System Data

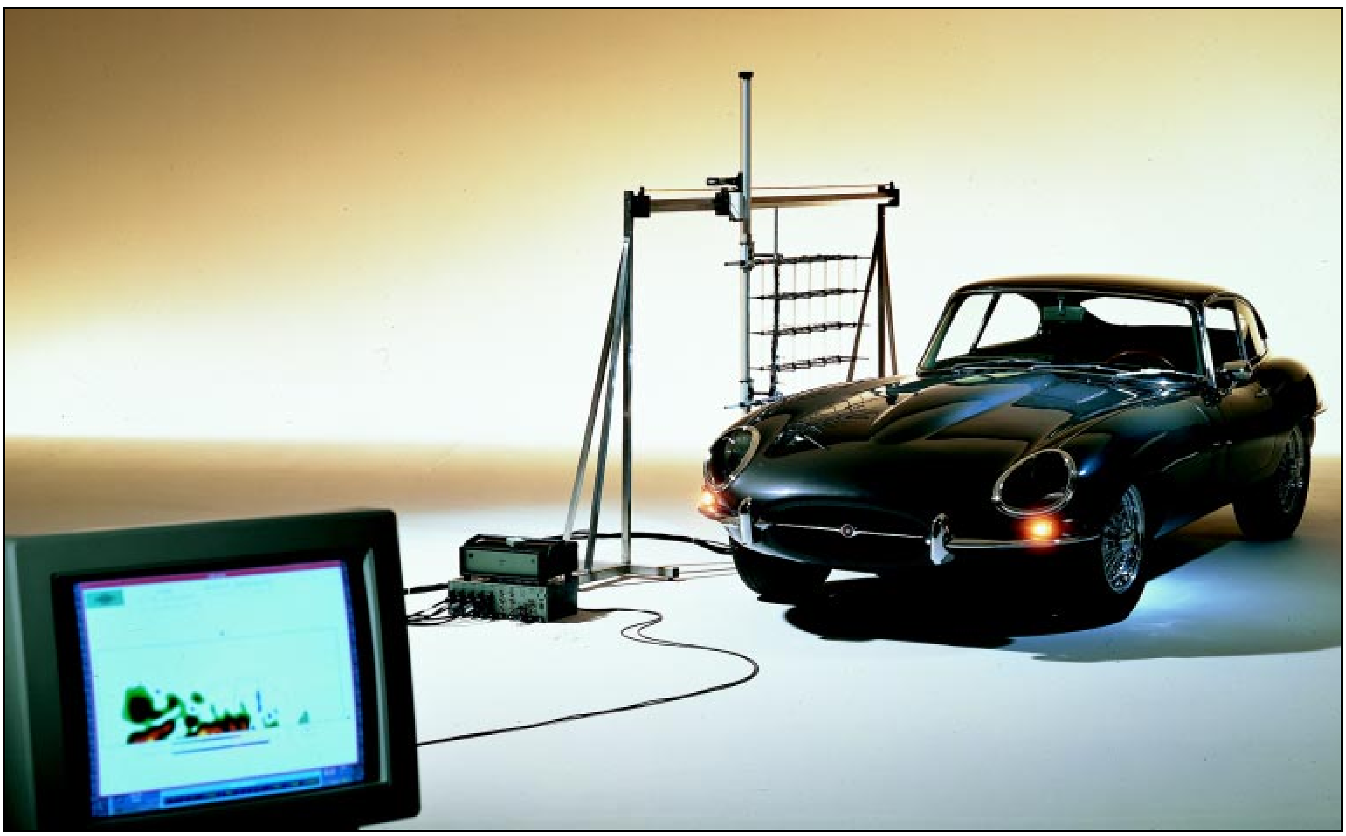
Spatial Transformation of Sound Fields (STSF) System — Type 9694

USES:

- ❍ High resolution source localization using active and reactive intensity, particle velocity, sound power and sound pressure
- ❍ 3 D visualisation of sound radiation
- ❍ Calculation of sound pressure level spectrum at specified points in space from near-field measurements
- ❍ Source contribution analysis
- ❍ Engine and gearbox testing
- ❍ Tyre/road noise analysis
- ❍ Complete vehicle noise analysis
- ❍ Wind noise measurements
- ❍ Underwater measurements

FEATURES:

- ❍ 42 channel STSF Type 7688 with 3561 front-end and 9665 microphone array configuration
- ❍ Inclusion and exclusion of partial fields
- ❍ Contour, vector and 3 D graphics for enhanced visualization of source location and sound radiation
- ❍ Complete measurement, data storage and analysis system
- ❍ Validation of measurement data
- ❍ Simulation of source modifications
- ❍ Support of flexible array size
- ❍ Fully annotated printer/plotter output



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STSF System Type 9694

Spatial Transformation of Sound Fields (STSF) System Type 9694 is a complete system for assessing the 3-dimensional sound-field of a test object, including functions for source modification simulation.

9694 includes Intelligent Data Acquisition System Type 3561 and Microphone Positioning Controller Type 9665.

A reference and scan microphone array of 42 transducers is used to obtain a complete description of the sound field (both near-field and far-field) within a given solid angle from measurements over a planar surface close to a stationary sound source.

The system runs under a HP9000 series 700 computer platform and includes the sophisticated colour graphics used to model measurement results. The enhanced colour graphics system includes:

- High resolution source localization and ranking
- 3D field assessment
- Simulation of source modification

General

STSF software applies the Helmholtz Integral Equation and Near-field Acoustic Holography to cross-spectra of the sound pressure over a plane close to the sound source, and then calculates the descriptors of the sound field at other points.

The Helmholtz Integral Equation is used to calculate the sound pressure level at larger distances, while Near-field Acoustic Holography is used to calculate pressure, particle velocity, and active and reactive acoustic intensity in the near-field region.

Sound is recorded using three sets of transducers:

- Scan microphones or hydrophones
- Reference transducers
- Exclude reference transducers

and measurements are made using Intelligent Data Acquisition System Type 3561

STSF software executes a number of data inspection functions including:

- Data validation
- Stationarity analysis
- Coherence and virtual coherence
- Principal component analysis

Measurement Description

A two-dimensional scan is made over a plane surface close to the test object, during which the cross-spectra are measured from each scan point to each of a set of reference points (scan measurement). The cross-spectra must also be measured between every pair of references (reference measurement). Further, the pressure is recorded at each measurement point in order to validate the data.

The system allows all power descriptors of the radiated sound field to be calculated from the sound pressure distribution, which is measured during the scanning of an array of single microphones over a measurement window. The source must be stationary during the scan.

During the collection of scan spectra, the use of traverse equipment for automatically moving the array microphones to the scan locations reduces the total measurement time significantly.

Reference Transducers

Reference transducers supply phase, amplitude and coherence information. The absolute values of the signals are not important although they must remain constant throughout the

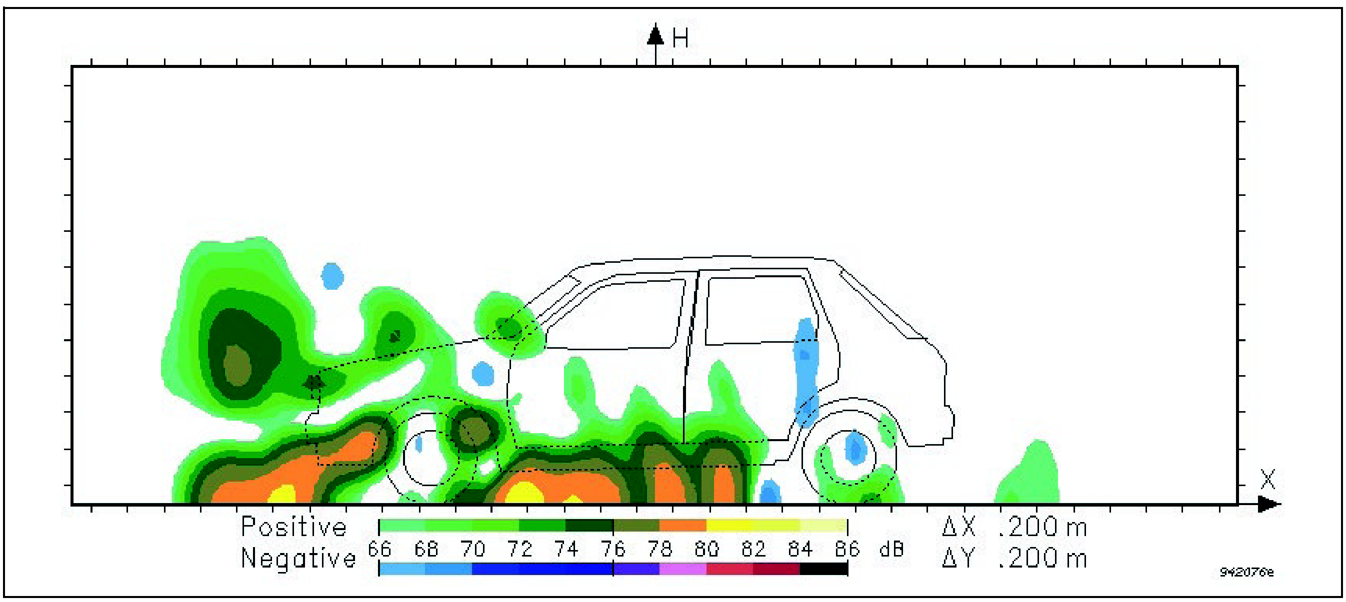

Fig.1 Active sound intensity of a vehicle on a dynamometer. Frequency range: 610 to 630 Hz with Z component of intensity at Z = – 0.2 m (at the surface of the vehicle)

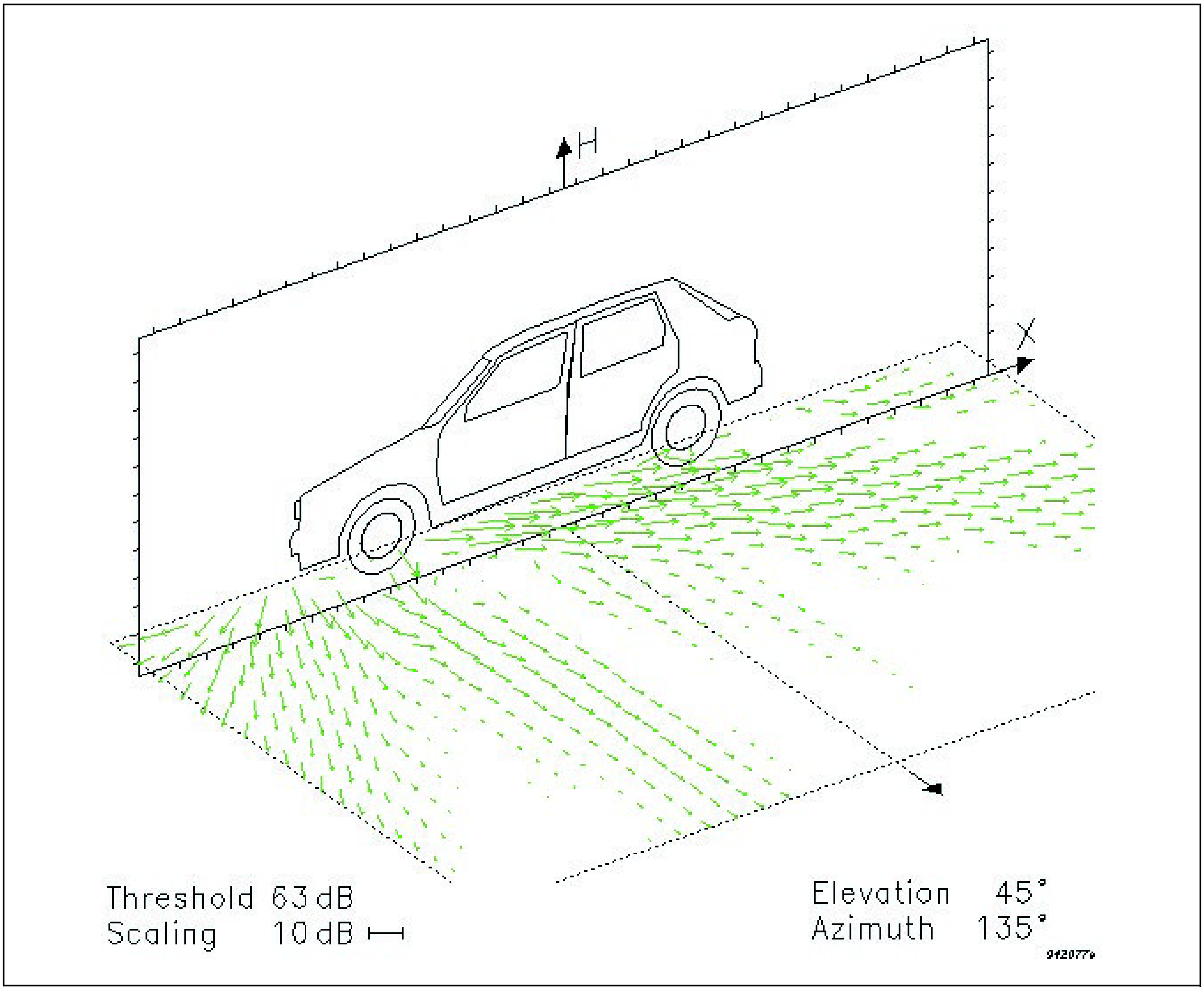

Fig. 2 Active sound intensity from a vehicle on a dynamometer. Frequency range 610 to 630 Hz with intensity vectors in the plane H = 0.1 m (0.1 m above the reflective ground plane)

measurement. Thus, the reference signals can be provided by microphones, hydrophones, accelerometers, laser velocity transducers, etc.

The reference transducers are used to distinguish between the different mutually uncorrelated partial fields in a sound field and to achieve a complete model of the sound field in the measurement region.

An STSF measurement provides a complete model of a sound field, if the set of references can distinguish all significant, independent sources through a number of sufficiently different views. Thus, the number of references must be at least equal to the number of significant, independent sound sources.

Exclude References

Exclude references are used to remove strong background noise in cases where this background noise cannot be avoided by the normal (include) reference signals. In order to be applied properly, the background noise must be the only noise picked up by the exclude references.

Scan Transducers

The scan transducers must be free-field or pressure microphones, or hydrophones, with mutual phase deviations not exceeding ±3° within the frequency range of interest. In addition, their amplitude linearity must be good and they must have a high stability.

Stationarity Monitoring

During a measurement, the STSF software monitors deviations from stationarity of the reference signals. For each reference this is done by comparing the current autospectrum with the autospectrum that was measured during the reference measurement, which is done first.

Inspecting the Sound Field Model

At any time during the measurement the validity of the measured data can be checked by inspecting various parameters in the sound-field model. In this way it can be verified that the correct number of reference transducers have been used, and that a reliable sound-field model has been calculated.

Data Post-processing

Once a measurement has been completed, various types of calculations can be performed using Near-field Acoustic Holography (NAH) or Helmholtz Integral Equation (HIE), or both.

To calculate the radiation pattern or Sound Pressure Level (SPL) along a line, NAH can be applied to perform a spatial windowing and filtering of the measured data before HIE is applied to obtain the desired output.

Summary of Post-processing Capabilities:

- **Holography:** calculation of pressure and the normal component of the particle velocity, active and reactive intensity in any plane parallel to the measurement plane (Fig. 1)
- **Vector Intensity:** calculation of 3D active and reactive intensity vectors in a set of planes parallel to the measurement plane. From these calculations, plots of the intensity vectors can be made in planes orthogonal to the measurement plane (Fig. 2)
- **SPL along a line:** calculation of the SPL spectra at a set of points along a horizontal line parallel with the scan plane (Fig. 3).
- **Radiation pattern:** calculation and graphical representation of the far-field SPL radiation pattern.

In addition to these functions a **Simulation of Source Attenuation** function can be applied to modify a given sound field. The results can then be viewed graphically.

Graphical Results

Sophisticated graphics output functions included in the STSF software provide a platform for viewing the calculated data both two and three-dimensionally.

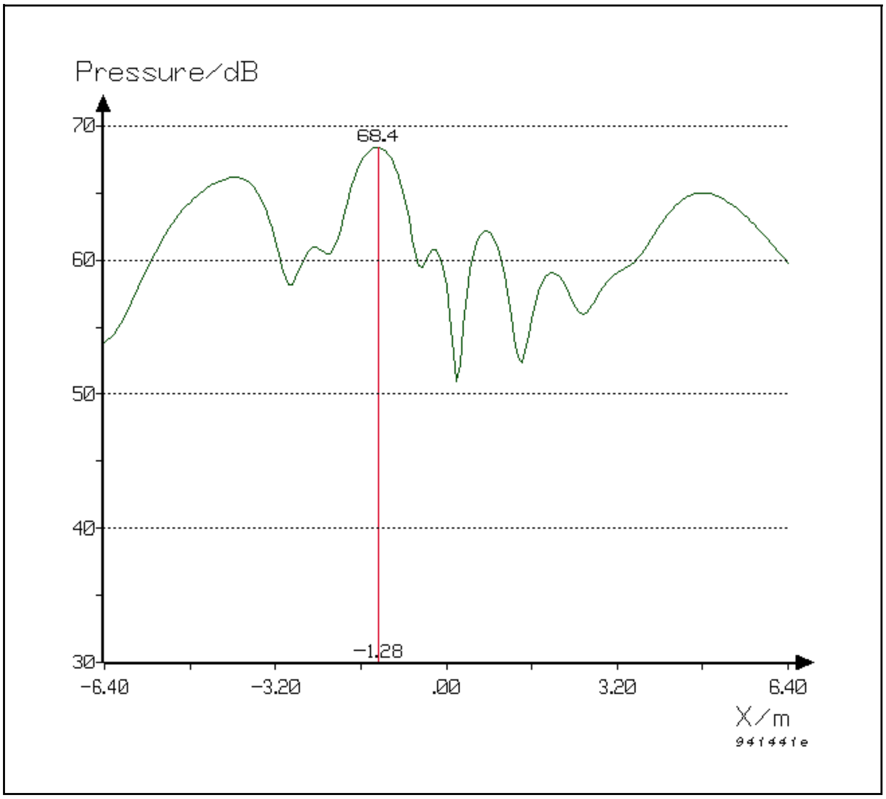

Fig. 3 Sound pressure level from the same vehicle and for the same frequency range as in Figs. 1 and 2: SPL along a line 0.1 m above the floor at Z = 3.6 m, the outer limit of the 3D vector plot in Fig. 2

Through the use of a digitizer or via mouse, source drawings can be introduced. Measurement results can then be displayed overlaid on the source drawing. In addition this function will allow you to align source drawings to define areas for source ranking and to define a source attenuation function for simulation of source modification with respect to the measurement scan area.

Another function provides a range of graphical representations of post-processed (calculated) data, for example spectra, function graphs, 3-D plots, line and contour plots, and vector plots in 2 and 3 dimensions.

A radiation pattern calculation enables the SPL over a (projected) hemisphere or a plane to be plotted (Fig. 3). An SPL calculation along a line allows plots of frequency-weighted SPL along that line or SPL spectra at points on the line to be obtained.

A holography calculation provides pressure, particle velocity, active and reactive intensity over an output plane parallel with the measurement plane. Any one of the four different parameters can be plotted. In addition, the sound power for various parts of the scan area can be obtained.

From a vector intensity calculation, all vectors in any principal plane (xy, yz or xz) can be plotted in a 3-dimensional view.

Computer Platform

STSF runs on the HP 9000 series 700 workstation which makes very fast Floating Point calculations.

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