BRUEL & KJAER application notes

Bearing Monitoring Equipment for Gear Driven Paper Machines

by *Hans Mærsk-Møller,* Brüel & Kjær

Introduction

The task of monitoring the bearings in a large paper machine in order to discover bearing defects at a very early stage and thus to ensure inexpensive repair work is not quite easy. The many assembled rotating elements influence each other, and the various structure resonances also interfere with the general pattern. Therefore, it is necessary to measure on each bearing.

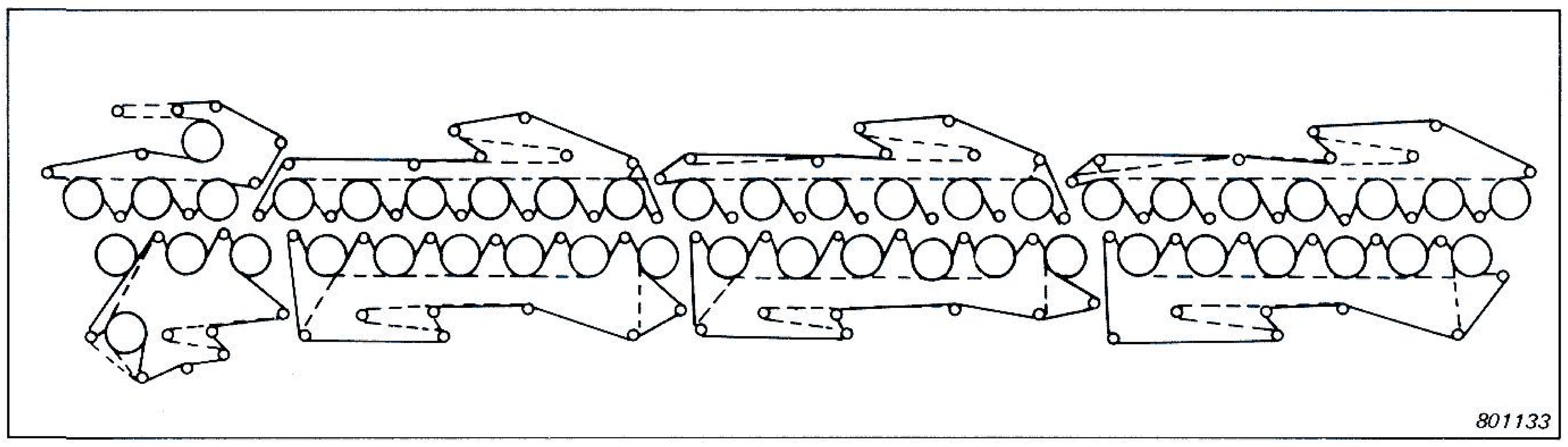

Fig.1. **Schematic diagram of a paper machine showing the large number of rollers and consequently the even larger number of bearings involved**

Those paper machines which have a gear drive of rollers have furthermore the tooth meshing frequency with the higher harmonic as a strong disturbance frequency that is transmitted widely in the machine. These disturbance frequencies totally cover the development of even severe bearing defects, and a monitoring system for such machines must therefore suppress these frequencies.

If approx. 300 bearings have to be monitored, the price per channel is, of course, of great interest. It is essential to bear in mind, however, that purely purchase price considerations can reduce the quality of the system so much, that the task of measuring cannot be performed reliably through the coming years.

On paper machines not all bearings are accessible when in operation, and it is therefore not possible to go and collect data with one accelerometer + one vibration meter + one tape recorder for later analysis. This method known from other process industries can be modified so that one accelerometer is permanently mounted for each measurement point with difficult access and then periodically connected with an analyzer and measured. In this case the accelerometers can be the assymetrical (single ended) types in stable standard version; there has to be, however, a permanently connected cable (not a plug) on the accelerometer for surviving the harsh surroundings.

Going further and trying to connect all accelerometers with a switch, so that all measurements can be performed at one place will involve necessary isolating work in order to avoid ground loops. The longer cables are also more sensitive to hum.

The actual B & K Industrial Accelerometers are internally isolated and are used together with symmetrical cables and preamplifier to suppress electromagnetic noise; they are mechanically very stable. It is no problem to mount them unisolated.

In principle, the 300 accelerometers can thus be connected to a joint switch from where the signals can be led to a vibration meter and an analyzer. With this system the vibration signal from each channel can be measured once a week or day and the spectrum be compared with an individual reference spectrum — either manually or automatically.

As the switch works before the preamplifier, it must have very high impedances. Unfortunately, such high impedance switches have a very short lifetime and give many switch pulses, that can interfere with the automatic measurements. If it is intended to build an actual monitoring system, it is therefore necessary to insert individual preamplifiers before the switch mechanism. Fortunately stable and low-cost multichannel-preamplifiers with electronic switches, so called Monitor Multiplexers, are available.

Many of these units can be operated with a monitoring instrument, and in principle only one monitor per installation is needed.

In practice seldom more than 40 channels per monitor are seen in order to avoid too long intervals between measurements in one channel and not to block the entire system with a fault in a single channel.

Preliminary Test

On the actual machine vibration measurements with analysis on a main roller and a felt guide roller have been made. The analyses are shown on Fig.2. The parameter used is acceleration and the analyzer is a Type 3348 Real-Time Analyzer with Type 2307 Level Recorder. It is clearly seen that all spectra are dominated by the tooth meshing frequency Z and the 2 higher harmonics 2Z and 3Z between 200 and 800 Hz. (Today one would use a Type 2033 Analyzer).

From experience we know that the height of these peaks is not much influenced by the gear condition and often not at all by changes in the bearing condition.

Early information about bearing changes are best seen from high frequencies (example: Roller 28 at 6—7 kHz) and working order (unbalance, misalignment, etc) is seen from rotation frequency and its harmonics. Monitoring the bearing vibration every 3 months shows the increase in vibration as indicated in uppermost curve of Fig.2.a. Only during the last few percent of the machine's life would there be a chance of seeing any change in the running speed component.

Further investigations concerning the relationship between the individual machine elements and the peaks in the frequency spectrum have been made. As they rendered no information essential for the construction of the monitoring system they are not mentioned here.

For this set-up we propose that the permanent monitoring system controls the total level in the ranges 2—200 Hz and 800—10000 Hz, and that an analysis equipment is used, with which periodical comparisons of the total spectra 2—10000 Hz can be done.

Monitoring parameter shall be acceleration, as integration (velocity) or double integration (amplitude) suppress the interesting high frequencies. (Please note, that the constant shock pulses of the meshing gears obstruct a measurement of the bearing condition with the so-called shock pulse meters, as for this purpose a separation of bearing and gear box vibration with filters is not possible.)

Analysis 0 to 10000 Hz, 400 lines

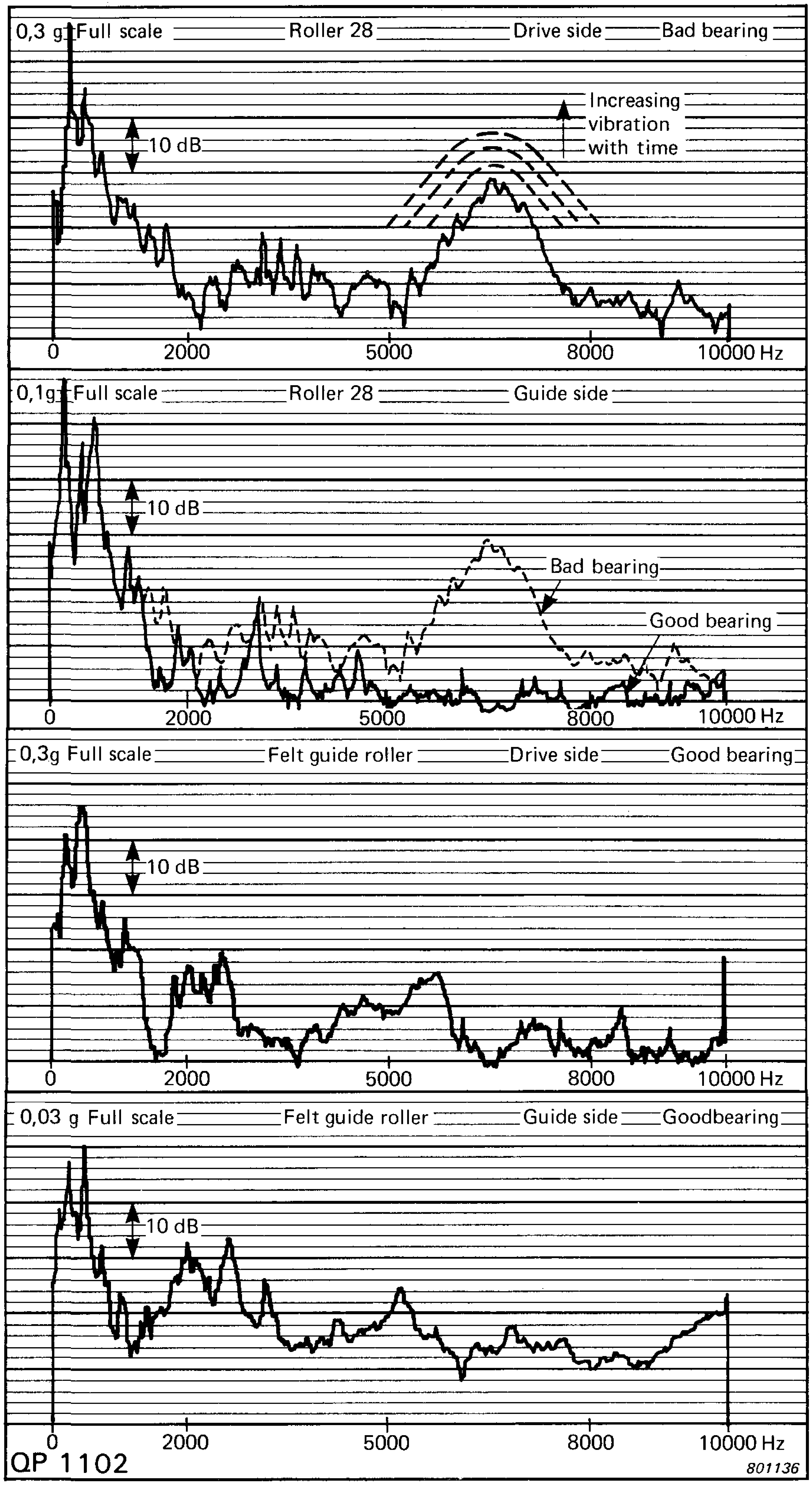

Fig.2.a. Analysis 0 to 10000 Hz, 400 lines

Analysis 0 to 1000 Hz, 400 lines

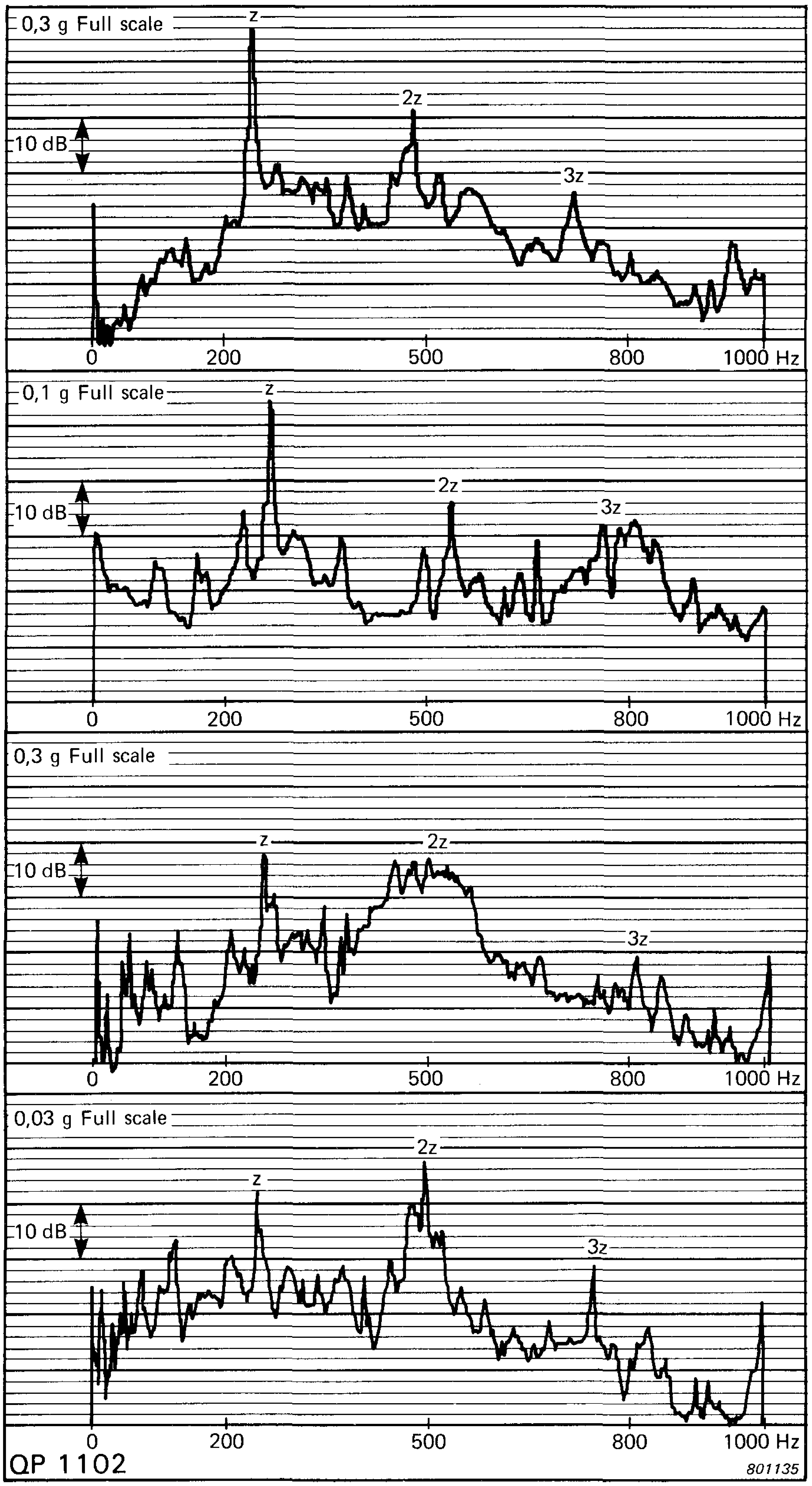

Fig.2.b. Analysis 0 to 1000 Hz, 400 lines

Vibration Monitoring Set-Up

The set-up is based on 2 parts:

a) a permanent monitoring system with 272 channels in 8 groups.
b) an automatic analysis and recording facility.

Permanent Monitoring System

Accelerometer (see System Development Sheet 5674 and 5704)

A specially robust Accelerometer Type 5674 is fixed on each bearing housing with one central or 3 periopheral screws. Adjustment to uneven surfaces can be done with high temperature epoxy or via a stainless steel bracket WA 0113.

Cable System (see System Development for Special Cable Systems)

A high quality Teflon cable Type WL 3145 with a twisted isolated pair of conductors is connected to the accelerometer with a special, sealed crimp connection for longer life.

On places where heavy items could be dropped, this cable can be *protected by a high quality steel* spring conduit Type WQ 0084 or strong pipes.

The accelerometer cable enters a junction box Type WB 0247 or some similar local version.

Each box contains 8 cables. In the box these are connected to an inexpensive PVC data cable with 10 isolated pairs Type WL 3127. This cable carries the 8 signals to the instruments.

Multiplexer (see page 9 in Product Data 2505)

The 8 signals in each data cable enter an 8 channel preamplifier Multiplexer Type 5833. Each channel is individually adjustable.

The 34 units of the 5833 are divided in 8 groups — with 3 to 5 pieces mounted together in each group.

Each group is run as a unit, and to the output of the group the signals from each of the 24—40 channels of the group come automatically, in sequence of 10 seconds. Manual channel selection is also possible.

Multipurpose Monitor (see Product Data 2505)

The signals of each group enter a Monitor Type 2505 per group. Limit exceedings in 3 steps are indicated on a light display and the corresponding output relay during the individual measurement.

If the limit is exceeded, the channel indicator — light display in the multiplexer will start blinking, so that it will be easy to find the channels with a high vibration level without further registration also later.

The monitor has 2 parallel filter ranges:

2—200 and 800—10000 Hz

and measures RMS value of acceleration. Each monitor has an AC output (0—1 V) and a DC output (0—5 V) for further analysis and registration. The automatic test cycle of the monitor ensures the testing of each multiplexer channel in the group for fast condition control. (see Application Note "Efficient Machine Monitoring").

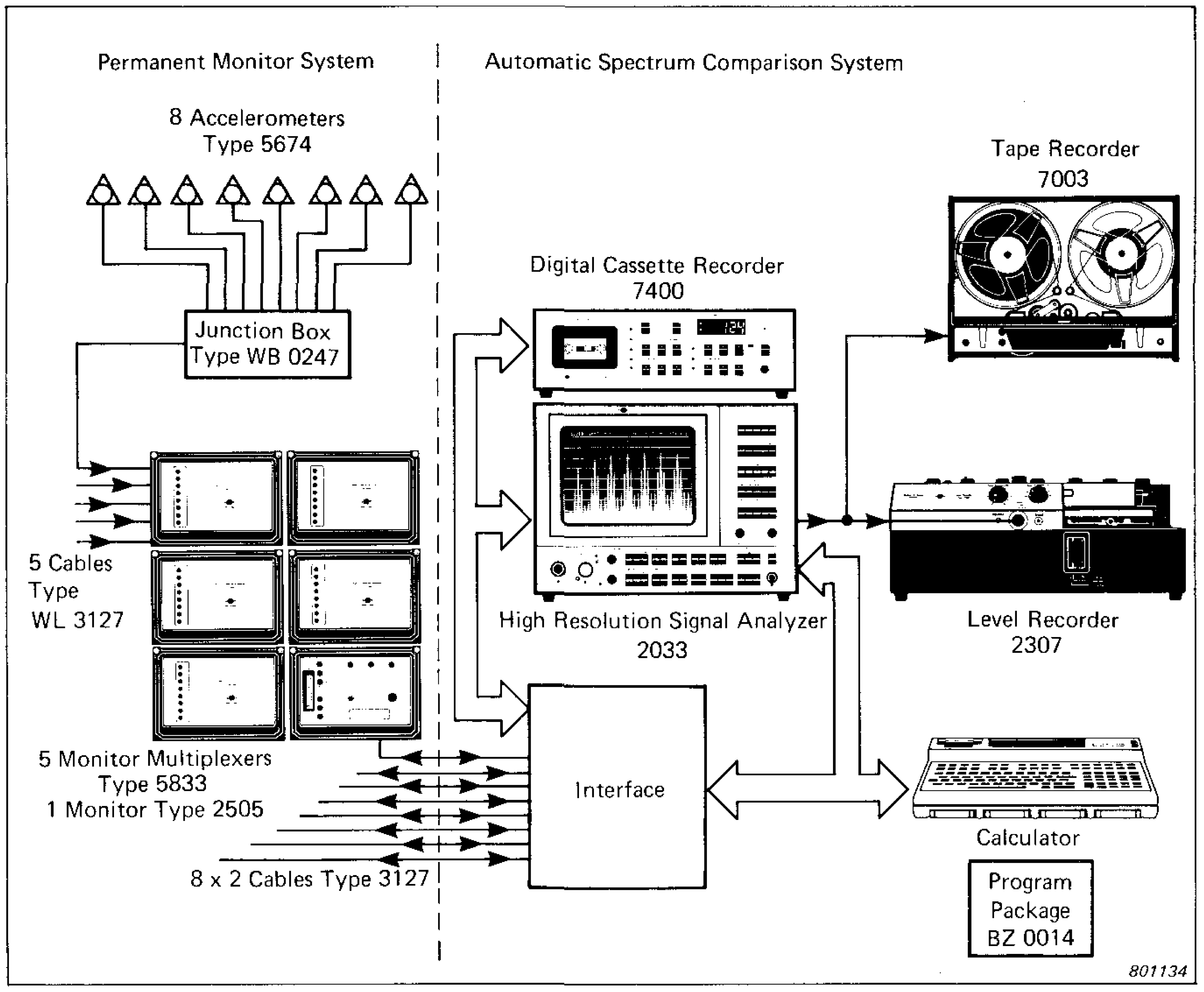

Fig.3. Permanent Monitor System and Automatic Spectrum Comparison System

Automatic Spectrum Comparison

The monitor system as described will react to definite changes in running and bearing conditions. To allow an even earlier detecting and a diagnosis a Narrow Band Analyzer Type 2033 plus a desk top calculator is connected to the monitor through an interface which permits the analyzer to go in every few hours and take a narrow band spectrum from each channel and compare it with the appropriate reference spectrum. When any component shows a significant change channel, time, frequency, and amount of change is printed out.

When the change is noted a full spectrum can be drawn out by a Level Recorder Type 2307, and a section of the actual vibration signal can be stored on a Tape Recorder Type 7003 or a Digital Cassette Recorder Type 7400 for later evaluation.

The whole process is automated via the proper program package which automatically sets up the analyzer and associated equipment. Even the generation of the individual reference spectra is part of the program.

The powerful spectrum monitoring will give months to years advance warning to allow the best possible maintenance planning.

This also means that it does not hurt to employ the analyzer set-up a couple of hours a day for other jobs, for example analyzing taped vibration signals from less important machinery where only periodic condition monitoring is employed.

Bruel & Kjaer Instruments, Inc.
185 Forest Street, Marlboro, Massachusetts 01752 / (617) 481-7000