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DETERMINATION OF HEAD DYNAMICS IN CRASH TESTS, USING A SPECIFIC HYBRID III INSTRUMENTATION

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A specific measurement device has been developed using 5 triaxial accelerometers to accurately determine the 3 D translational and rotational accelerations of the Hybrid III dummy head (see figure 1).

Four accelerometers are positioned with the aim of using the WSU method to calculate head kinematics.

An other method can also be used if the first one fails (in the case where a needed channel is missing) : it is the Burkhard method developed in the 30th Stapp Car Crash Conference.

The fifth accelerometer allows to validate calculations and measurements from the four others.

A series of frontal sled tests with Hybrid III dummy has been conducted, using this specific instrumentation :

Aim of the tests :

- to determine the respective parts of the neck restraint and of the impact in the HIC computation,
- to evaluate the Hybrid III Biofidelity.

Test conditions :

The Hybrid III dummy is seated on a sled, restrained with a 3-point belt in order to obtain a neck restraint of the head.

The head impacts a dynamometric balance covered by 8 cm of damping material (see figures 2 and 3).

The accelerations of the upper plateform of the balance (m = 1.6 kg) are measured so as to substract from the curve F (t) the forces due to the inertia of this uper plateform.

The sled impact velocity is 13.6 m/s.

In order to measure the head contact duration, a first net is plastered on the Hybrid III head (see figures 3 and 4) and an other on the padding of the balance to establish a contact.

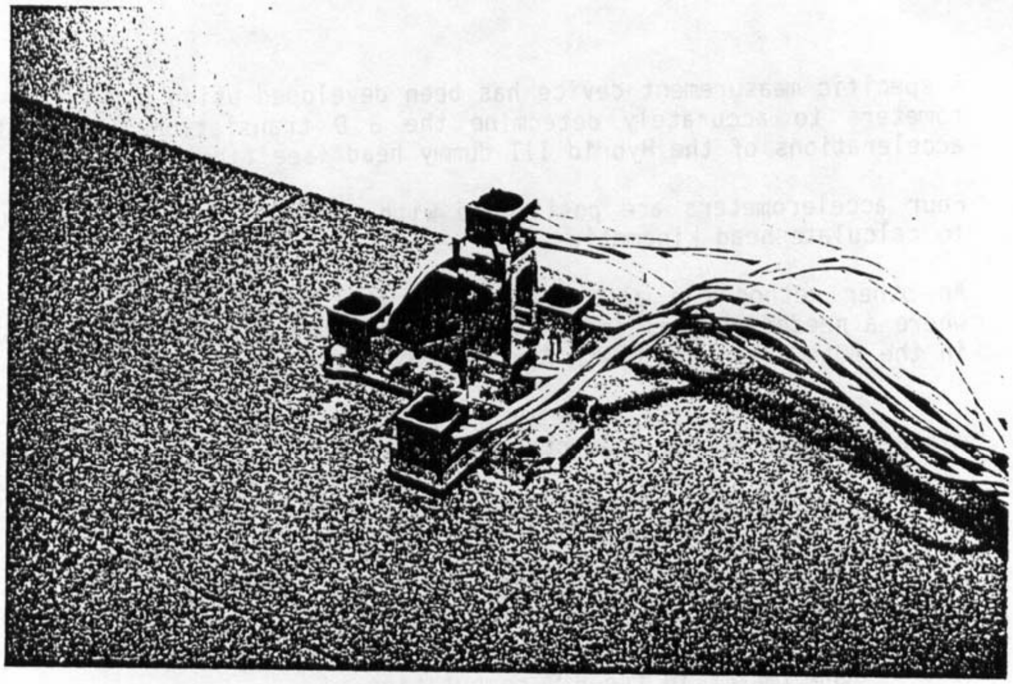


Figure 1. Hybrid III specific device

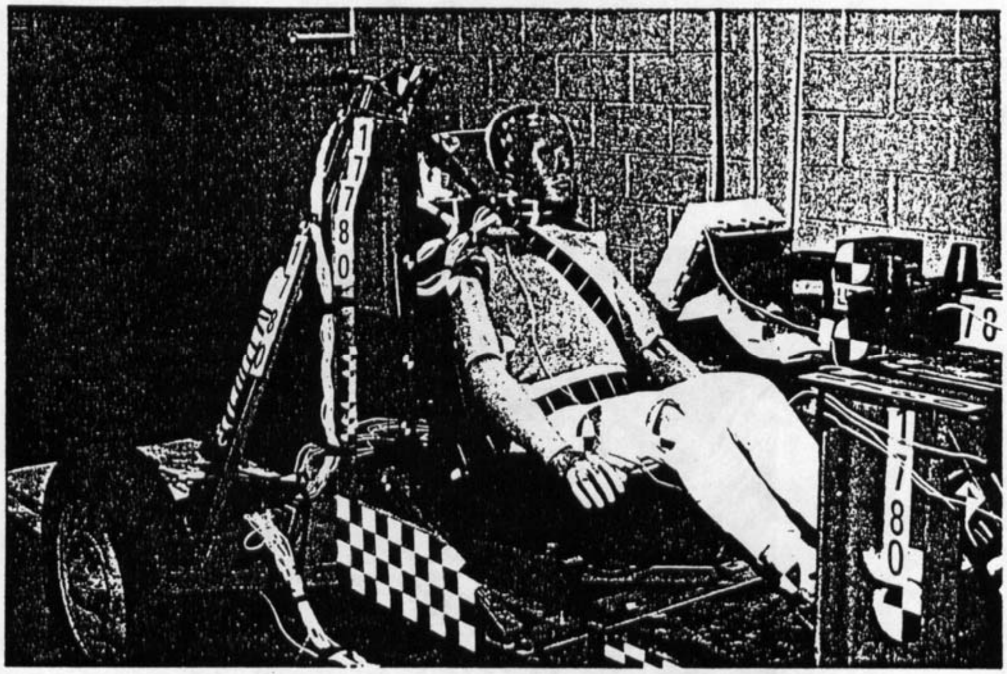


Figure 2. Hybrid III seated on the sled

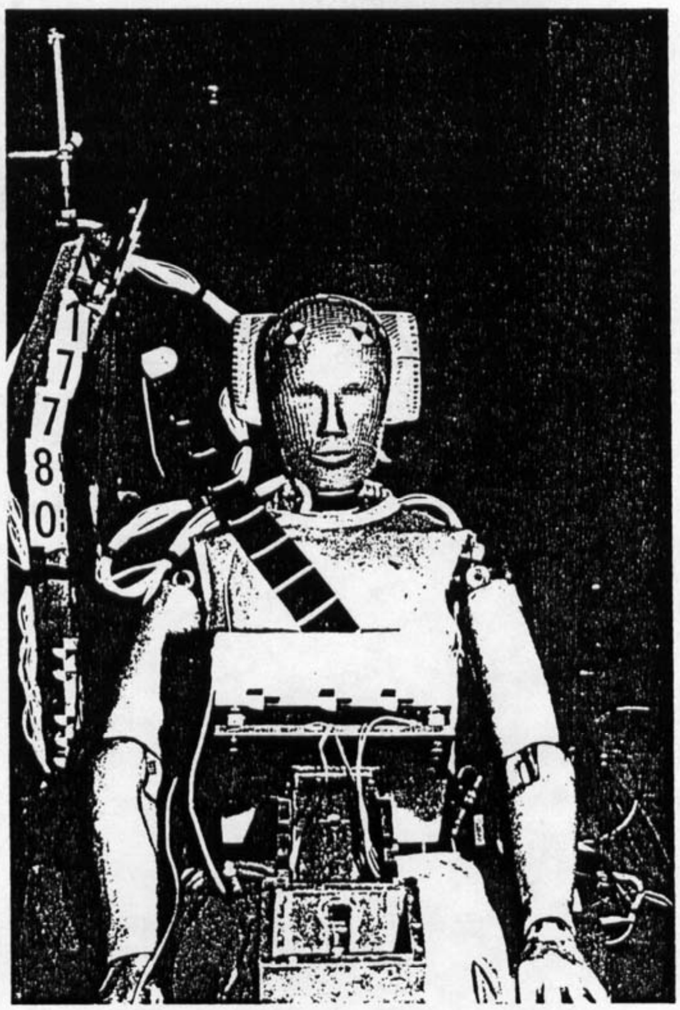


Figure 3. Front view of the Hybrid III

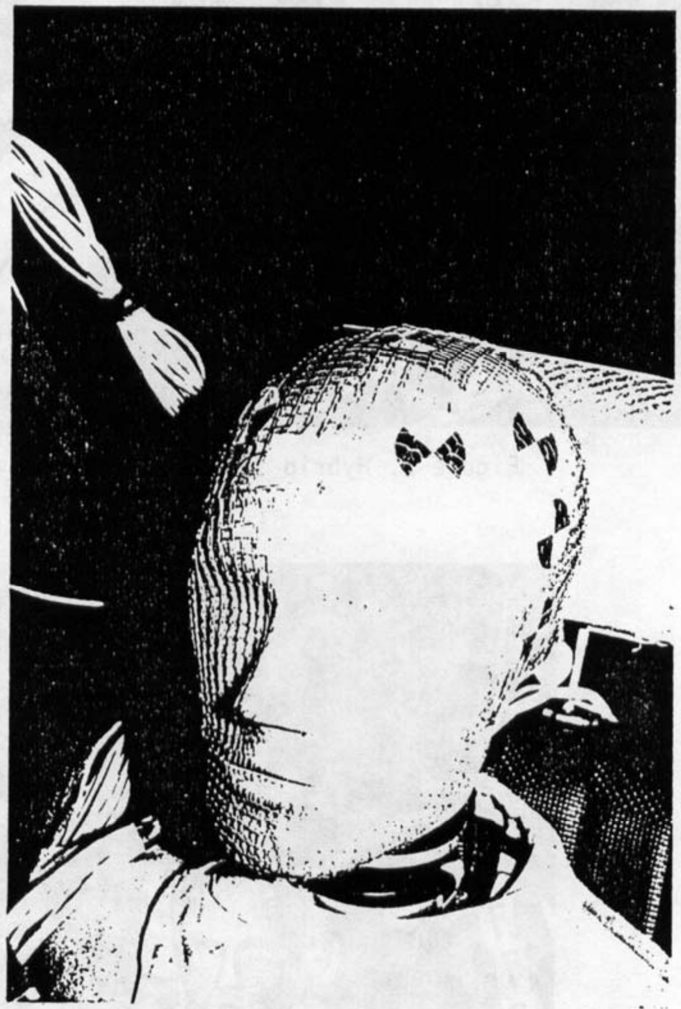


Figure 4. Hybrid III head after the impact

Experimental results :

The tests being now in process, only the first results are given here concerning linear accelerations and neck forces.

1. The resultant acceleration of the head at the center of gravity can be splitted in two parts : the acceleration due to the neck restraint
   the acceleration due to the impact

$$M\gamma_{CG} = Fneck + Fimpact = M(\gamma neck + \gamma impact)$$

so by identification :

$$\frac{Fneck}{M} = \gamma neck$$

$$\frac{Fimpact}{M} = \gamma impact$$

Fneck are directly measured by the neck transducer of Hybrid III (see figure 5).
Fimpact is measured by the balance and can be deduced from ${}_{CG}$ and Fneck, component by component :

$$FXimpact = -FXneck + M.\gamma Xcg$$
$$FYimpact = -FYneck + M.\gamma Ycg$$
$$FZimpact = -FZneck + M.\gamma Zcg$$

The result of this calculation is given in figure 6 and compared to the measured force.
From these results it seems that the Hybrid III instrumentation is a good mean to precisely determine the parts between forces generated by the neck and those generated by the impact.

2. Determination of the head contact duration

Three methods are compared to determine this duration :

- the contact of the two nets,
- the resultant head contact force calculated,
- the head mass calculated from resultant neck forces and head acceleration.

$$M = \frac{\text{Resultant neck forces}}{\text{Resultant head acceleration center of gravity}}$$

Corresponding curves are given on figure 7.

FIGURE 5 : TEST U_1780

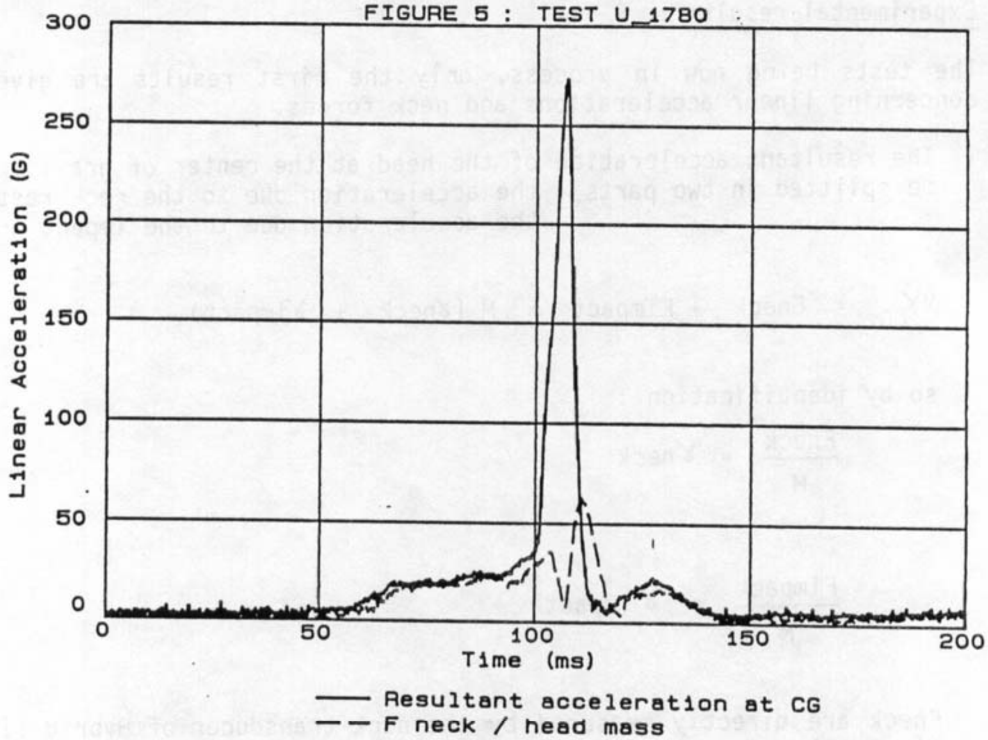
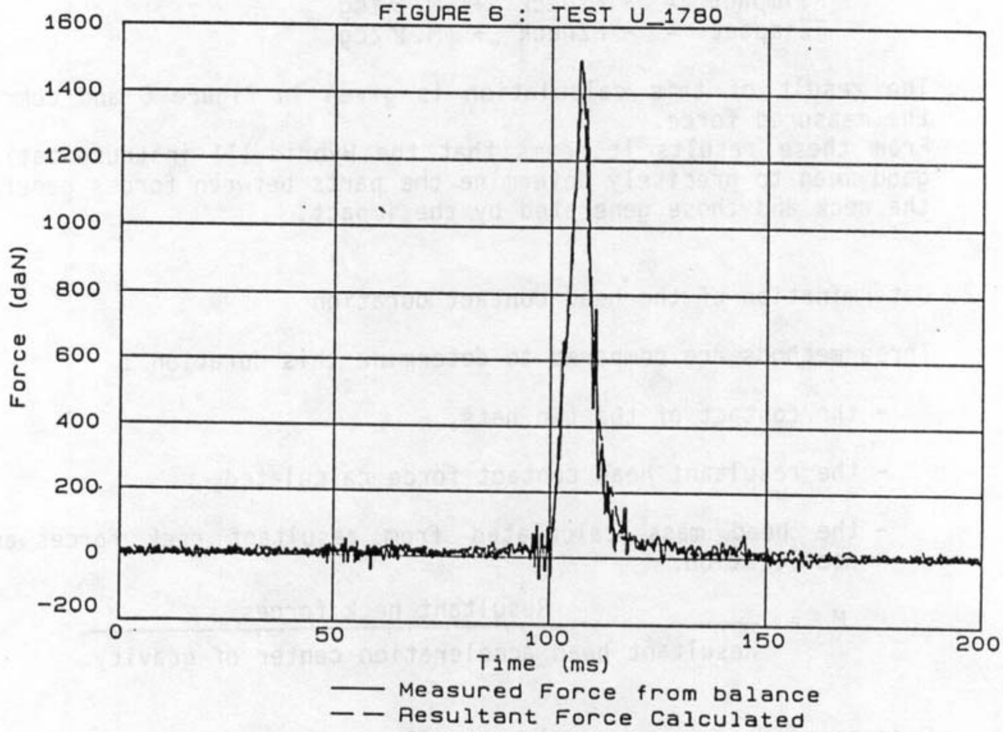
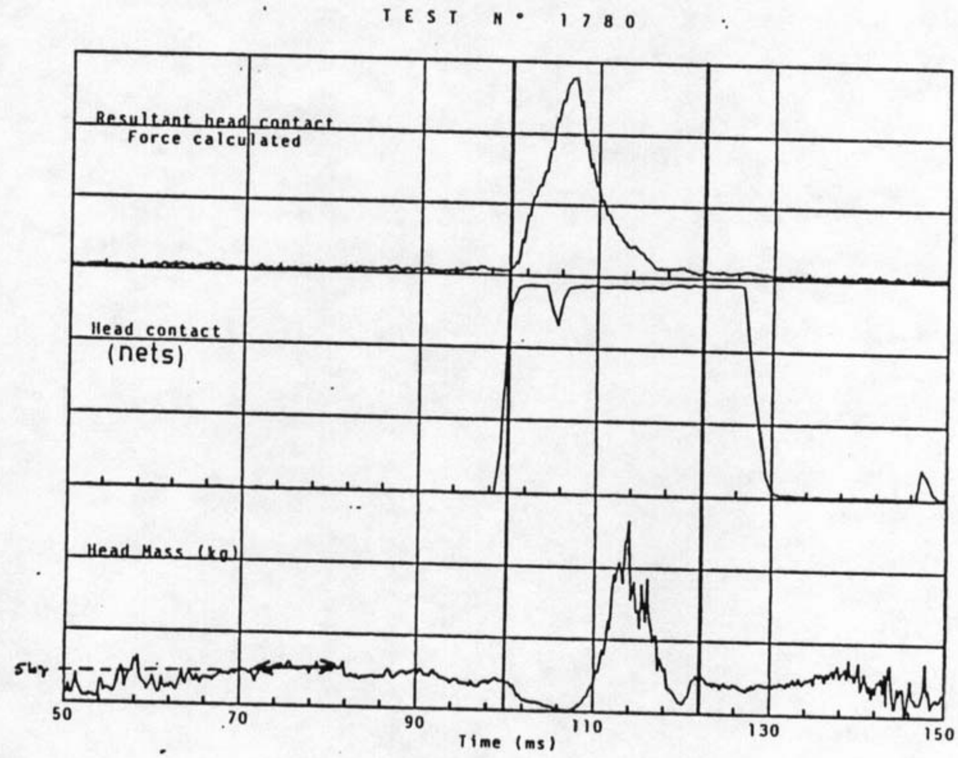


FIGURE 6 : TEST U_1780



The determination of time 0 is not very precise with the two calculation methods. If the net seems to be quite good for the determination of time zero, it is not the case for the end of the contact, probably due to the hooking of net meshes.



Head contact duration analysis

FIG. 7

DISCUSSION

PAPER: Measurement of Head Dynamics in Crash Tests using a Specific Hybrid III Instrumentation

SPEAKER: Forit Bendjellal, Association Peugot Renault

Q. John Melvin, GM Research Labs
I'm trying to understand your 15-accelerometer arrangement. Those are five triaxes?

A. Yes. Let me explain, we have five triaxial accelerometers. As you know, there is a great redundancy of information. We can move back to the first slide. For computation, we need four accelerometers in order to use the 3-2-2-2 method. One triaxial accelerometer is completely redundant and is used as a control point or control information and it's also possible to use the 3-3-3. Let us say that this is the origin of the head anatomical coordinate system. You have here one triaxial, second triaxial, third, and the fourth. You can apply the 3-2-2-2 method. You can do the calculation of the head acceleration at this point and you can compare the accuracy of your calculation of the linear acceleration.

Q. I would suggest, as Wayne State is trying with their method now, that the biggest problem in measuring three-dimensional motion in the head is getting an accurate angular acceleration. If you are using 15 channels of data, it would probably be better to have three rows of five axial accelerometers, or as Wayne State is doing, at least three rows of two, to do this problem. The more accelerometers that are measuring the gradient of acceleration in space, the better off you are in determining what it is. It's always going to have to be sort of a statistical fit to the slope of the acceleration position at any point in time because it's such a severe environment. It would seem to me that if you're going to have 15 channels of data coming out, that there's a better configuration for them. I guess the biggest problem with that, from a routine testing standpoint, is that the people that do crash tests don't like the little bitty accelerometers. They like these big accelerometers, and we've got to convert the testers to believing that they can live with the so-called peanut accelerometer or the 2264-7264 type Endevco.

A. I don't know the GM approach concerning the three rows of five accelerometers. I've just heard about it. However, what we try to do is directly compute the angular acceleration without a sophisticated routine and it does not mean that we need 15 accelerometers. It's just a first step.

Q. I guess I didn't express my point clearly. It is that the 3-2-2-2 method or the 3-3-3 method, in effect, is trying to determine the slope of the acceleration position with two points, and you will always get a straight line between those two points. You can't tell whether you've got an error or not. If you have a multiple-point determination of that gradient, then you can have a statistical fit to it and you have a much better idea of the angular acceleration. As long as it's based on two points, you'll always get a straight line through them, and that will be what you know as an angular acceleration. If it's one accelerometer vibrating, it still looks like angular acceleration. As Warren has shown, if you've got an accelerometer vibrating in the least squares, multiple points in a line approach, it diminishes the effect of that one accelerometer and gives you much more consistent information. I think that provides a better basis for making judgments on angular acceleration.