

AN ACOUSTIC WAVE GAUGE

E.S. de Sa, R.G. Prabhu Desai, & B.A.E. Desa
National Institute of Oceanography, Dona Paula, Goa.

I INTRODUCTION

Waves on the sea/ocean surface can be measured in several different ways. The measurements are made possible by using either one of the following sensors to detect waves :-

- 1) Resistive, capacitative, and inductive sensors.
- 2) Accelerometer bouy which floats on the wave surface.
- 3) Pressure transducer (strain-gauge type) fixed on the sea-bed.
- 4) Acoustic transducer placed on the sea-bed.

In the first section of this paper, the design of an acoustic wave gauge developed by us is briefly outlined. The second section deals with the results obtained in field trials of this instrument, and their comparison with the wave data obtained with the Datawell Waverider Buoy deployed by N.I.O. at the mouth of the Mandovi River in Goa.

II EXPERIMENTAL

The acoustic wave gauge discussed here works on the echo-sounder principle. In the set-up, a single acoustic transducer operating at 150 KHz is mounted on a rigid weighted platform, and lowered via a 2 core cable to the sea-bed. The transducer is pulsed through the cable from the deck-unit electronics on board an anchored boat. The ultrasonic pulses are beamed upwards to the water-air interface (i.e. the wave surface), and the reflected echoes are picked up by the same transducer. Fig.1 is an illustrated diagram of the sensor unit.

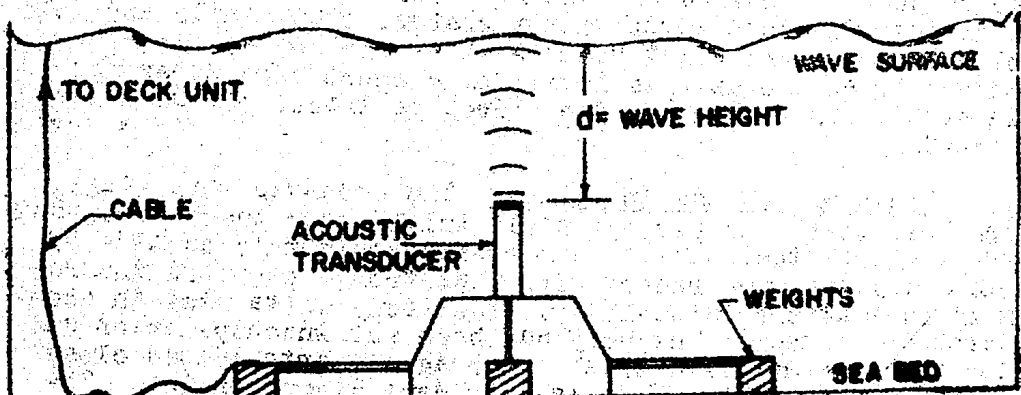


Fig.1. Acoustic Wave Gauge Sensor

The block diagram shown in Fig.2 enables the measurement of the waveheight d (of Fig.1) by finding the time interval between the start of the transmit pulse and the reception of the first echo. The changing waveheight values are displayed in centimeters/or meters on a L.E.D. (light emitting diode) display, as well as recorded as a wave trace on a chart recorder, and printed out for subsequent computer analysis. As the contents of Fig.2 are self-explanatory only a brief description of its function follows :-

The acoustic sensor is energised by feeding a 200V pk to pk burst of 150 KHz pulses obtained by gating the clock pulses from a CMOS crystal oscillator, and passing this through a drive circuit and a step-up pulse transformer. The repetition of the transmitter waveform is fixed at 10 Hz and its pulse width is selectable over the range $50\mu s$ to $300\mu s$.

The use of a TR (transmit/receive) switch makes it possible to use a single transducer to transmit and receive signals successively. The echo signals pass through a narrow band tuned amplifier after which they are amplitude demodulated, filtered and squared. The output of the R-S flip flop in Fig.2 contains the time interval signal mentioned above. This echo-time signal and the $150\text{ KHz} \div 2$ clock pulses are ANDED together and with the use of decade counters, latches, and B.C.D. to seven segment chips the final readout of the waveheight on the LED display is indicated in centimeters. A readout in meters is obtained by the appropriate frequency division of the basic 150 KHz clock.

The B.C.D. output from the latches is fed to any printer that accepts parallel bit entry. The print command pulse is divided by five so that the sampling rate of the printer equals 2 samples per sec. If the wave data is to be simultaneously recorded on a chart recorder then the echo-time signal is fed to a switched integrator. The sample and hold block samples the final d.c. level at the end of the time interval, and holds this level for a short time after the interval. This changing d.c. level is traced out as a wave record.

1. Field use of the Instrument The acoustic wave gauge has been tested in several field trials near the shore. However, a real test of its performance could only be made by comparing its wave record with that from a standard instrument such as the Datawell Waverider Bouy which uses an accelerometer sensor. The bouy had been put into operation at the time of the field trials near Aguada Bay located close to the mouths of the Mandovi and Zuari Rivers in Goa. The wave data from the bouy is transmitted to N.I.O. via a 27 MHz r.f. link once every 3 hours for a time span of 20 minutes. Measurements with the acoustic wave gauge were made shortly after the transmission from the bouy. The wave gauge was lowered to a depth of 6 meters at low tide from a small boat

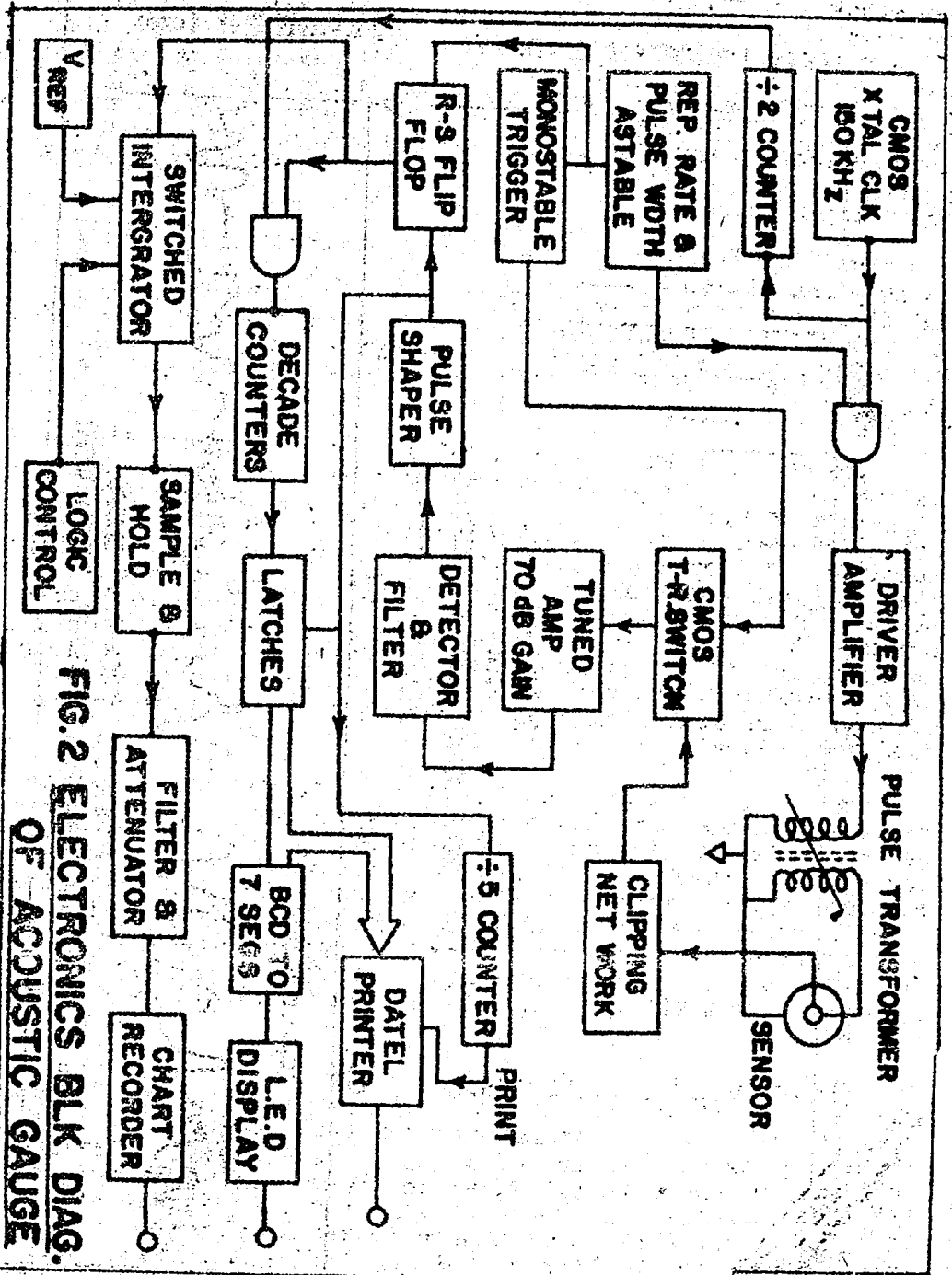


FIG. 2 ELECTRONICS BLK DIAG. OF ACOUSTIC GAUGE.

Fig. 2. Electronics Block Diagram of Acoustic Gauge

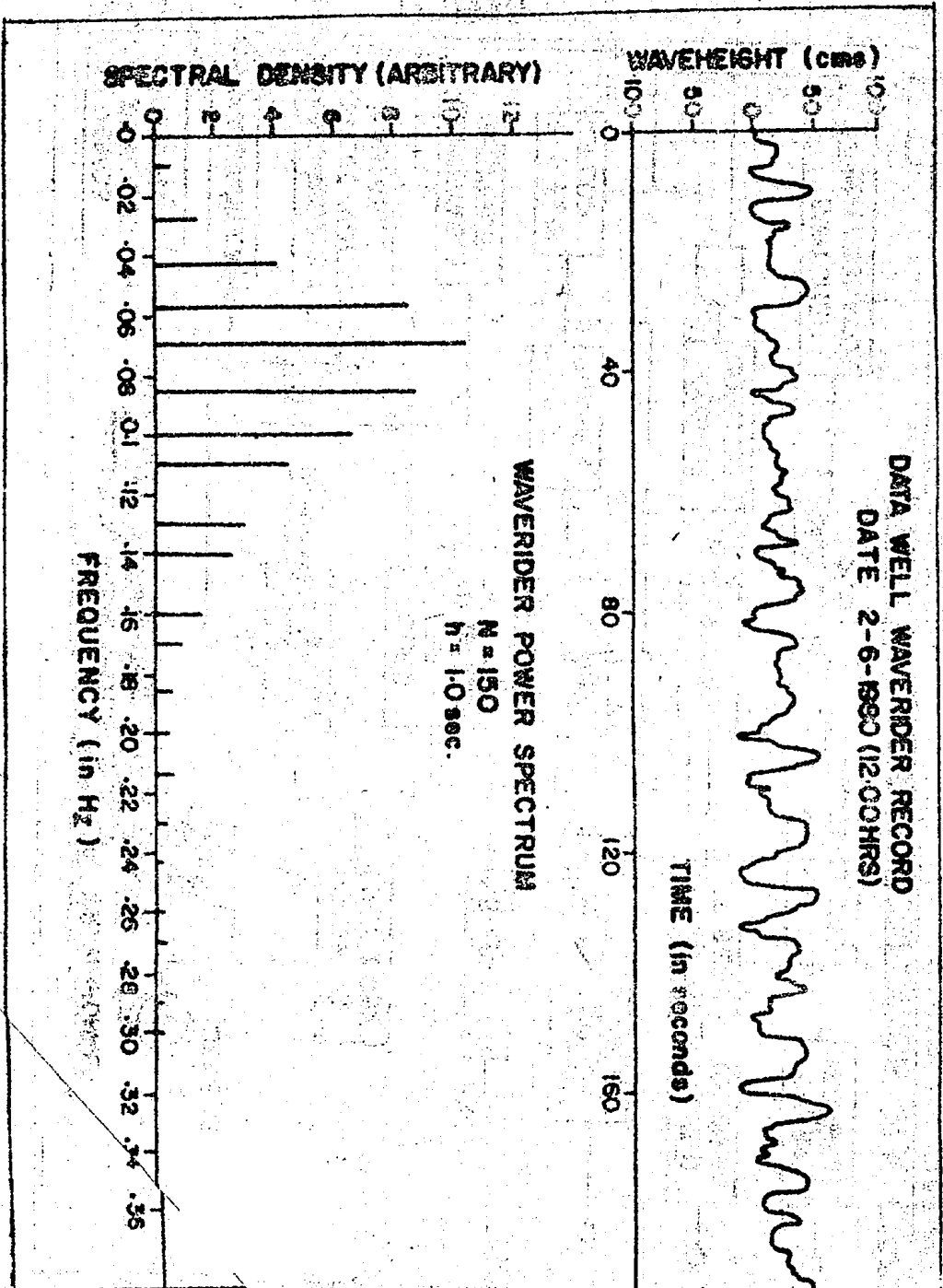


Fig. 3. Wave record and power spectrum of Waverider Bouy

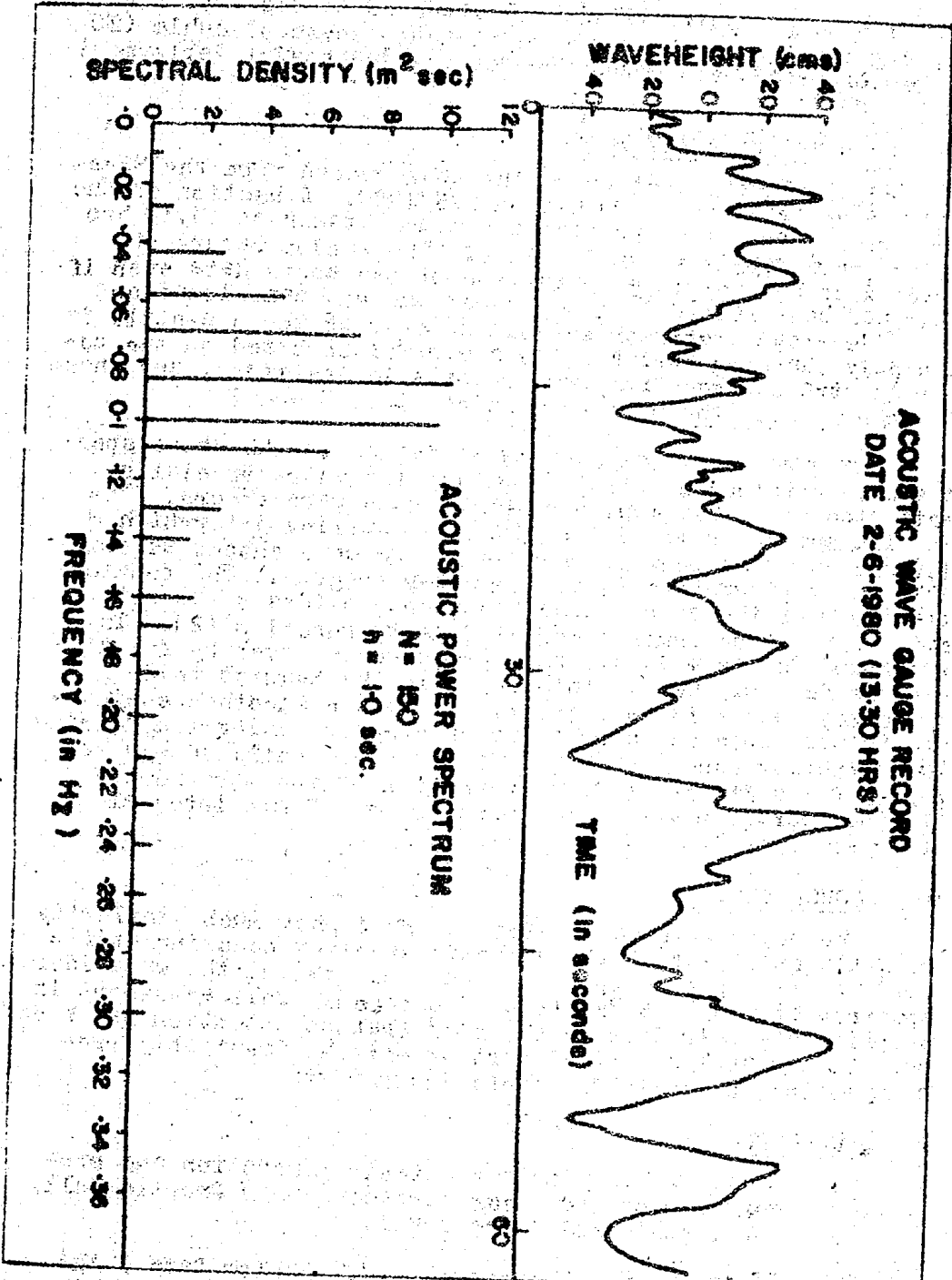


Fig.4. Wave record and power spectrum of Acoustic gauge

near the buoy. Suitable weights attached to the sensor unit housing the transducer and a sufficient length of cable (20 meters or more) were necessary for the successful deployment of the unit.

III. RESULTS AND ANALYSIS

Fig. 3 shows a section of the wave record from the Wave-rider Bouy taken at 12.00 hrs on 2/6/1980. A section of the wave record from the acoustic wave gauge taken at 13.30 hrs on the same day is shown in Fig. 4. The random nature of waves does not permit a comparison of the above data even if they had been recorded at the same time and same location with identical instruments (1). However as the sea-state is a slowly changing variable (1) a comparison based on the power spectra derived from wave records is justified, and these are shown below the wave records of Figs. 3 and 4.

The power spectral density estimates of the above spectra were obtained by first computing the auto-correlation estimates for a 2.5 min. section of each wave record. The total number of samples $N = 150$ at a sampling interval $h = 1.0$ sec and a maximum lag number $m = 28$ were chosen as suitable input parameters in the computer program. The Fourier transform of the correlation function provides a raw estimate of the true power spectral density function (2). This was found for $(m + 1)$ discrete frequencies given by $f = kfc/m$ where $fc = 0.5$ Hz (in this case) is the Nyquist folding frequency, and k is an integer. Finally a smoothed estimate of the true spectral density is obtained by using the Hanning lag weighting function (2). The procedure outlined was repeated for a different 2.5 min section of the wave record, and the average power spectrum covering a 5-min interval drawn in Figs. 3 and 4.

IV. CONCLUSION

The power spectra of Figs. 3 and 4 show much similarity with the main peak of the acoustic spectrum occurring at $f = .075$ Hz (time period $t_p = 13$ secs) and that of the waverider spectrum at $f = .066$ Hz ($t_p = 11.6$ secs). This agreement is surprisingly fair despite the fact that no attention has been paid to the analysis of distortion effects inevitably present in the wave data from both instruments.

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