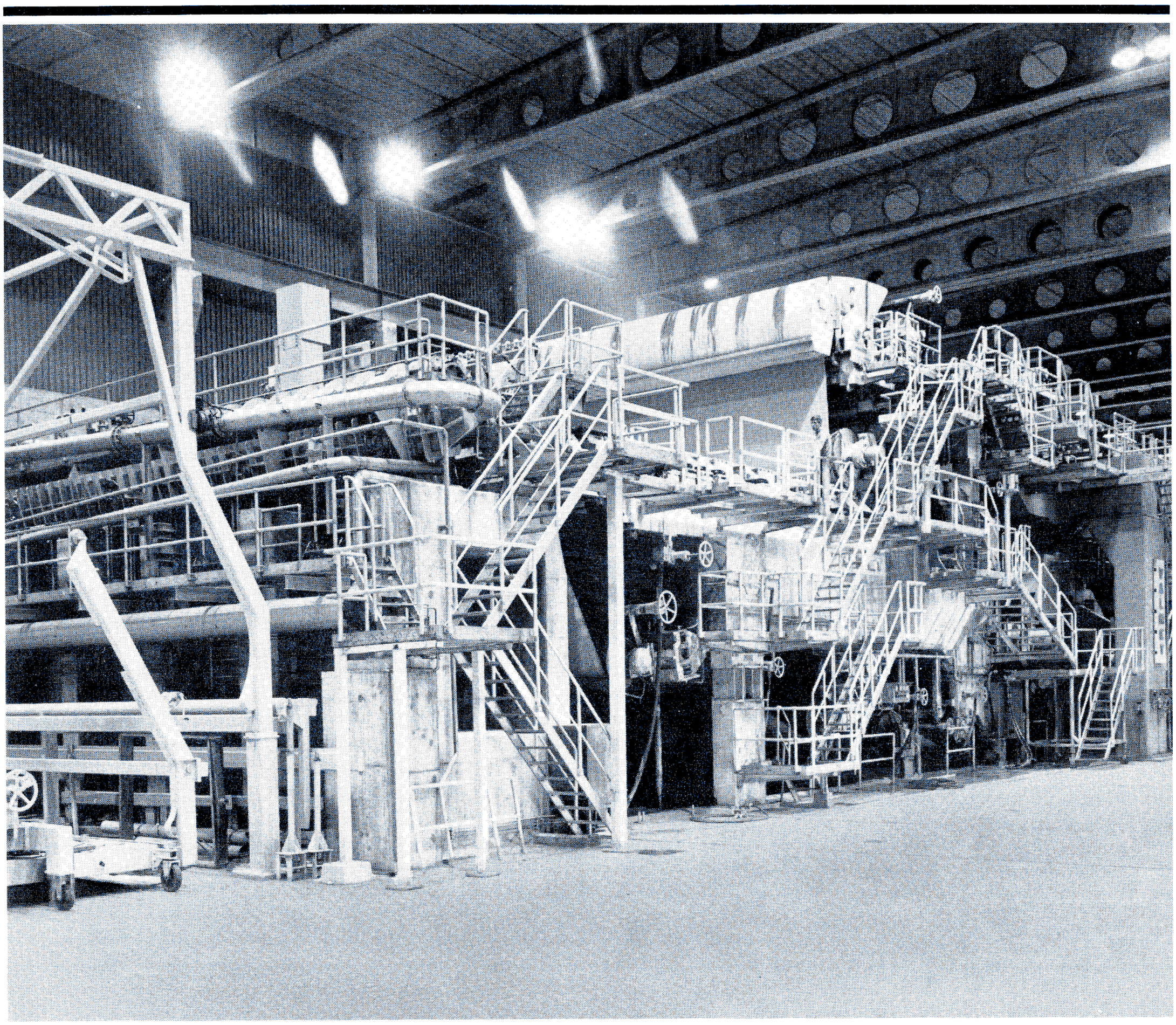
Brüel & Kjær application notes

Bearing Monitoring Equipment for Gear Driven Paper Machines



BO 0072–12

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 easy. The many assembled rotating elements influence each other, and the various structure resonances also interfere with the general pattern. It is therefore necessary to make individual measurements on each bearing.

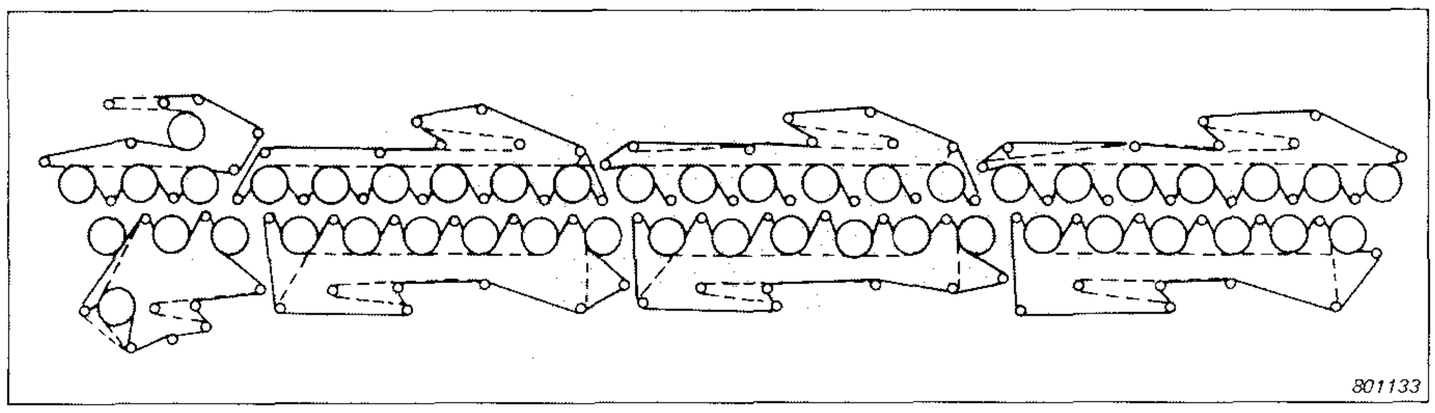


Fig. 1 Schematic diagram of a paper machine showing the large number of rollers and consequently the even larger number of bearings involved

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 through the machine. These disturbance frequencies totally cover the development of even severe bearing effects. A monitoring system for such machines must therefore suppress these frequencies.

If approximately 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 price considerations can reduce the quality of the system so much, that the task of measuring cannot be performed reliably through the years.

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

Going further and trying to connect all accelerometers with a switch, so that all measurements can be performed at one place, involves necessary isolating work in order to avoid ground loops. The longer cables required here are also more sensitive to noise. The B&K Industrial Accelerometers fulfil all these requirements: They are internally isolated and are used with symmetrial cables and a preamplifier to suppress electromagnetic noise; they are also mechanically very stable and no problems are encountered mounting 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 or an analyzer. With this system the vibration signal from each channel can be measured once a week or day and the spectrum compared with an individual reference spectrum - either manually or automatically.

As the switch operates before a preamplifier, it must have a very high impedance. 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 preamplifers before the switch mechanism. Fortunately, stable and lowcost multichannel preamplifiers with electronic switches, so called Monitor Multiplexers, are available.

Many of these Multiplexer units can be operated with one monitoring instrument, and in principle only one monitor per installation is needed. In practice, however, 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 and analysis have been made on a main roller and a felt guide roller. The analyses are shown in Fig.2. The parameter used is acceleration and the analyzer is a Type 3348 Real-Time Analyzer with Type 2307 Level Recorder. (Today one would use a Type 2033 Analyzer). It is clearly seen that between 200 and 800 Hz the spectra are dominated by the tooth meshing frequency Z and the two higher harmonics 2Z and 3Z.

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 the high frequencies (example: Roller 28 at 6 to 7 kHz). Working order (unbalance, misalignment, etc.) is seen from the rotation frequency and its harmonics. Monitoring the bearing vibration every three months shows the increase in vibration as indicated in the uppermost curve of Fig.2. 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 investigation concerning the relationships between the individual machine elements and the peaks in the frequency spectrum have been made. As they rendered no informa-

tion essential for the construction of the monitoring system they are not mentioned here.

For this set-up we propose that permanent monitoring system controls the total level in the ranges 2 - 200 Hz and 800 - 10 000 Hz, and that analysis equipment is used with which periodical comparisons of the total spectra 2 - 10 000 Hz can be done.

The monitoring parameter shall be acceleration, as integration (velocity) or double integration (displacement) 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.)

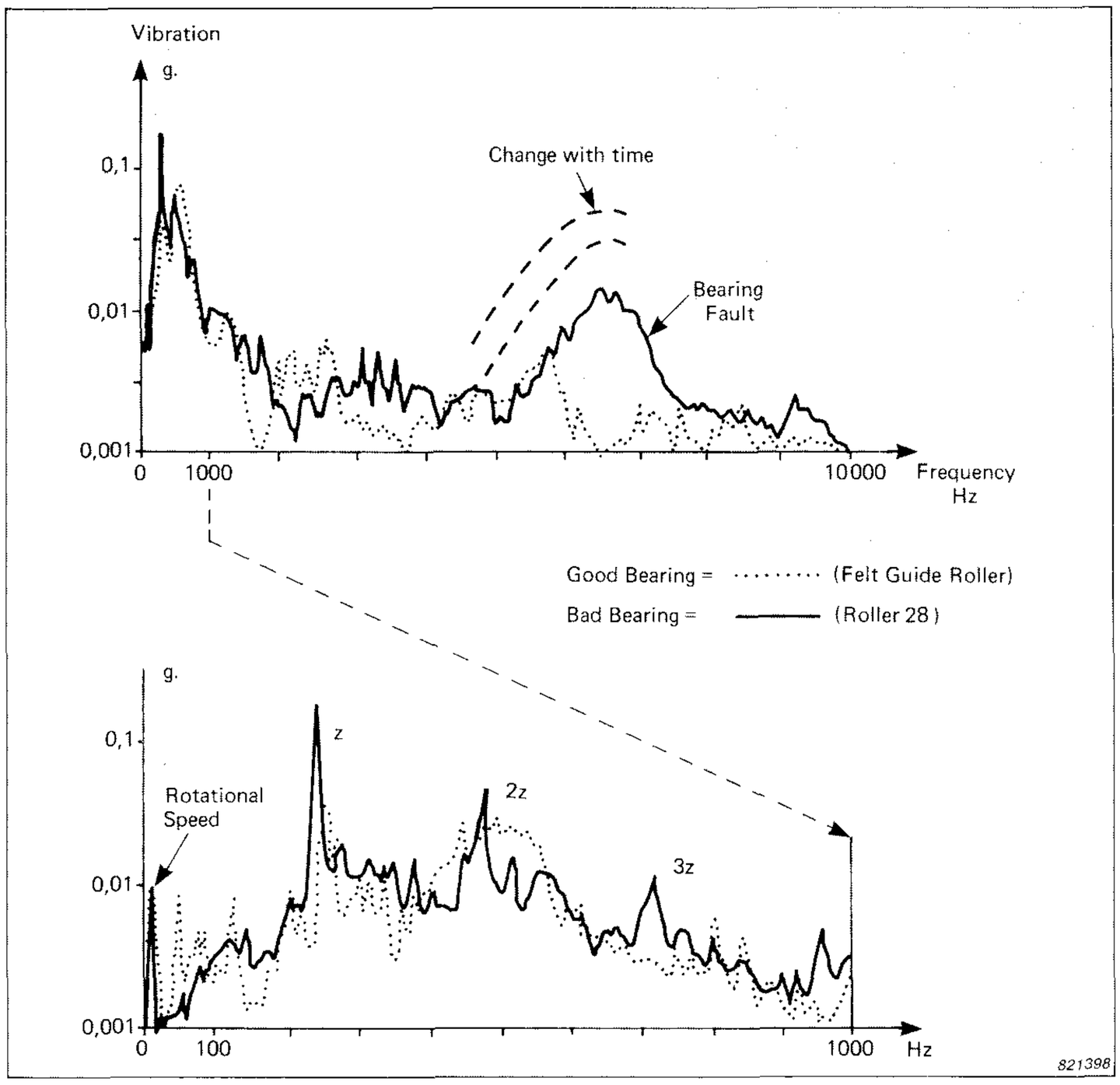


Fig. 2. Vibration spectrum of a bearing with a definate bearing fault and a good bearing in a similar position using a 400 line Narrow Band Analyzer

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 5674/5704)

A specially robust Accelerometer Type 5674 is fixed on each bearing housing with one central or 3 peripheral screws. Adjustment to uneven surfaces can be made 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 in a stainless steel sheath is connected with a special, sealed crimp connection for more reliability.

In 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 WB 0564/WH 1388 or some similar local version, which is capable of containing 8 cables. In each box the accelerometer cables are connected to an inexpensive polyethelene

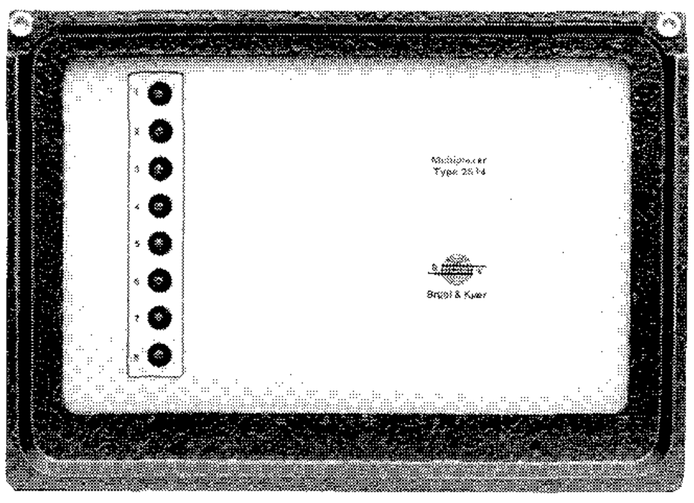


Fig. 3. Front panel of the Type 2514 Multiplexer

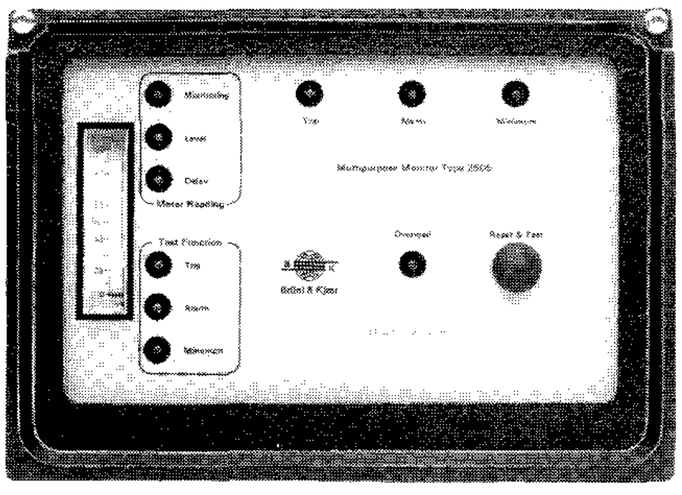


Fig. 4. Front panel of the Type 2505 Multipurpose Monitor

covered transmission cable WL 3128. This cable carries the 8 signals to the instruments.

Multiplexer (see Product Data 2514)

The 8 signals in each length of transmission cable enter an 8 channel preamplifier Multiplexer Type 2514, see Fig.3. Each channel is individually adjustable.

34 Type 2514 Multiplexers are used, divided into 8 groups, each of 3 to 5 Multiplexers.

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

Multipurpose Monitor (see Product Data 2505)

The signals from each group enter a Monitor Type 2505 - one 2505 per group, see Fig.4. Three warning limits are included and violations of these are indicated on a light display and a corresponding output relay.

If the limit is exceeded, the channel indicator/light display on the Multiplexer will start flashing, thus making it easy to find the channels with the high vibration level without further recording.

The Monitor has 2 parallel filter ranges: 2 - 200 Hz and 800 - 10 000 Hz, and measures the RMS value of acceleration. Each Monitor has an AC output (0-1 V) and a DC output (0-5 V) for further analysis and recording. The automatic test cycle of the Monitor ensures the testing of each Multiplexer channel in the group for fast condition control.

Automatic Spectrum Comparison

The monitor system as described will react to definite changes in running and bearing conditions. However, to allow for even earlier detection and diagnosis a Narrow Band Analyzer Type 2033 plus a desk top calculator is connected to the Monitor through an Interface Unit WB 0503, see Fig.5.

The WB 0503 Interface Unit serves two independant purposes; providing both a digital and an analogue interface for control and recording of up to 16 channels. The digital interface connects the Monitor/Analyzer system to the calculator via a serial RS 232 C level loop. It is then possible to read status parameters and the levels of the 16 channels, and to stop the system at any selected channel. The analogue interface provides the possibility of connecting up to 16 channels to a multitrace recorder for level recording of signal levels. Up to ten Interface Units may be served from one serial channel giving control over 160 channels.

This set-up permits the analyzer to take a narrow band spectrum from each channel every few hours and compare it with an appropriate reference spectrum. When any component shows a significant change the channel, time, frequency and amount of change is printed out. A full spectrum can then be drawn out by a Level Recorder Type 2307, and a section of the actual vibration signal be stored on a Tape Recorder Type 7005/6 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.

This powerful spectrum monitoring will give months to years advance warning to allow the best possible maintenance planning. This means, therfore, that it does not hurt to employ the analyzer set-up a couple of hours a day for other jobs. For example, it could be used for analyzing taped vibration signals from less important machinery where only periodic condition monitoring is employed.

For more information on spectrum comparison see the Application Note "Efficient Machine Monitoring using an FFT Analyzer and a Desktop Calculator".

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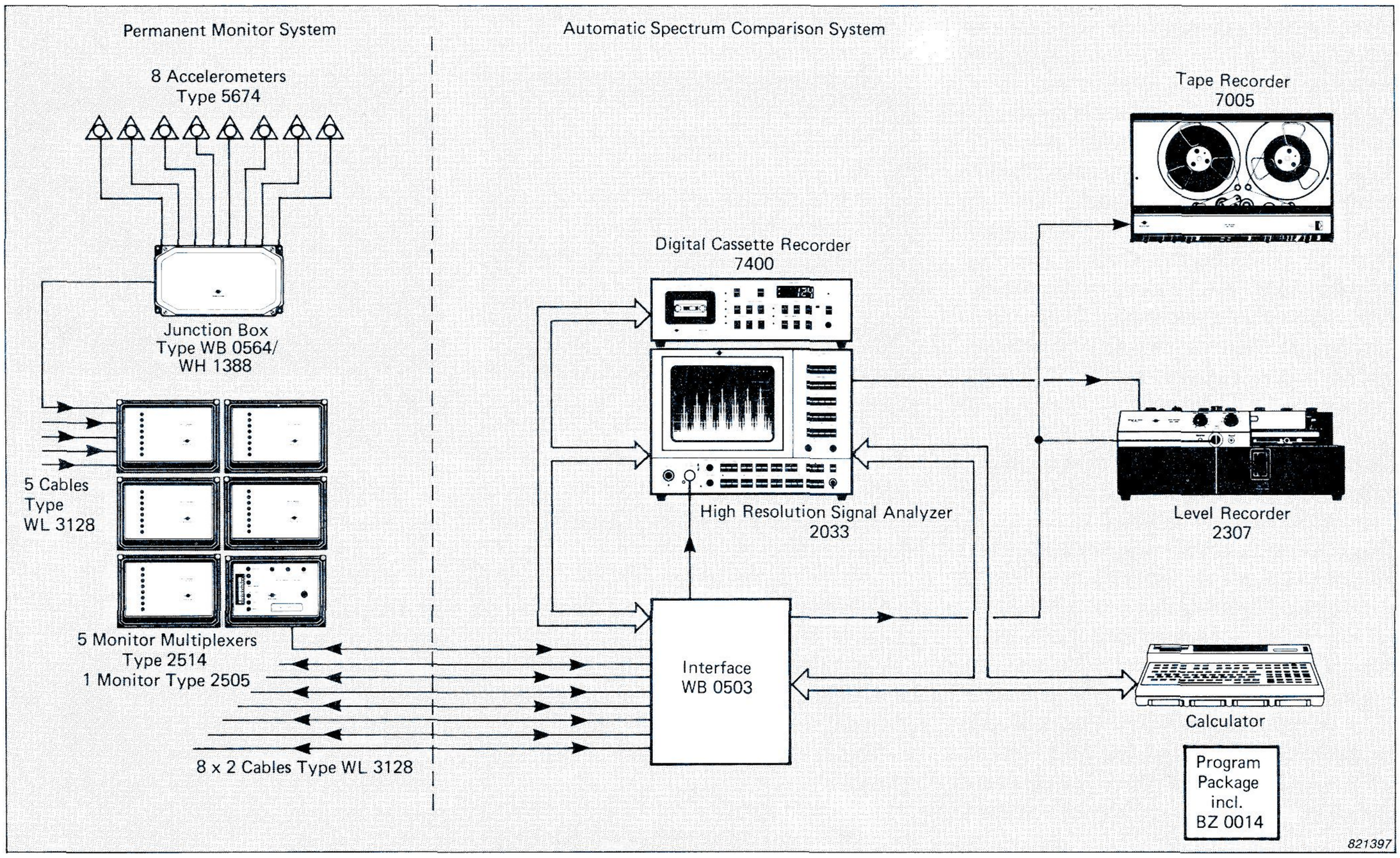

Fig. 5. Permanent monitoring system and automatic spectrum comparison system

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