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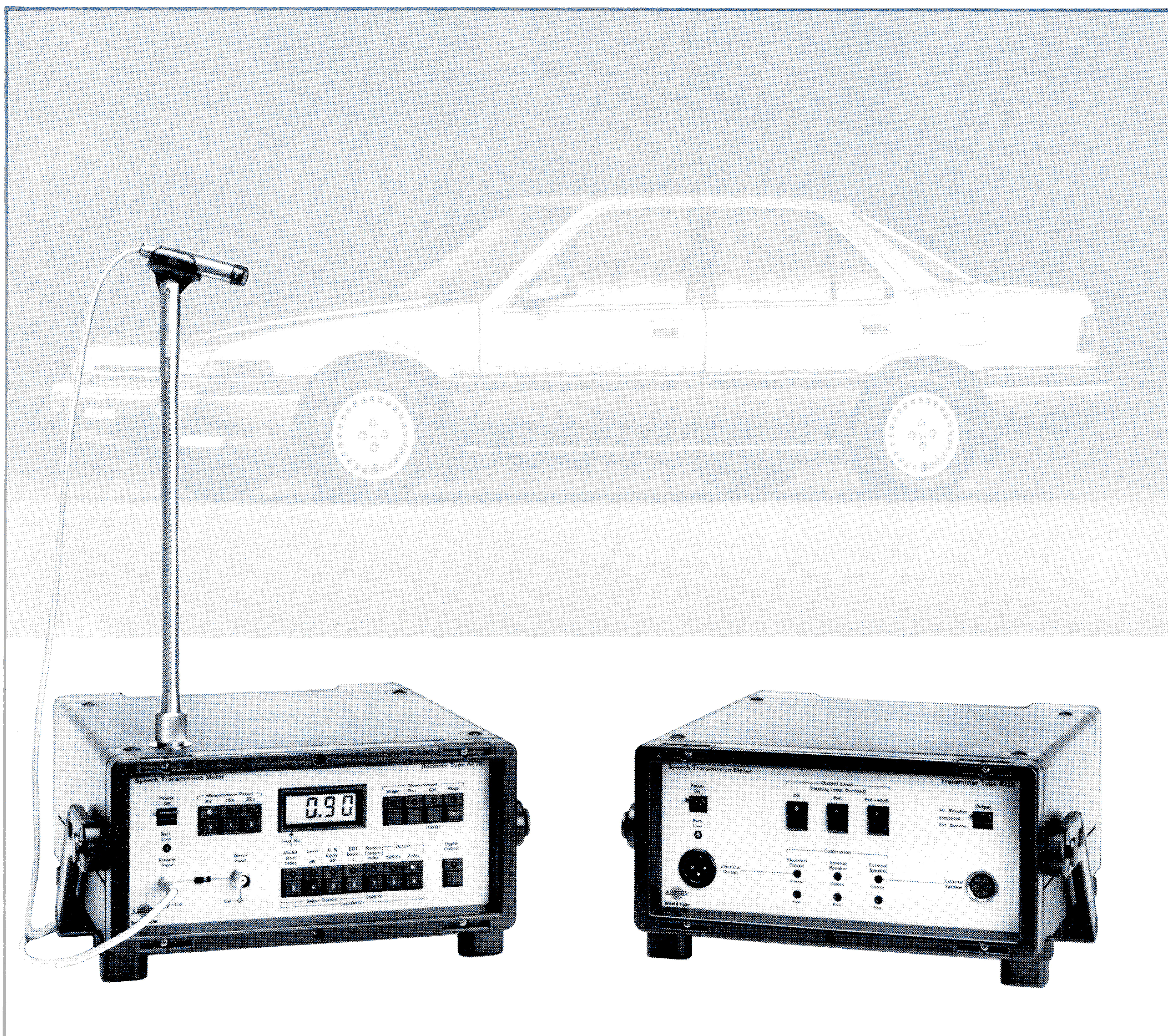

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Measurements in Cars using the RASTI Method

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Introduction

Until recently the RASTI method (Rapid Speech Transmission Index) has mostly been used as a quick and easy method for evaluating speech intelligibility in rooms and the quality of public address and reinforcement systems [1, 2]. Lately, however, other applications such as evaluation of speech intelligibility in aeroplanes and field testing of speech privacy have also become important. This application note will discuss the use of the RASTI method in connection with the evaluation of noise and the quality of speech conditions in cars.

Why consider noise and the acoustic "comfort" of the interior of a car? There are several reasons: the driver and the passengers are exposed to noise from the road/tyre contact, the transmission, the engine, wind, etc., and therefore it is often difficult for them to communicate with each other or listen to the radio/cassette player. This causes tiredness and, in addition, the passengers on the rear seat must sit uncomfortably near the front seat if they wish to communicate with the driver. Further, car manufacturers often evaluate how the car "sounds" so that, for instance, the frequency characteristic of the noise is just how the customer likes it!

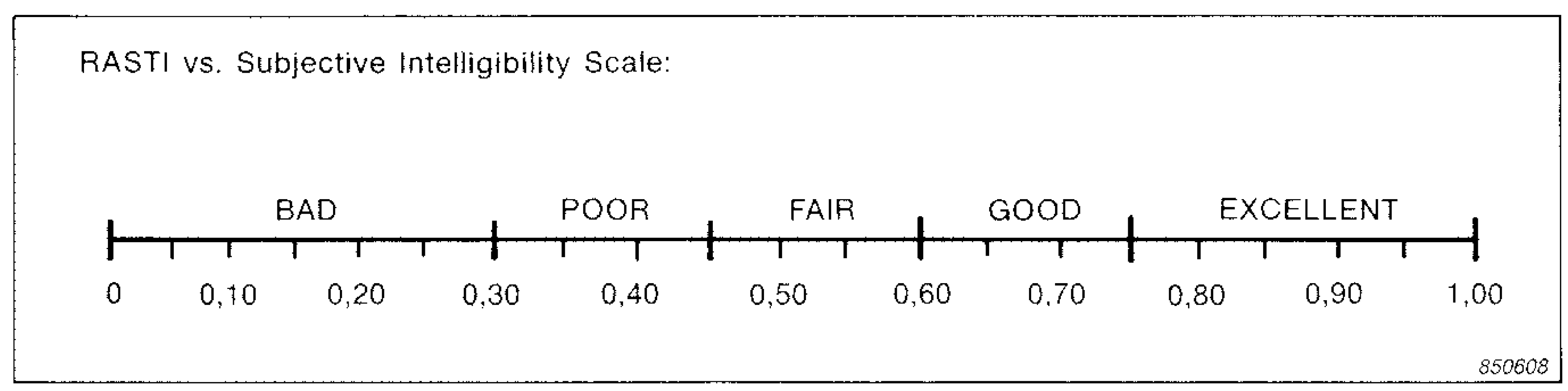

Fig. 1. Qualitative interpretation of RASTI

The RASTI Method

RASTI has been developed from experiments on sound transmission systems using Modulation Transfer Function (MTF) analysis, [3, 4]. The method is standardized by IEC [5]. By means of the RASTI method it is possible to measure speech intelligibility on a scale from 0 to 1, see Fig. 1. It is possible to complete one measurement in no more than 8 seconds.

The RASTI system consists of a transmitter, which is placed at the speaker's position and a receiver placed at the listener's position. By means of these two instruments it is possible to measure what happens with the speech intelligibility between the two positions.

The RASTI method takes into consideration the effects of:

a. background noise, i.e. in our case noise from the tyre/road, engine, wind, etc., and
b. reverberation and reflections. The reverberation and reflections inside a car depend upon the interior trim, i.e. the type of carpet, the seats, the roof lining and all reflecting surfaces.

Both these phenomena are automatically taken into account when carrying out the measurements and no corrections have to be applied. Another advantage is that measurements are performed with both the test signal and background noise present at the same time so that the signal and the noise do not have to be measured separately. The RASTI value is derived from MTF measurements in 500 Hz and 2000 Hz octave bands.

Noise in Cars

The noise in the cabin comes from several noise sources. Usually the dBA level is used in connection with noise control design but because a rather small difference in the dBA level can subjectively be evaluated as a significant difference, most car manufacturers also use a subjective evaluation of the noise. It is a time-consuming and not very exact method. RASTI is a measure for speech intelligibility, but in the future it can also perhaps be used as a descriptor of the noisiness of the car and its "sound" quality. Therefore several car manufacturers are evaluating the possibility of using the RASTI value instead of the subjective evaluation.

In connection with speech intelligibility and radio listening the problem is to design the car cabin in such a way that the noise is attenuated as much as possible, whereas the speech level remains as high as possible. Therefore the speech sound ought to be reflected round to the different seats in the cabin, whereas the noise should be absorbed. By means of the RASTI method it is easy to evaluate the effect of a change in the cabin design.

In the next section, a few measurements are mentioned where speech intelligibility between the seat next to the driver and the rest of the seats in the car is evaluated. The idea is not to show final results for the car design but just to show how it is possible to work with the RASTI method.

Measurements

The measurements described below were performed at Honda Research and Development, Tochigi Center, Japan.

Measurement Conditions

The measurements were performed in a standard passenger car, a Honda Accord, 2.0 Si, using the Brüel & Kjær Type 3361 Speech Transmission Meter. The transmitter was placed on the front passenger seat pointing towards the windscreen and at a height level with the passenger's head. This position was used during all the measurements.

The receiver was placed in five different positions, 0,20 m to the left of the driver's ears (DS, left) and 0,2 m to the right (DS, right) and on the left, center and right rear seats (RS left, RS center and RS right). Measurements were performed in a stationary car at different rpms and in a cruising car at different speeds. The car was mounted with studless tyres and driven with the automatic transmission in position D–2. The measurements in the cruising car were performed on dry asphalt and with no wind. The rpm was constant during the measurement.

Results and discussion

In Fig. 2 the results for the different positions in the stationary car are shown.

The difference in RASTI-value is only small between the positions for 1000 and 2000 rpm, whereas it is much greater for higher rpms, especially for 3000 rpm. The best results were obtained for DS left because this is the measurement point nearest to the transmitter. DS is at the right side of the car.

Fig. 3 shows the results from two positions at the rear seat for each of the two octave bands, 500 Hz and 2000 Hz. The results are better (higher RASTI-values) in the 500 Hz band for 3000 and 4000 rpm for RS left probably because of the directivity pattern of the transmitter, which is equal to the directivity of a human being.

The results from the driver's seat (DS, right) show much higher RASTI-values for the 2000 Hz band than those for the 500 Hz band, perhaps due to reflections from the windscreen (result not shown in the figures).

Fig. 4 shows an example of measurements made with different kinds of absorption in the cabin. All the results are from position DS, right in
(1) the standard cabin,
(2) with a thickness of 25 mm felt placed on the ceiling and
(3) with felt placed on the lower part of the four doors and on the floor.

By making experiments like these it is possible to optimize the attenuation of the noise and reflect the speech, so that the speech intelligibility is as high as possible.

Fig. 5 shows results from the cruising car. The car was mounted with normal radial tyres and was driven with the automatic transmission in position D–2 on a dry road.

It can be seen that the speech intelligibility is much better between the driver and the front passenger compared to the rear-seat passengers.

Conclusion

The measurements performed have shown that it is possible to evaluate the acoustics in a car cabin by means of the RASTI method. By experimenting with absorption material and its positioning the speech intelligibility can be optimized.

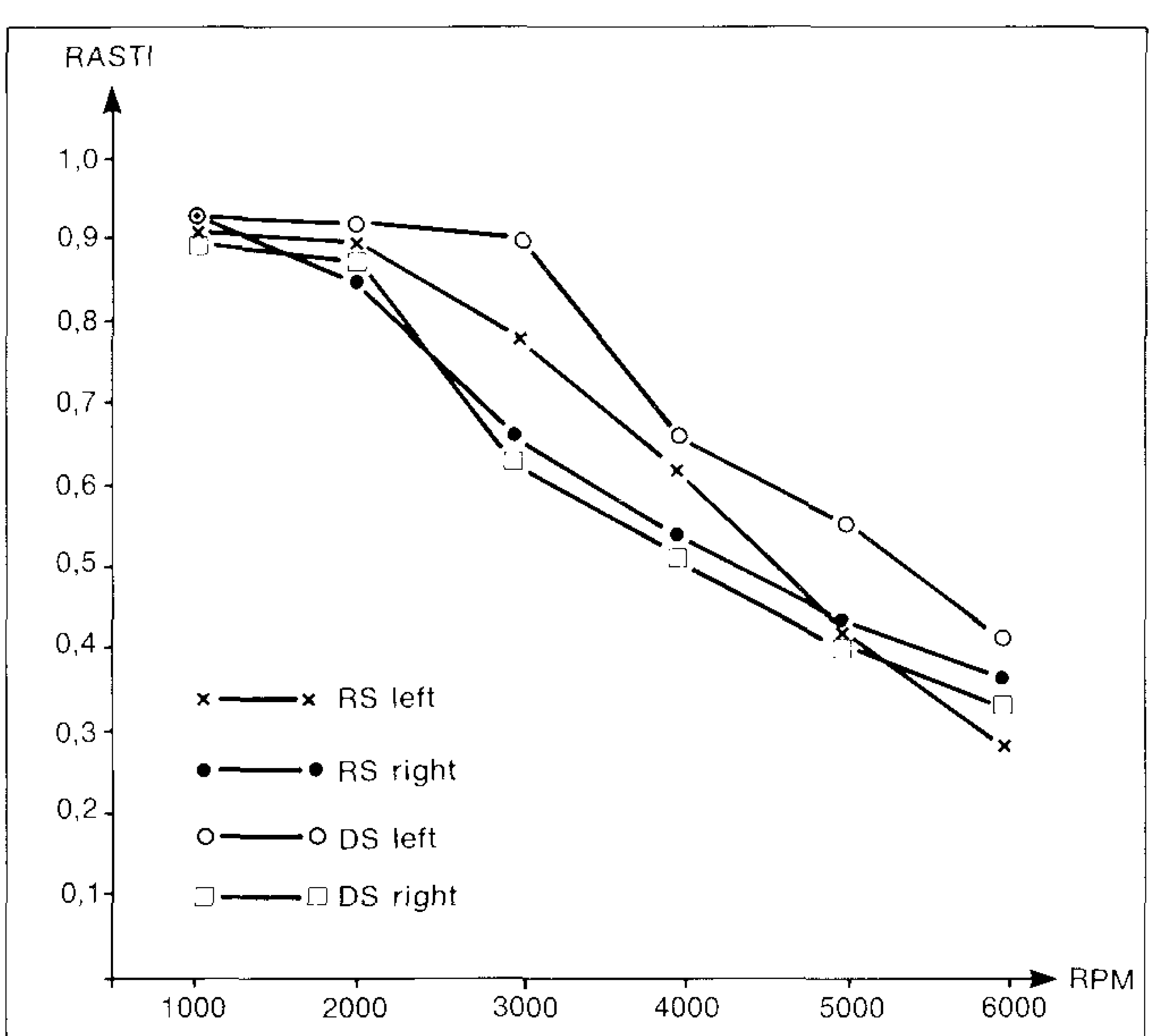

Fig. 2. RASTI results from measurements in a stationary car

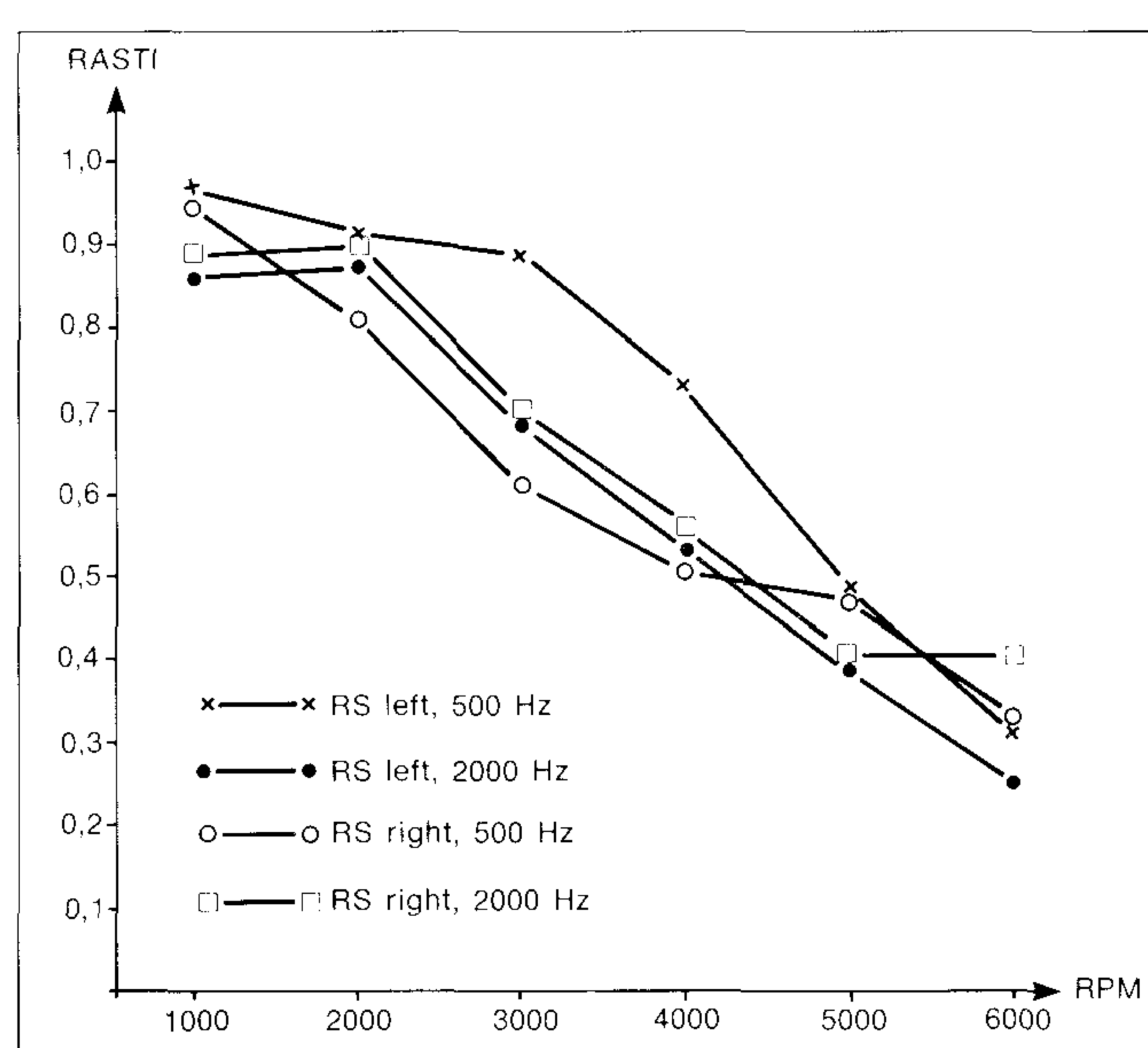

Fig. 3. RASTI results for the rear seats from Fig. 2 shown separately for 500 Hz and 2000 Hz octave bands

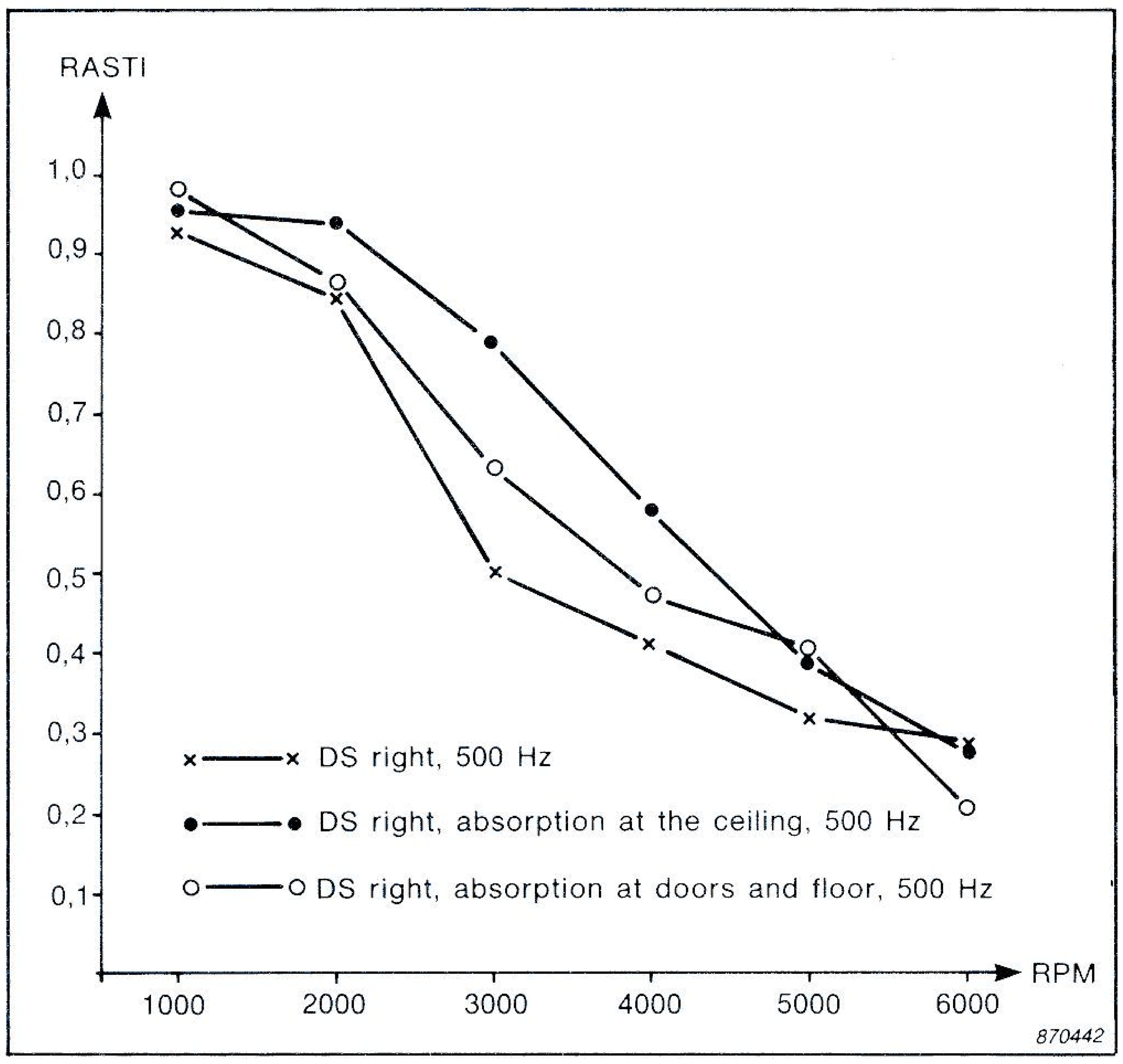

Fig. 4. Results with different kinds of absorption in the cabin for DS right and only for 500 Hz

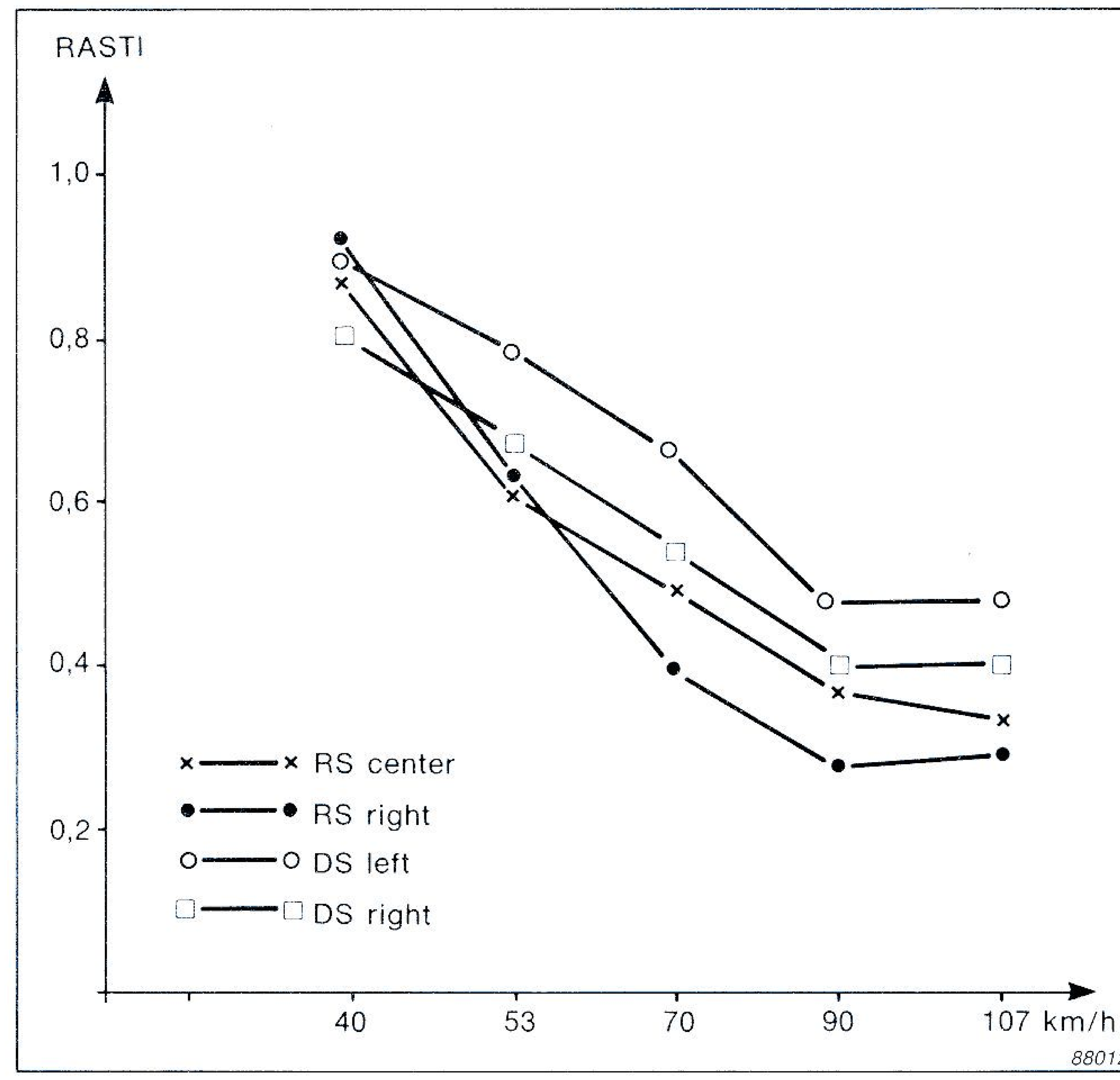

Fig. 5. RASTI results from measurements in a cruising car

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Fig. 6. The transmitter (Type 4225) of the Speech Transmission Meter placed at the front passenger seat

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