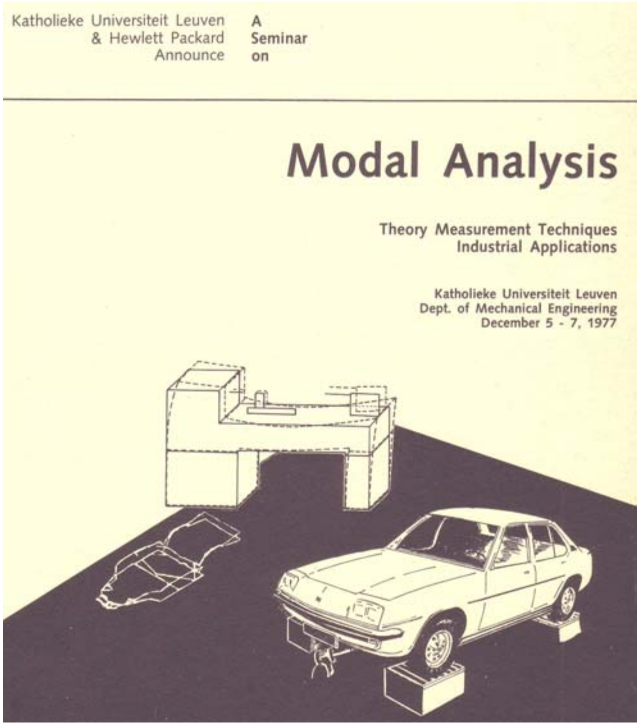
Excerpt from the Proceedings of the Seminar of Modal Analysis, Leuven 1977



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Chapter F : Industrial Applications

* Visual representation of the dynamic behaviour of machine tool structures	M. Weck
* Isolation of large structures with respect to seismic excitation	M. Alexandre
* Vibration Analysis of static elements of large turbo-alternators	Van Hulse Bellière
* Detecting noise sources with correlation techniques	P. Sas
* Aspects of Modelling machine tool structures	Prös̈zler
* Modelling	P. Van Honacker
* Vehicle Body Modes	Scheelke
* **High frequency noise associated with local modes**	**Thijs**
* Dynamics of Rubber	C. Demeersman
* Critical Speeds and Modal Analysis of anisotropic shafts: an experimental study of Bipolar alternators	G. D'Ans
* Vibration Analysis of Rotating Machines	L. Van den Noortgate
* Frequency Response Measurement Details. Calibration.	D. Brown

M. Weck & R. Thijs

VOLVO
Volvo Car Produktie St. Truiden N.V., St. Truiden, België

HIGH FREQUENCY NOISE ASSOCIATED WITH LOCAL MODES (*)

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SUMMARY :

Modal analysis has shown that the rejection of the Volvo CVT units (continuously variable transmission) by the plant's Quality Control department because of gear noise is, in most cases, not due to the gears themselves but to amplification of normal mesh frequency noise by local structures.

(*) This report was presented at the seminar on Modal Analysis held at the Catholic University of Leuven from 5th to 7th December, 1977.

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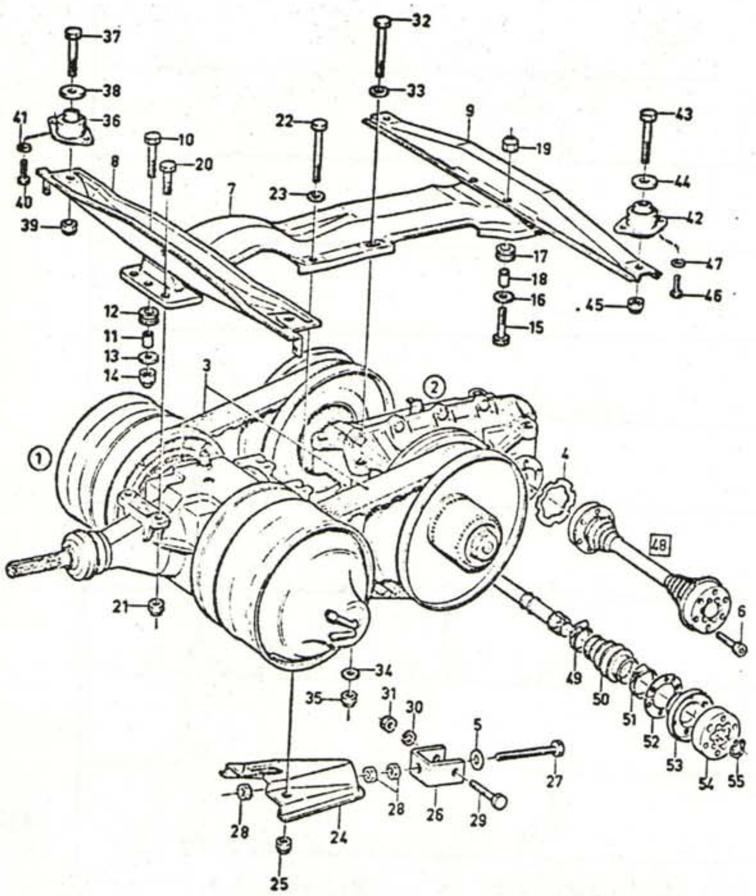
The Volvo CVT (fig. I) consists of:

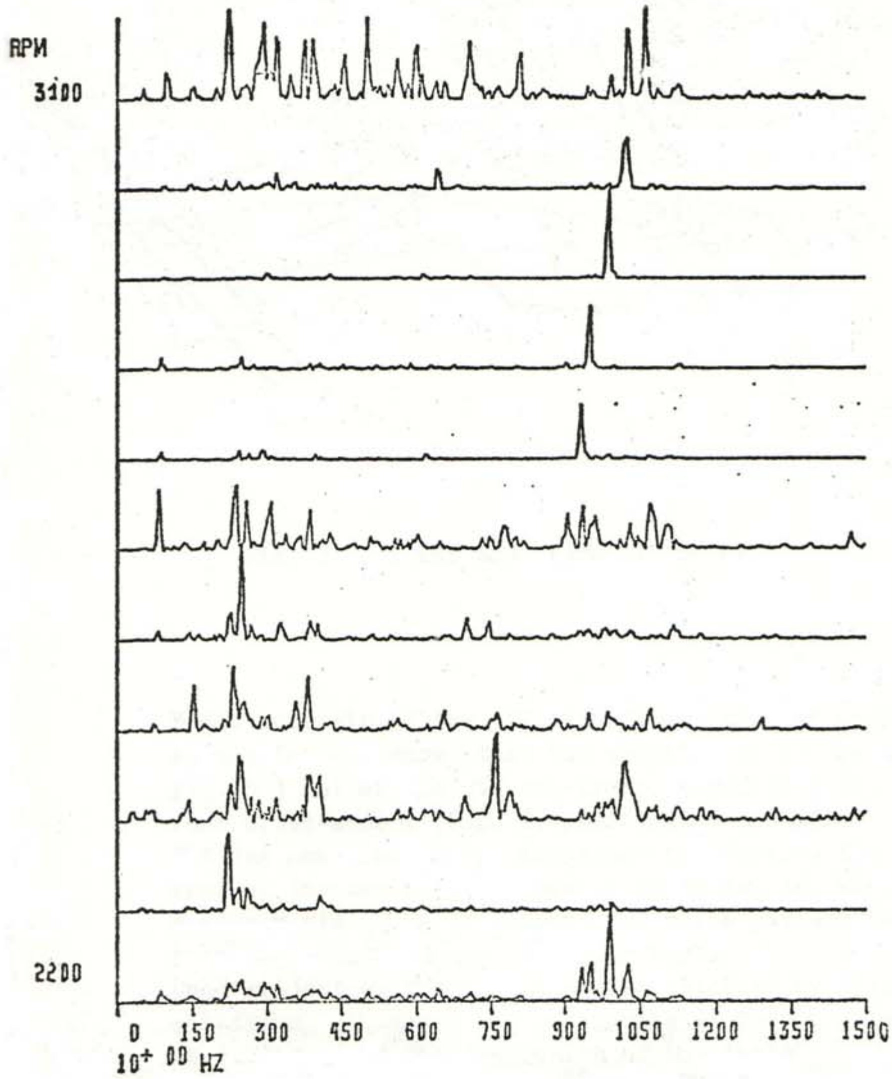


- A bevel gear reduction coupled to...
- ...a dual belt drive, with the endless belts running between four sets of mutually separable pulley halves. This permits continuous variation in transmission ratio because of the continuously changing running diameter of the belt between the pulleys. The final drive is obtained from...

...two helicoidal gear reductions, the final gear being matched with a satellite housing to form a differential.

Some transmission gearboxes are rejected by the plant Quality Control department because of unacceptable noise level when being tested under power in one of the test cars, even though they were initially approved on the test bench. This is usually a single tone irritation, shifting with engine speed in a limited rpm range. The source has been identified by the car test drivers as bevel gear mesh noise, and this has been confirmed by Campbell analysis (as for instance fig. 2) of the interior noise level of the car between the front seats; the recordings were made when driving under normal road conditions.

A complete set of diagrams and an explanation can be found under I.2.
The critical zone is situated around approximately I kHz.
A large number of gear testing measures are intended to allow for the control of the gear quality, up to predicting the noise behaviour under functional car conditions (see, for example, 3,4 and 5).



It has, however, been shown by tests conducted by the plant's Manufacturing Control department that marginal conditions can make one and the same gear set (with a good behavious pattern on both the gear test bench and the gear-box test bench; with optimal positioning, including relative angle and with a good gear mesh pattern) acceptable when combined with some series of mating parts such as the housing, etc.
On the other hand, rejection may follow when this gear set is combined with other mating parts, even though all the parts in question are - to a certain degree - identical. This results in reducing gear quality tolerances to an extremely fine degree until, suddenly, and without clear explanation, the noise problem is over.

Fig. 2 Campbell diagram for the interior noise level in the car between the front seats. The lower spectrum is the sum of the spectra covering the rpm range. Note: the vertical scales for each spectrum have been adapted (i.e. reduced or increased) in order to be able to illustrate the highest peaks in the range.

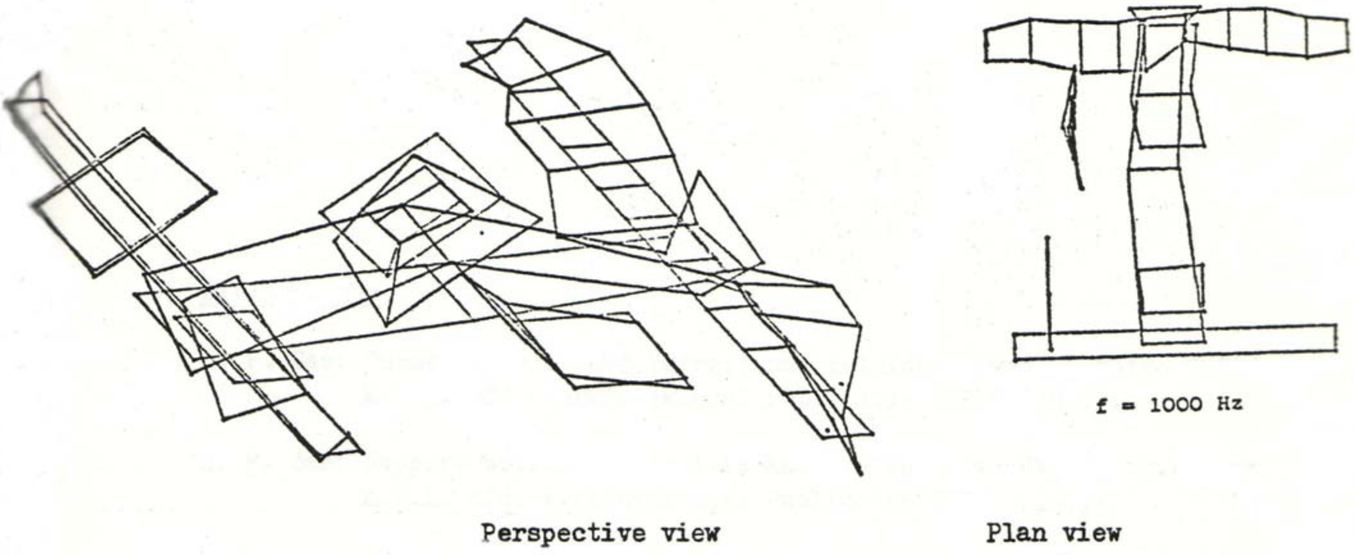


Fig. 3 I kHz mode form of the CVT

Modal analysis of the CVT itself, and the car underbody around the CVT suspension has shown that the sensitivity is due to I kHz local modes (see fig. 3) (6) of the CVT sub-frame, especially the longitudinal girder and rear cross-member (fig. I, positions 7 and 9).
Fitting new type rubber mountings to insulate the entire CVT unit from the rest of the car (fig. I, positions 36 and 42) was expected - from dynamical measurements (7) - to improve the noise pattern, but, up to now, this has not been confirmed by subjective car tests.
Good subjective results have been obtained by fitting rubber mountings in the sub-frame. Tests are continuing at Leuven University, and the results will be published at the conclusion of the tests.
Thanks are due to Mr P. Sas and to Mr M. Mergay (Leuven University) for the careful execution of the analyses.

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Items I and 2 have been included in the Volvo report 6.77/ST/2205, together with supplementary diagrams.

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