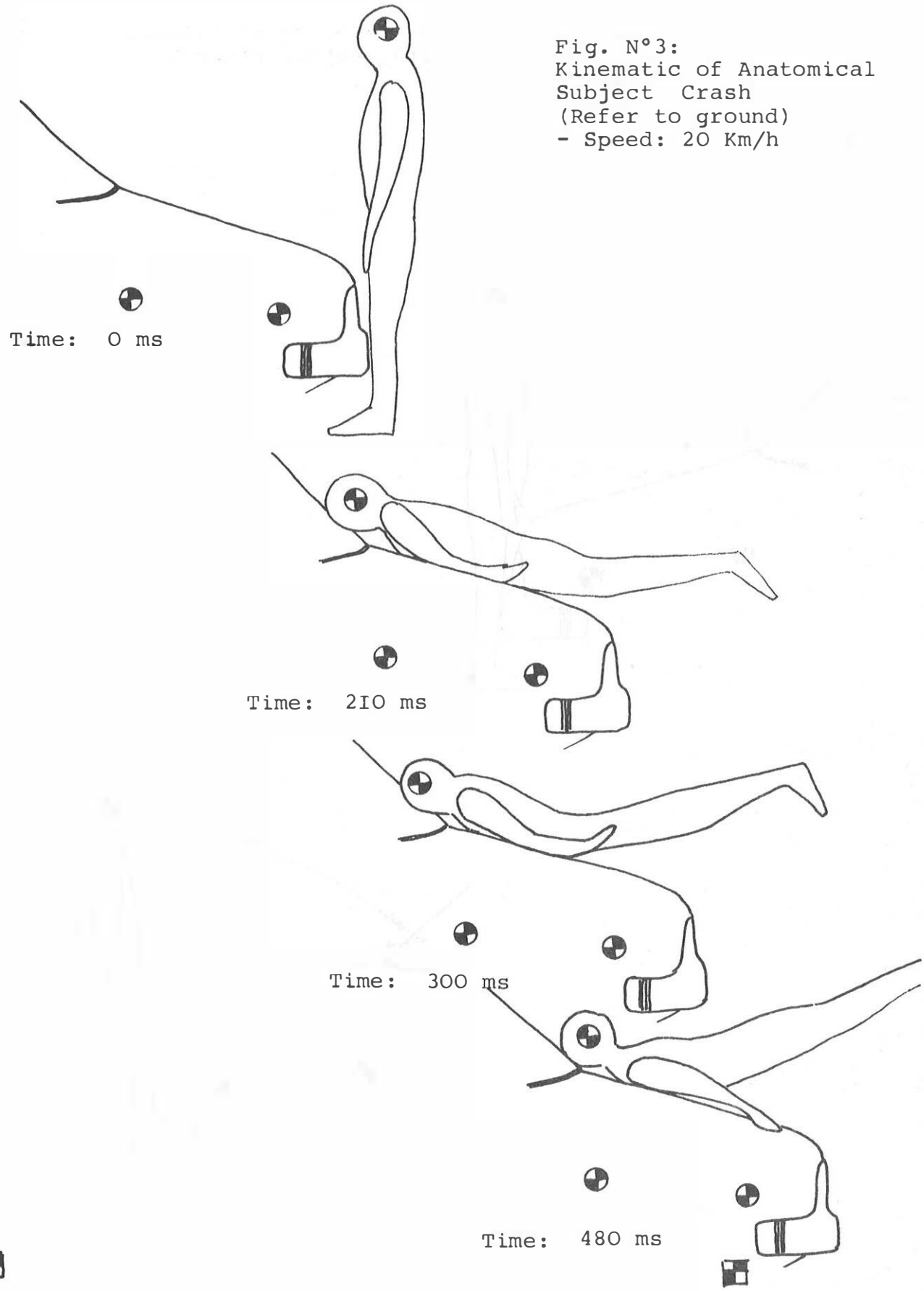
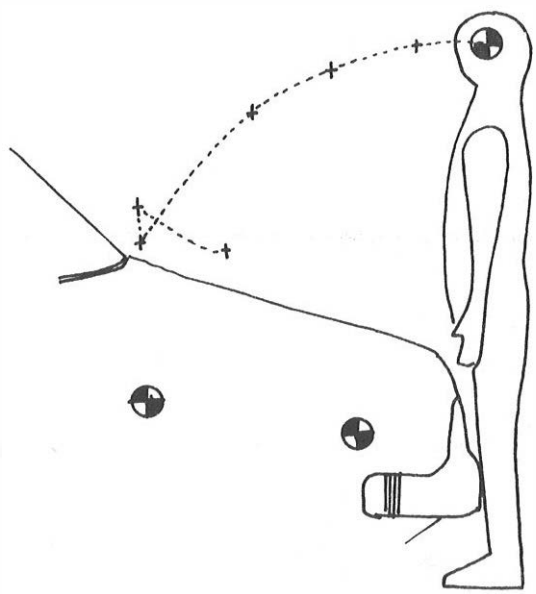
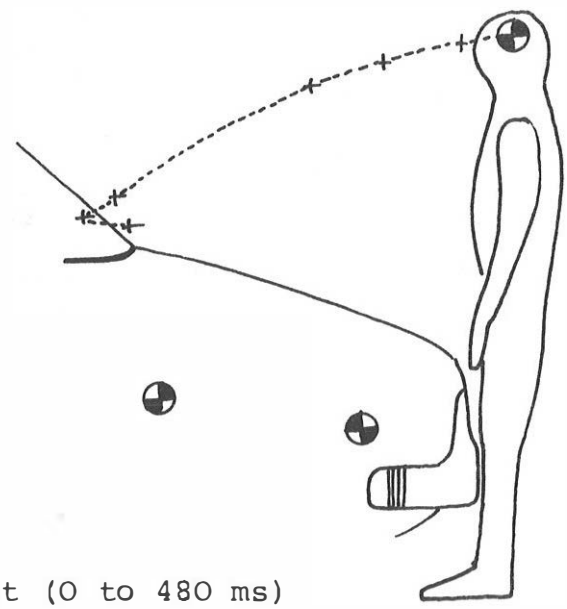


Fig. N°3:
Kinematic of Anatomical Subject Crash
(Refer to ground)
- Speed: 20 Km/h

Fig. N°4: Comparison of head trajectories between Dummy and Anatomical Subject crashes (Refer to vehicle)
- Speed: 20 Km/h



Dummy (0 to 470 ms)



Anatomical Subject (0 to 480 ms)

CONCLUSIONS

This is certainly not the first time that Doctors and Engineers work and realize together biomechanical researches on impacts, but the tridisciplinary collaboration for this work offers a certain number of original aspects enabling on the one hand to combine the efforts of Medical Universities oriented towards the biomechanic, the Engineers from a biomechanic laboratory, and the planning departement of an Automobile Manufacturer in an analysis of auto-pedestrian shocks, with a maximum of precision, but on the other hand allows each one of these elements to perform its own research susceptible of developing and orienting its studies.

The first aspect then is reached in the performance of shocks on pedestrians utilizing at the same time, dummies, and anatomical subjects, furnished to a Faculty Laboratory by Body Donations.

These tests, carried out in modifying several parameters, speed, breaking down of primary, secondary, and tertiary shocks, study of the injuries provoked in considering the different morphological types and modifications of the form and materials of the fronts of the vehicles, necessitating a team-work perfectly coherent, at the same time, precise and meticulous, the analysis of which must be prudent and followed up by an important sampling as the variations of the different parameters require great prudence in order to affirm the results.

Furthermore, each discipline keeps for itself precious lessons.

The Doctors, of course, collect information on the injuries with the therapeutic consequences which are thus indicated, but here it is especially the aspect in biomechanical research which must be stressed, since it is an Anatomical Laboratory which has interested itself in this study, the researches in this field no longer being static but today being obliged to orient themselves to an anatomical study of deformations and resistances of our tissues and components of our bodies.

The Engineers in biomechanic of impact are going to try by comparison between the tests on dummies and those using anatomical subjects to demonstrate the reliability of the O.N.S.E.R. dummy and to create a mathematical model which will permit more tests easier than with bodies.

Finally the planning office of the Manufacturer discovers the complexity of the safety problem, an aspect which with modern imperatives for speed and lightening of the vehicle becomes more and more important. The breaking-down of the shocks, the secondary and tertiary injuries demonstrate a somewhat different order to attribute to the modifications of forms and the utilized materials.

This tridisciplinary operation is the beginning of a fruitful collaboration which should multiply its researches in order to culminate in statistically valuable results.