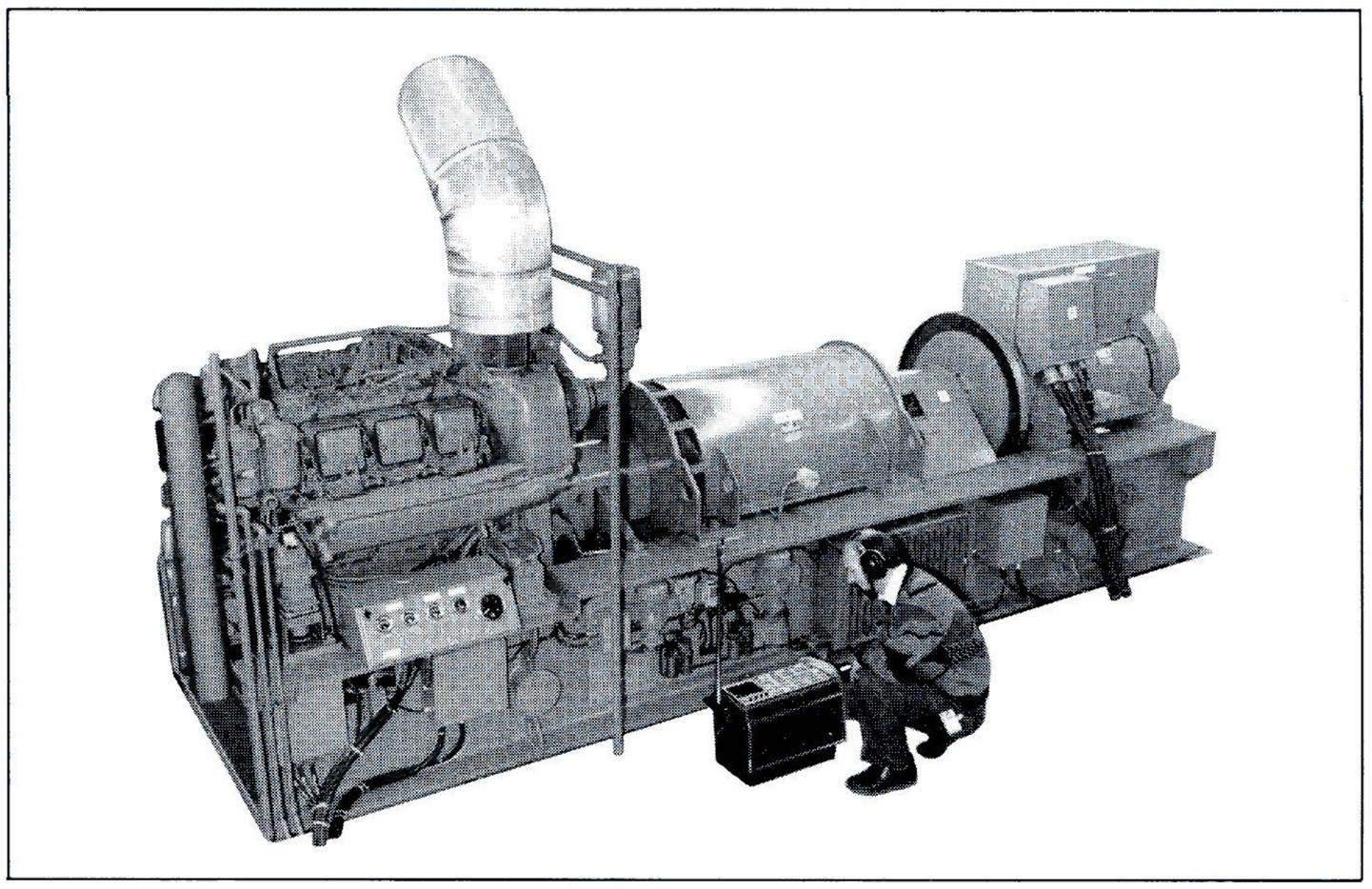
Brüel & Kjær application notes

# Power on – whatever the weather!

## Vibration monitoring on a canadian weather-centre's diesel-generator sets

This Application Note describes a machine monitoring system in use at the Canadian Meteorological Center, Montreal, Canada. Vibration analysis is used to maintain a check on the condition of 3 backup diesel-generators, essential for ensuring the continuous operation of the weather center's computers.

A portable vibration analyzer allows accurate and reliable on-the-spot fault-detection and trouble-shooting of vibration problems. The analyzer interfaces to a personal computer for a high level of data management, postprocessing of data for further fault-analysis and maintenance scheduling.



**Measuring vibration on one of the three diesel-generator sets providing back-up power for the weather center's computer systems. It is imperative that the condition of the three sets is kept up to scratch as a failure of the power supply would have very serious effects**

## Introduction

Maintaining a proper power-supply to a weather center's computer systems is of the utmost importance. Data and information procedures are distributed from the Canadian Meteorological Center to regional offices and from there redistributed to airlines, cities, shipping, farmers and fishermen, and so the importance of maintaining constant weather information is paramount. A computer crash would obviously have some very serious effects, both with regard to safety (no snow and storm forecasting) and finance (the cost of computer downtime can vary from 10000 Cd$ to 40000 Cd$/hr).

The computer systems used by the Canadian Meteorological Center are two Cray Supercomputers and a number of Control Data Computers. They analyse weather from the whole of the northern hemisphere for retransmission to local weather stations across canada. The vibration-monitoring programme is run by 101430 Canada INC, who are the general contractors responsible for the maintenance of the Meteorological Center.

### The Success of the Monitoring Programme

The vibration analysis system has proven to be a very valuable tool for maintaining a high level of reliability of the generator sets. On average, the back-up system experiences some 400 starts per year, including a recent 6 hour run. Since initiation of the monitoring programme in April 1986, there has been zero computer down-time due to power supply irregularities.

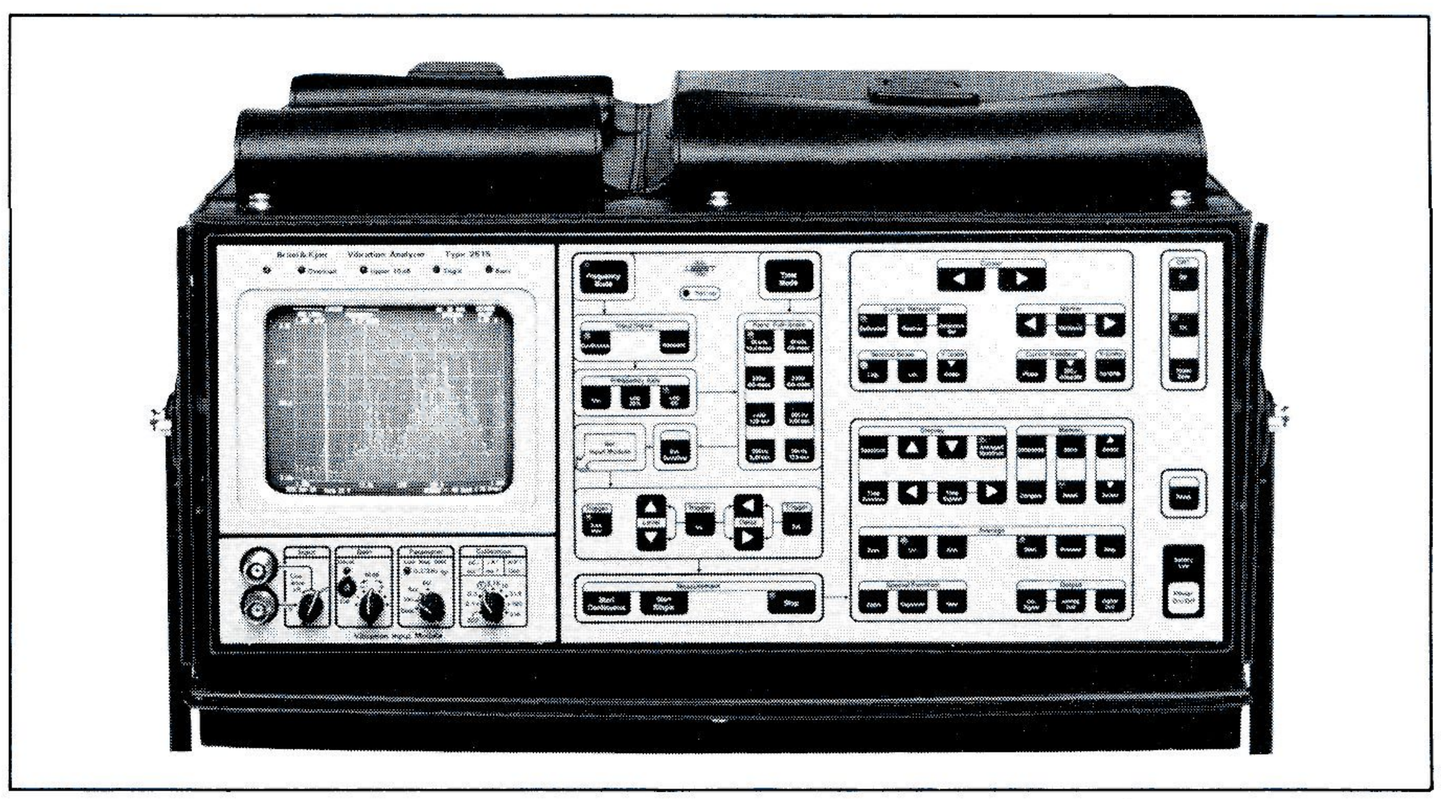


*Fig. 1. The Type 2515 Vibration Analyzer*

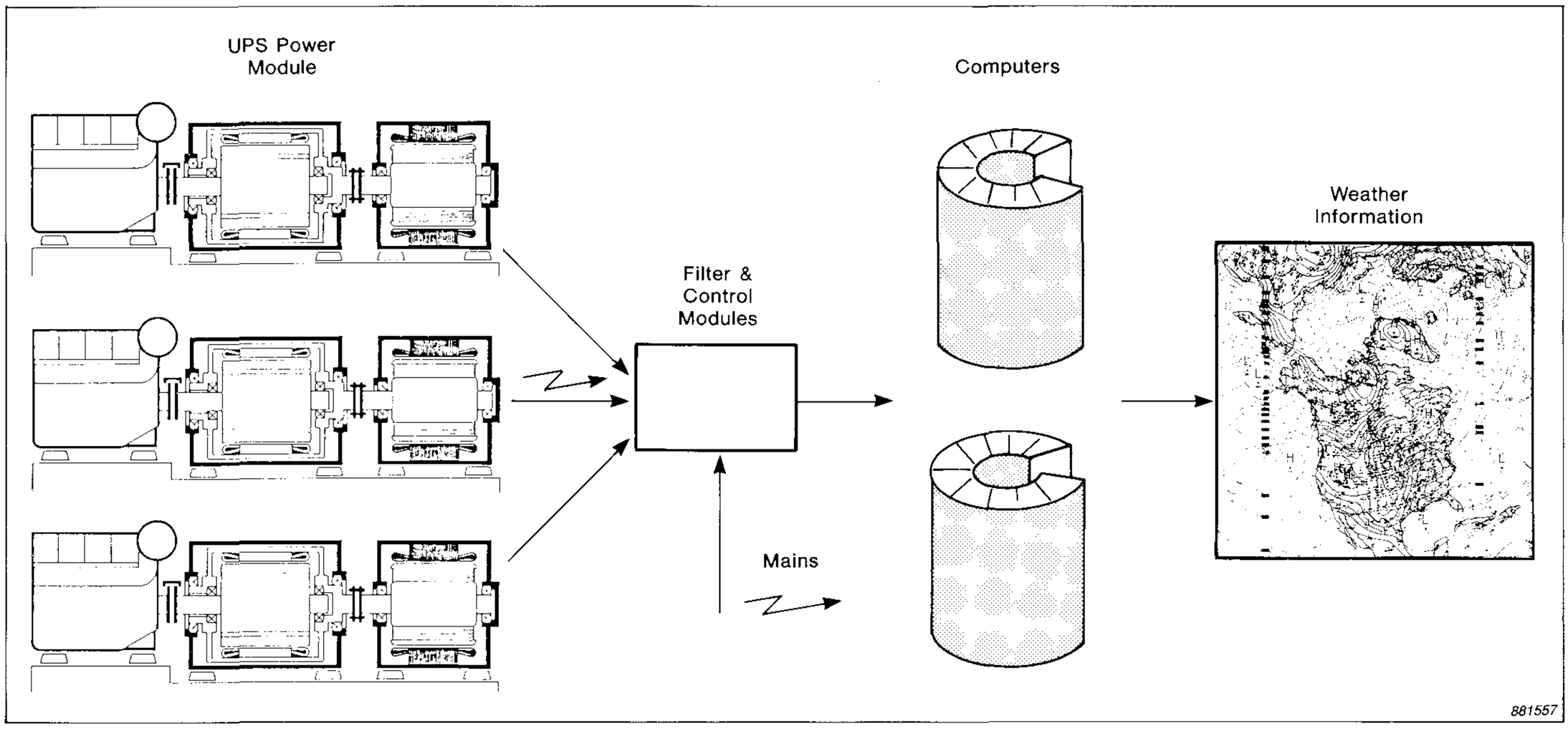



*Fig. 2. Layout of the UPS back-up power supply system. On average the system starts up some 400 times/year, and must be up and running within 1,2 seconds of starting, making it critical that a high level of reliability is maintained at all times*

# The Diesel–generator Sets

Back-up power is supplied to the computer systems by a Holec Diesel UPS (Uninterrupted Power Supply) System, comprising three 400 kVA Diesel-generator Sets, see Fig. 2. The purpose of the UPS system is to provide power at the required quality when mains-power interruptions, phase failures and voltage or frequency variations occur that cannot be cured by filtering. The system should do so without any interruption and for an unlimited period. On average, the UPS system cuts in some 400 times per year to provide the backup power for the computers.

The generator system comprises a diesel engine, induction coupling and an AC generator. In the event of a mains power irregularity, the diesel will start up to a speed of 1840 RPM within 1,2 seconds. During this start-up time, there is enough energy stored in the induction coupling to provide current (for about 4 seconds) to the computer systems.

## Monitoring the Generator Sets

Problems could arise from a number of sources. The most cause for concern is the fact that the diesel engine, induction coupling and generator units are mounted in-line on a common base. If the base twists or the diesel engine moves then misalignment could occur, the effect of which can be to damage the generator set's six journal bearings. Vibration monitoring of the sets has in fact detected journal bearing problems after as little as 50 running hours. Unbalance of any of the rotors could also be a problem and, of course, magnetically induced problems could occur in the induction coupling and AC generator.

## Monitoring Vibration for Predictive Maintenance

Together with monitoring vibration from the generator sets, 101430 Canada INC permanently monitor all operating parameters, i.e. load, voltage, current, temperature, oil pressure etc. However, these performance parameters, which may of course respond in some way to a fault, cannot be used effectively for predictive maintenance. Unlike vibration monitoring, they cannot be used to detect faults at an early stage, to diagnose the exact nature of the fault or to carry out trending for maintenance scheduling.

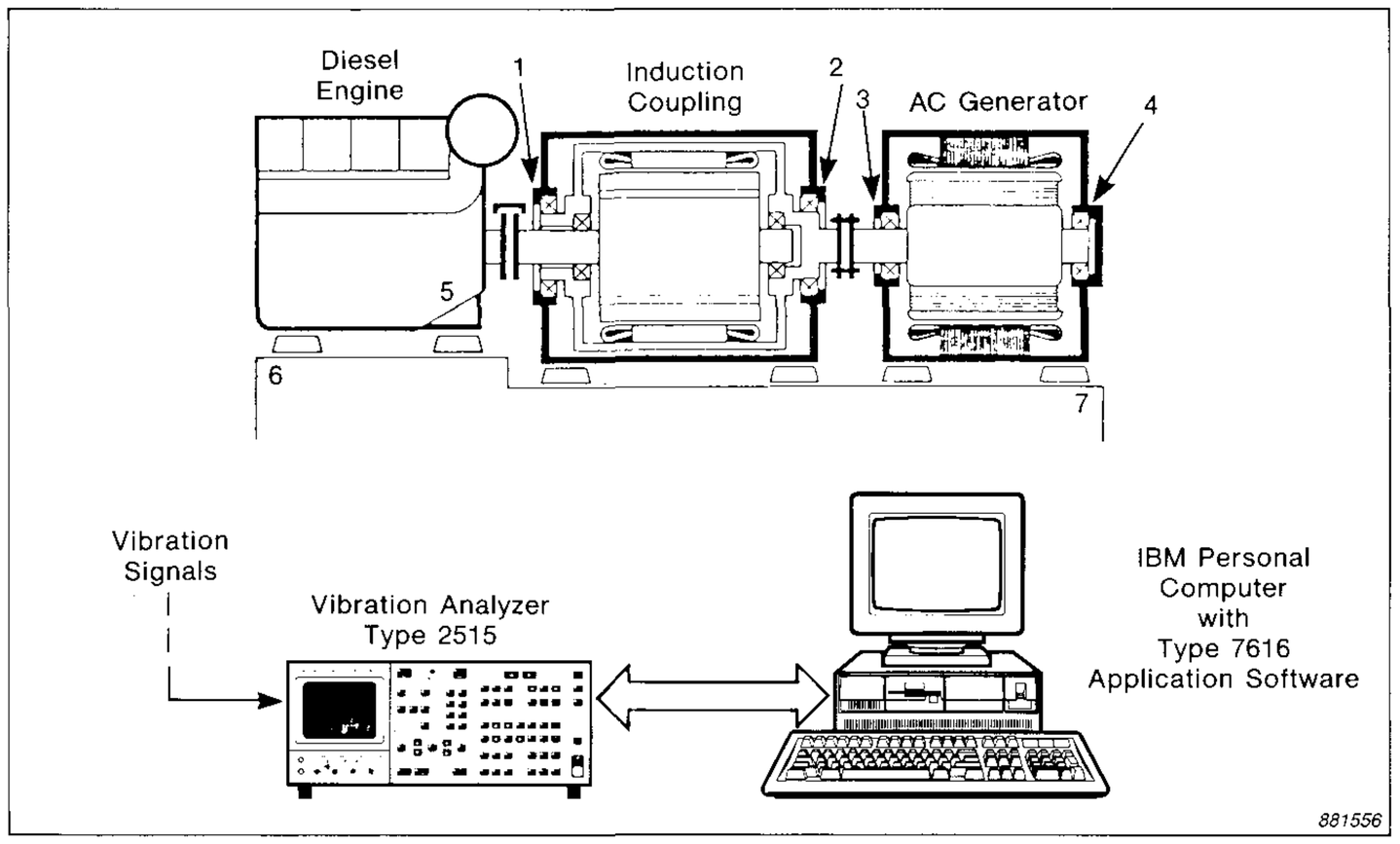



*Fig. 3. Layout of one of the three diesel-generator sets, showing the monitoring instrumentation and measurement positions used for the vibration analysis*

# The Machine Monitoring Programme

The vibration monitoring system comprises a Type 2515 Vibration Analyzer and Type 7616 Application Software. Fig. 3 shows the measurement setup and the measurement positions on the diesel, inboard- and outboard-bearings of the induction coupling and generator, and the common base.

### Type 2515 Vibration Analyzer

The Type 2515 is a portable, battery-operated FFT analyzer that can be used for on-the-spot detection and diagnosis of machine faults. It is an extremely powerful analyzer, with built in features like spectrum comparison for fault detection, and narrowband analysis, zoom, phase and cepstrum for fault diagnostics.

### Type 7616 Application Software

For mass storage of data, post processing etc., the Type 2515 is interfaced with an IBM Personal System 2 computer running Application Software Type 7616.

At the beginning of each measurement operation, reference data is loaded from the computer into the analyzer. The 2515 is then used to collect current vibration data, comparing this with the reference data on-the-spot if required. When all measurements are finished, the data is unloaded back into the computer where spectrum comparison can be carried out. This determines if the current spectrum has changed relative to the reference spectrum, indicating a fault.

In the event of a fault being detected, the Type 2515's powerful analysis functions can be used to accurately diagnose the nature of the fault. 3-D plotting and trending can then be carried out to help with maintenance scheduling. Any operating parameters (such as the load, voltage, current, temperature or oil pressure) can be entered into the computer for trend analysis along with the vibration data.

### Making the Vibration Measurements

Fig. 4 shows an example of a spectrum comparison taken from UPS System #1 measuring at point 7 in the horizontal direction, comparing measurements made on the 07/1/88 with the reference recorded on the 23/9/87. Increases at the ½ ×, 1 ½ ×, 2 ½ × and 3 × rotational frequency are evident. These increases were indicative of looseness, and thus perhaps the beginning of a journal bearing problem.

Using the computer's trend programme will enable the maintenance engineer to follow the development of this fault, allowing him to maximize the running time of the unit before scheduling maintenance.

Fig. 5 shows a narrowband spectrum from UPS System #2 measuring at point 5 in the vertical direction. This shows the power of the analyzer, as each of the peaks in the spectrum can be related to individual machine components/phenomena with extremely high accuracy. Note the difference in the frequency scales of Figs. 4 and 5. Fig. 4 goes from 60 RPM to 60 000 RPM on a logarithmic scale, and Fig. 5 from 24 RPM to 6 000 RPM on a linear scale. Hence the type of spectrum in Fig. 4 can be used for fault detection over a wide frequency range, and that in Fig. 5 for a more detailed vibration analysis. An even higher resolution can be obtained with the use of the Analyzer's zoom function. This could be necessary, for example, when checking the condition of the unit's journal bearings where frequencies at slightly less than half rotation speed (42 to 48%) could appear and would thus have to be watched closely.

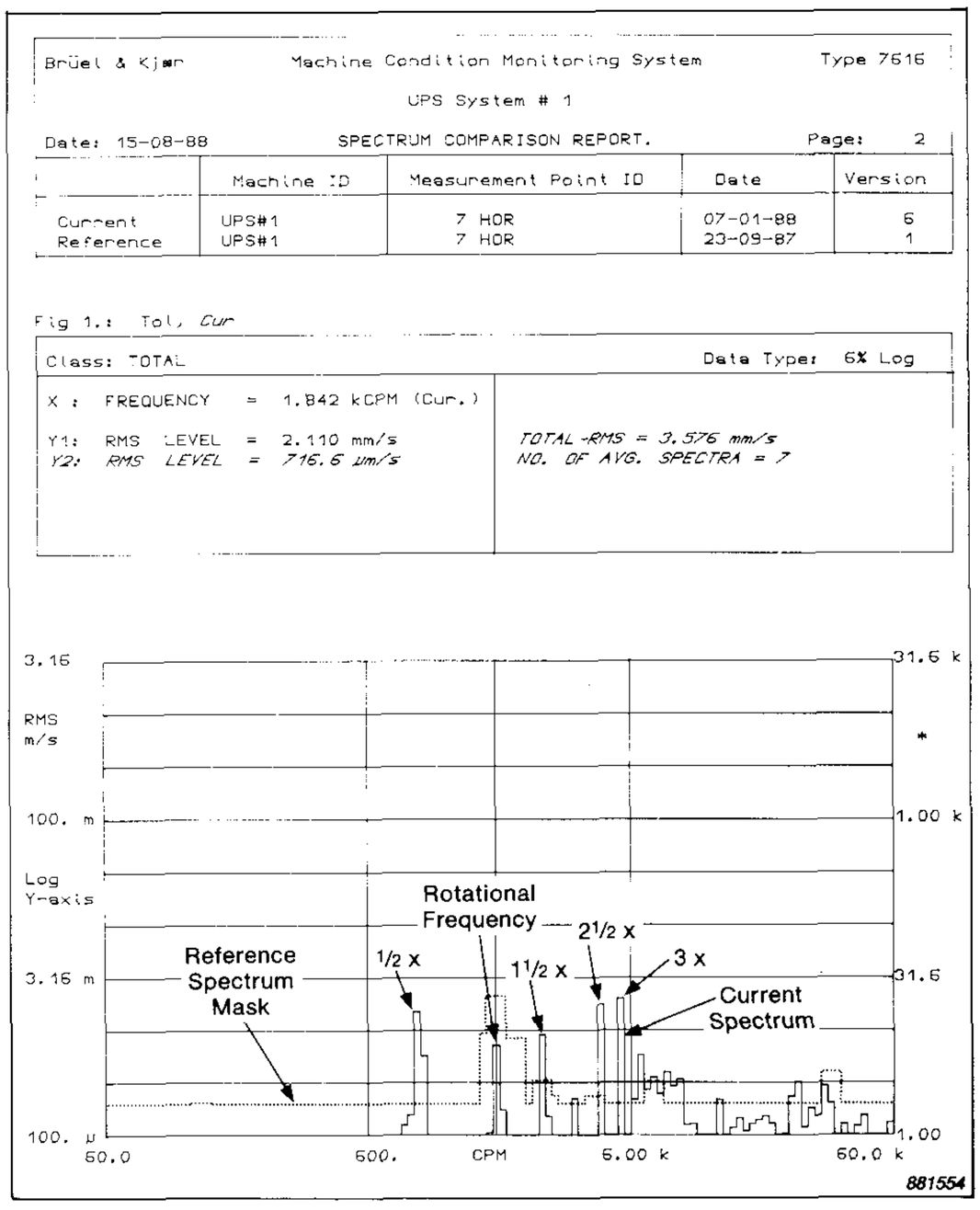



*Fig. 4. Spectrum comparison from the generator showing significant increases at ½ ×, 1 ½ ×, 2 ½ × and 3 × rotation frequency*

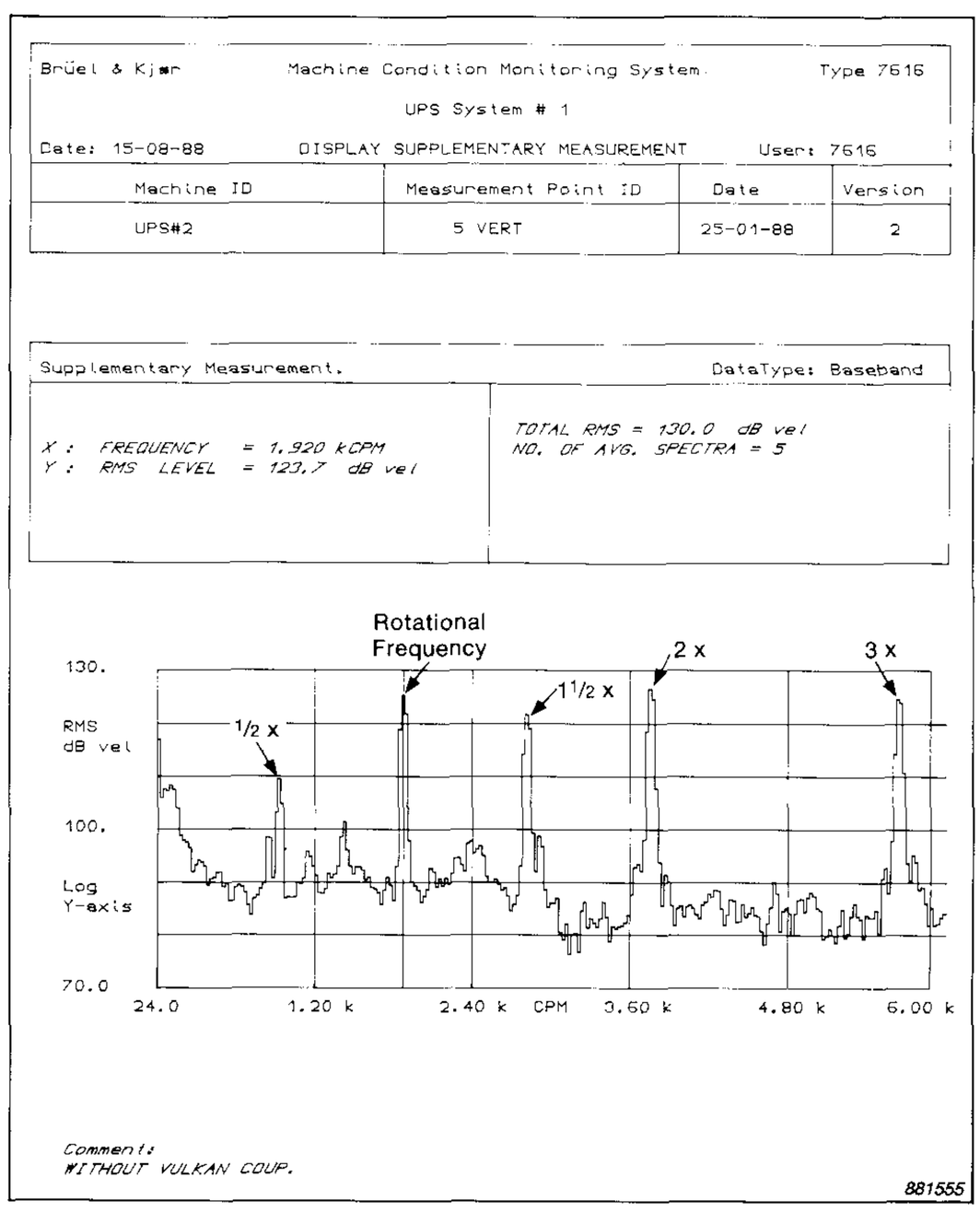
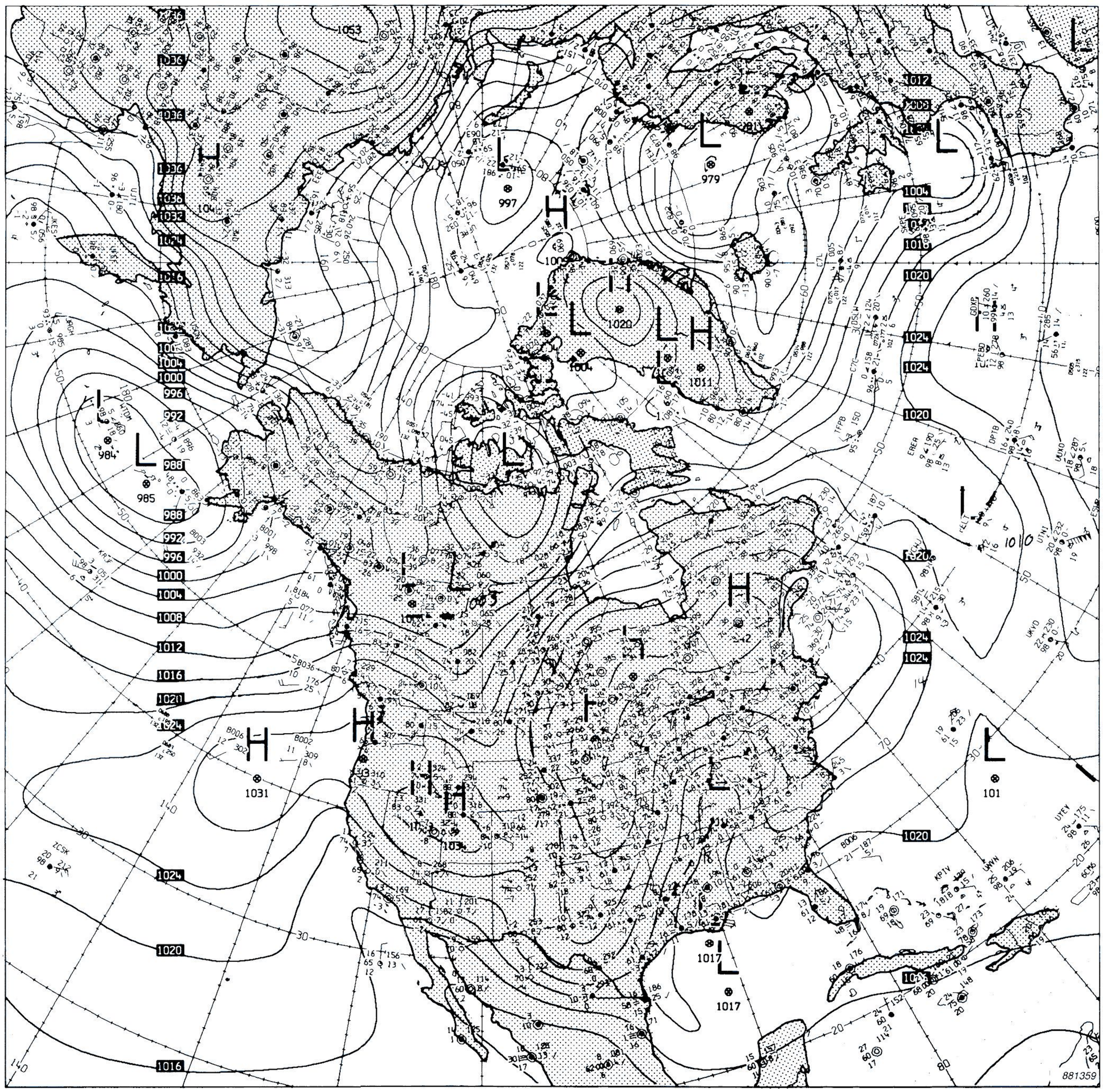



*Fig. 5. Narrowband spectrum showing the high frequency-resolution needed for trouble-shooting vibration problems*

# Acknowledgments

*The author wishes to thank Richard Desrosiers, Building Manager for 101430 Canada INC, for his help in gathering information for this Application Note.*



The early days of weather forecasting, just like the early days of vibration monitoring, suffered a bad reputation from poor accuracy and reliability. Measurement and analysis techniques in those days were just not the sophisticated tools they are today. This has now all changed, with the correct measurement techniques, dedicated analysis systems and a fuller understanding of the problem. What, in those days, was mostly art and guesswork, is now science and understanding.

Brüel & Kjær has been in the sound and vibration business for well over 40 years and has built-up a well-earned and enviable reputation. Our transducers are unrivalled for accuracy and reliability, and our analysis systems use unique yet well-tried techniques to confidently pickup just about any fault on any type of machine. Call or write to your local Brüel & Kjær representative today. We can't promise that the sun will always shine on your plant but we'll at least put a stop to those rainy-day breakdown blues.

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