QA2000 accelerometers available from Sundstrand Data Control Inc. The output voltage signals S1, S2 and S3 of the accelerometers **11**, **12**, **13** respectively are converted into digital form within the sensor and are first fed into a multiplexer switch **14**, after each having passed through a respective high impedence buffer **16** and an anti aliasing filter **17** to produce a very high precision signal. The multiplexer switch **14** also receives a reference signal So, preferably zero volts, from a reference signal transmitter **10**. The signal So also passes through a respective buffer **16** and filter **17**, so that the reference signal passes through the same operational path as the accelerometer output signals. The four signals S0, S1, S2 and S3 can only be passed singularly through the multiplexer switch **14**, which is operated by a controller **15** which selects each signal S0, S1, S2 or S3 in sequence for passage of the signal through the multiplexer **14**. Each signal is connected through the multiplexer for a time period of about 1.5 milliseconds. The signals S0, S1, S2 and S3 are then passed in sequence through a second high impedence buffer **26** to a Track and Hold amplifier **18** (TAH). The signals S0, S1, S2 and S3 are then passed to an Analogue Digital Converter **19** (A.D.C.) which converts each analogue voltage signal into a 16 Bit representative digital number. The 16 Bit output signal is then passed through an output shift Register **21** to convert the 16 Bit parallel line data signal into a single line serial data signal. The serial signals SS0, SS1, SS2, SS3 is then passed through a Data Transmitter **22**. The data transmitter **22** has an internal clock which governs the frequency with which the signals S0, S1, S2, S3 are passed through to a data processor which then converts the digital signals into information relating to the vertical movement of the floating platform. Because the frequencies of sea wave motion of more than 1 Hz have no practical importance, then the sampling of a signal at the multiplexer every 1.5 milli-secs means essentially that the sensor operates in real time.

The Data transmitter **22** is also connected to the TAH **18** and the control **15** for the multiplexer switch **14** to co-ordinate the signals passed to the TAH for digital conversion in the ADC **19** and subsequent transmission of that information. The TAH **15** holds a signal frozen at a moment controlled by the clock of the data transmitter **22** whilst the ADC **19** converts the frozen signal.

The digitalised serial signal is transmitted from the data transmitter **22** to a data processor through a data link which would normally be cable, but which could be a radiolink, in frames of four numbers each of which corresponds to a respective signal S1, S2, S3 or S0, each number being in 16 Bit serial format.

Now with reference to FIG. **3**, the digitalised signals S1, S2, S3 and S0 are fed into a data processor unit D which then performs a series of operations in sequence. The signals are converted back to parallel format and at a first processor **31**, eight signals of each respective digitised signal S1, S2, S3 and S0 are collected and averaged out to give mean values for S1, S2, S3 and S0. The mean reference signal S0 is then substracted from the mean accelerometer signals S1, S2, S3 to give the true accelerometer outputs AX, AY, AZ. This is represented by:

$AX = S1 - S0)$ Where AX, AY and AZ are the
$AY = S2 - S0)$ accelerometer signals in the
$AZ = S3 - S0)$ X, Y and Z axes respectively.

Since the reference signal has passed through the same operational path as the accelerometer signals, by subtracting the reference signal it is possible to remove the voltage offsets from the equation.

At a second processor **32** the magnitude of the total acceleration A is expressed as the square root of the summation of the squares of the accelerometer outputs. Thus

$$A=(Ax2+Ay2+Az2)^{\frac{1}{2}}$$

In the absence of any appreciable external forces A will be the gravitation acceleration G whatever the orientation of the sensor axes to the vertical. If the apparatus is now accelerated vertically (due to the rise and fall on the ocean surface waves) in the absence of any appreciable horizontal components of acceleration, then the total vertical acceleration A equals the gravitational acceleration G plus the vertical acceleration 'a' due to wave movement that is

$$A=G+a$$

This holds true irrespective of the orientation of the apparatus to the vertical. Since G is constant the signal A is passed through a high pass filter **33** to remove the constant gravitational component.

The resultant signal 'a' is then passed through a phase equalisation filter **34** to remove any phase distortions introduced by filters in the system and is then integrated by integrator **35** by either computation or by use of electronic circuitry. The integrated signal a**2** is then passed through a high pass filter **36** and then integrated for a second time by integrator **37** to give a double integrated signal A**3** which is passed through another high pass filter **38** which produces a high quality signal which is proportional to the vertical travel of the platform. The double integrated signal a**3** is in digital form and if being used on board a marine survey vessel can be coupled directly to an echo sounder **40**.

The signal a**3** relating to vertical displacement is taken at a rate of about 22 times per second, so that the signals S1, S2, S3 and S0 are being fed into the processor unit D from the data transmitter **22** at a total rate of about 680 signals per second.

The heave compensator signal will be a few milliseconds behind the echo sound signal but this can be compensated for in a known manner.

If the echosounder operates on a digitalised signal to produce a numeric depth value, the signal from the heave compensator can be directly fed into the echosounder to give a corrected depth. The echosounder can display measured depth, heave and corrected depth. These measurements can be visually displaced on an echo chart recorder **41**. If the total component of acceleration is in the vertical axis only as in a sudden rise on a wave, then the digitalised accelerometer output signals S1, S2 and S3 can also be utilised to give a measure of the vessel pitch and roll angles, as indicated below: