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A TECHNIQUE FOR RECORDING THE SKUA ROCKET SONDE SIGNAL USING A LOW COST TAPE RECORDER

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A TECHNIQUE FOR RECORDING THE SKUA ROCKET SONDE SIGNAL USING A LOW COST TAPE RECORDER

1. Introduction

The Skua rocket sonde transmits a frequency modulated signal within the 27 MHz Met Band as it makes a parachute descent following ejection from the rocket vehicle. The modulation is produced by a resistance controlled oscillator the active device of which is the exposed temperature element. The sonde signal is received on the ground by a standard communications receiver and the demodulated signal, which is a note in the audio range 750 - 1000 Hz, is the input to a data logging system comprising a solid state version of the Met Office Cintel equipment coupled with a Perifile data logger. The latter also accepts position information on the sonde from the tracking radar for logging along with the sonde signal to enable the wind velocity to be deduced.

Recently there has been an increased interest in daytime Skua firings because of the requirements for comparison of the observed temperature profile with simultaneous satellite information. Daytime reception at South Uist on the 27 MHz band is considerably worse than at night because of transmissions between foreign trawlers. The noise problem has also been aggravated by the sunspot maximum period in which we are at present.

To reduce the effect of this interference, which at times completely blots out the sonde signal, a frequency agile filter was introduced between the receiver audio output and the Cintel input. This device tracks the incoming audio signal and by means of a variable bandwidth control substantially rejects unwanted noise. Because this was a new devise it was thought desirable that if possible the unfiltered output from the receiver should be recorded so that, in the event of misuse or malfunction of the filter, the raw information would be available on tape for another attempt. In addition of course it could enable a better temperature profile to be derived at leisure after the event by more judicious use of the filter controls. Up to the present the only sonde information available has been the real time output from the receiver.

2. Recording the Signal

What was required then was a recording of an approximate sine wave the frequency of which varies smoothly within the range 750 - 1000 Hz and on the face of it there should be no great problem as this is comfortably within the scope of any recorder for audio work. An initial experiment was performed using a stereo cassette tape deck of reasonable quality made by Technics

(Model RS – 263US). A fixed frequency was recorded from a signal generator and then replayed through the Cintel, the results can be seen in Fig 1a – c. Fig 1a is the real time output from the Cintel chart recorder during the time that the recording was being made and this corresponds to a steady sonde signal with a period of 1158.9 μsec or a frequency of about 863 Hz. The recording of this note played back through the Cintel produced Fig 1b and several differences are evident. There is a large initial offset of about 10 Cintel units, (1 Cintel unit being 1 small square on the period axis), which is equivalent to about 5°C in element temperature. This offset changes with time in irregular fashion and in addition superimposed on the signal is considerable noise of higher frequency. The trace is not reproduceable as Fig 1c shows – this is a second replay of the same recording and indicates a more constant offset at the start but has a sudden change at the end of the test. These deviations in frequency are of the order of a few Hertz and for the purpose for which it was designed the recorder is working satisfactorily. For our purposes however these changes are equivalent to uncertainties in element temperature of several degrees centigrade and this is not good enough.

The frequency fluctuations are due to tape speed variations on record and replay (wow and flutter). Given the perfect recorder and ideal recording medium than the replayed frequency must be identical to the original signal. In practice however motors and drive systems are not perfect and do not run at constant speed, this varies with the load ie the amount of tape on each spool and in addition tapes stretch in use (very small). Variations in replay frequency are therefore inherent in any simple record/replay system.

We had three options then

1) To obtain a better recorder – it would have to have been a superior instrumentation type of instrument costing a few £1000s rather than the few £10s for the Technics. This expense could not be justified for what is really a back up system.

2) To attempt to stabilise the tape speed. This would have involved considerable effort on the internal operations of the recorder and this had to be discounted for reasons of time and also because the recorder did not belong to the rocket group.

3) To introduce a correction to the replayed signal when it was being processed by the Cintel to allow for tape speed variations. This offered real possibilities because of the way the equipment operated.

3. The Modified Recording System

The Cintel measures the period of the incoming audio frequency at pre selected intervals of time and these can be adjusted from 1 sec to 60 sec in length. At the time of making the measurement exactly 100 cycles of the signal are gated and the number of pulses from an accurate 100 KHz clock occurring during the 100 cycles are counted. The total count at the end of the counting period is therefore numerically equal to the period of the audio signal (smoothed over 100 cycles) in units of 0.1 μsec. This total count is shown on a front panel LED display and is also the input to a 12 bit D-A converter which produces the drive signal to the chart recorder pen. The latter produced Fig 1 - the stepped nature of the trace is due to the 1 second sampling interval.

If the tape speed increases then the total count decreases and the replayed frequency is higher than that of the original signal; the converse is also true of course. Suppose however that the pulse rate of the nominal 100 KHz pulse train is varied in sympathy with the tape speed variations then the total count and therefore the periodicity measurement will be constant irrespective of changes in speed. This is what was attempted in the experiment. The result could be achieved by recording a constant frequency of 100 KHz on the second channel of the stereo recorder <u>at the same time</u> as the audio signal recording is made. On replay instead of using the internal 100 KHz of the Cintel the counters are supplied by pulses derived from the replayed 100 KHz tone and this corrects for speed variations in the recording and replay processes. In practice of course 100 KHz could not be recorded because of tape speed, tape head and amplifier limitations within the recorder. However 10KHz can be used and this can be frequency multiplied on replay to generate the required 100 KHz.

Fig 2 is a block diagram of the system developed for the Skua sonde. On record the audio signal from the receiver is buffered to give compatibility with the recorder and the signal goes directly to the left hand (LH) channel input. In addition a 10 KHz sine wave, derived by passing the Cintel 100 KHz through a ÷ 10 circuit and then a band pass filter, is simultaneously recorded on the right hand (RH) channel. On replay the LH channel is connected directly to the Cintel input, replacing the receiver as in normal operation and the internal 100 KHz pulses are disconnected from the counting circuits. The nominal 10 KHz signal from the RH replay amplifier supplies the input to a phase locked loop circuit where a ÷ 10 is inserted between the voltage controlled oscillator (VCO) and the phase comparator effectively multiplying the 10 KHz by 10. Thus if the VCO is set up with no input for a free running centre frequency of 100 KHz then on replay the VCO output will exactly track the 10 KHz input and replaces the internal clock of the Cintel for the periodicity measurement.

The result of applying this technique is shown in Fig 1d which is the trace obtained after replaying the recording of Fig 1a through the circuit. There is no detectable offset or drift with time and negligible noise on the trace. These results were confirmed by further tests in the laboratory using varying signals to simulate a changing sonde output, the Cintel trace was always faithfully reproduced on playback. The reproducability over the 750 - 1000 Hz range was better than 0.1 Hz with noise of ± .2 Hz p.p on the replayed signal.

The circuits tested were mounted on Veroboard in a diecast box which interfaces very simply between the recorder and Cintel. The operation of one switch alters the mode of operation from record to replay and interchanges the 100 KHz sources for the Cintel. Details of the circuit are given in the documentation with the equipment and are available on request.

5. System Test at South Uist

The complete system was tried in earnest during the Skua campaign of February 1980 and proved very successful especially when used in conjunction with the agile filter. Fig 3 shows part of the real time Cintel trace for M502 fired at 08.40 GMT on February 15th. Radio reception was typical of the usual daytime quality and the noise on the trace is all too obvious - between 25 and 31 minutes from launch there is little useable information available. Compare this with Fig 4 which is the same portion of the flight replayed through the agile filter, here the period of signal loss has been reduced to about one minute and the trace is much cleaner overall.

6. Conclusion

A cheap tape recorder has been successfully used to perform a job for which it is not suitable by using information stored on a second recording track to correct for the wow and flutter content of the audio signal. This has enabled the system to faithfully record and replay information contained in a frequency related format.

Over the range of frequencies 750 - 1000 Hz the accuracy of record/replay is better than 0.1 Hz with noise of ± 0.2 Hz p.p on the replayed signal with the particular recorder used in the experiments. No investigation into applications over a wider frequency band has been done but there is no reason to doubt that a much wider range can be accomodated, provided of course that it is within the capabilities of the available recorder.

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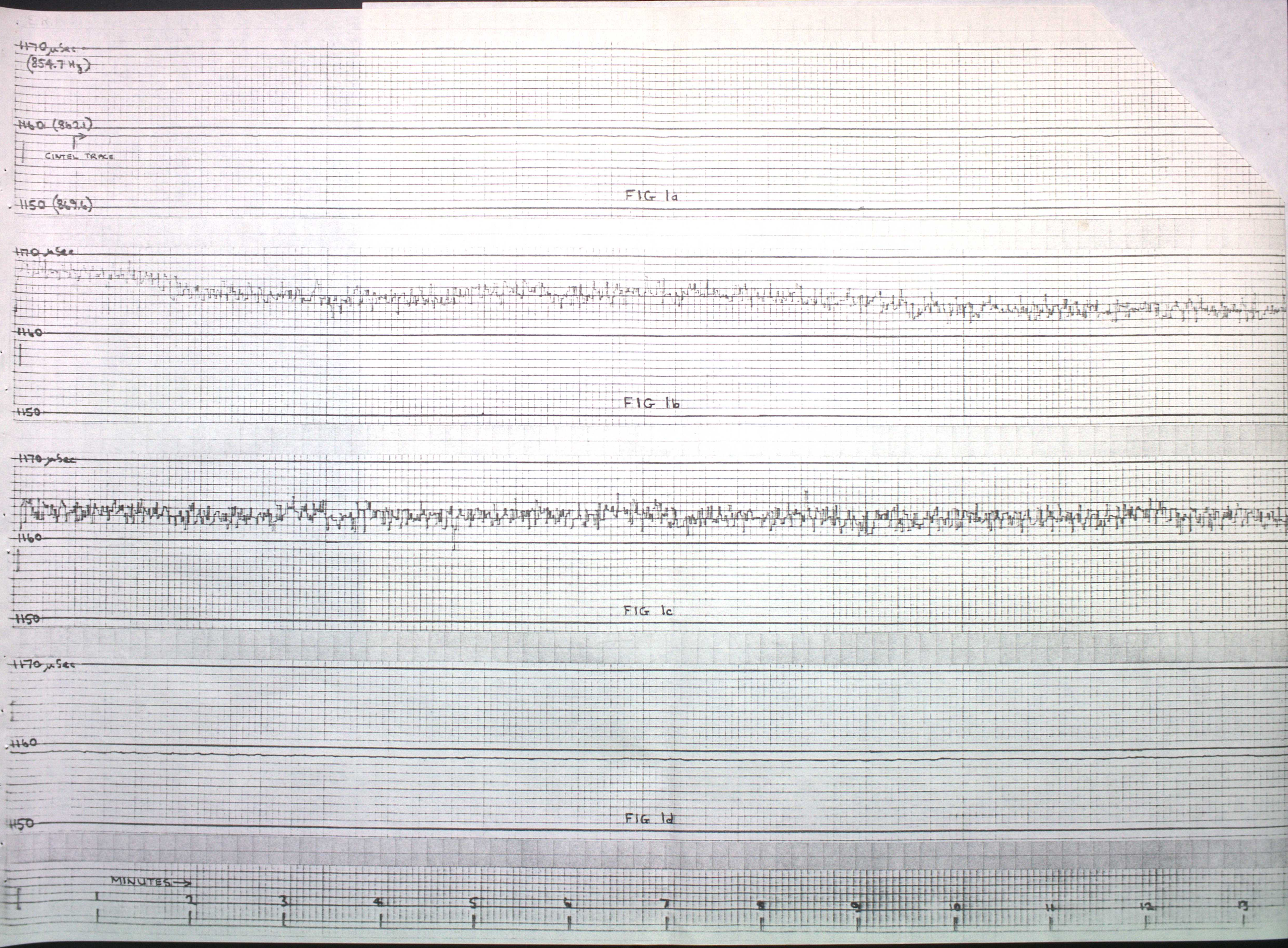
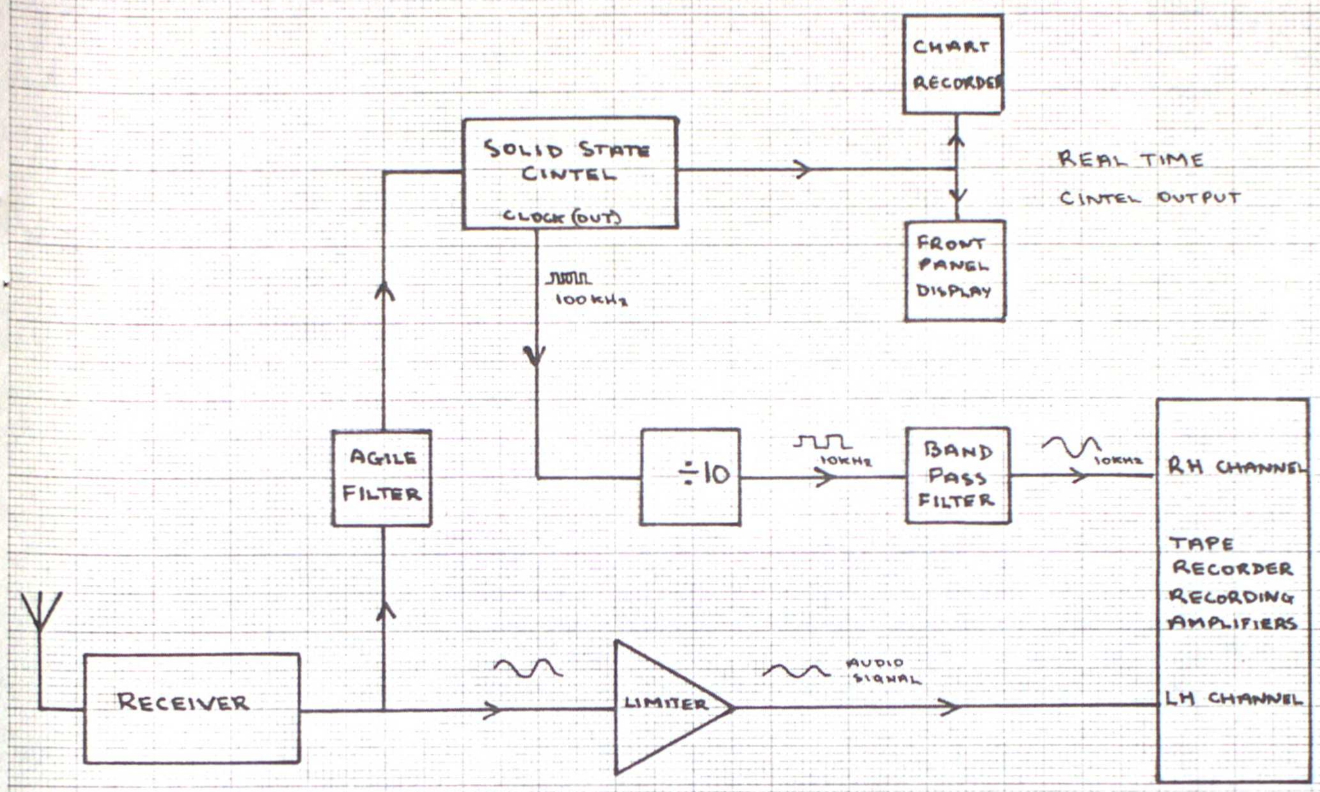

1170 μSec (854.7 Hz)
1160 (862.1)
CINTEL TRACE
1150 (869.6)
FIG 1a
1170 μSec
1160
1150
FIG 1b
1170 μSec
1160
1150
FIG 1c
1170 μSec
1160
1150
FIG 1d
MINUTES→
1 2 3 4 5 6 7 8 9 10 11 12 13

SYSTEM ON 'RECORD'



SYSTEM ON 'REPLAY'

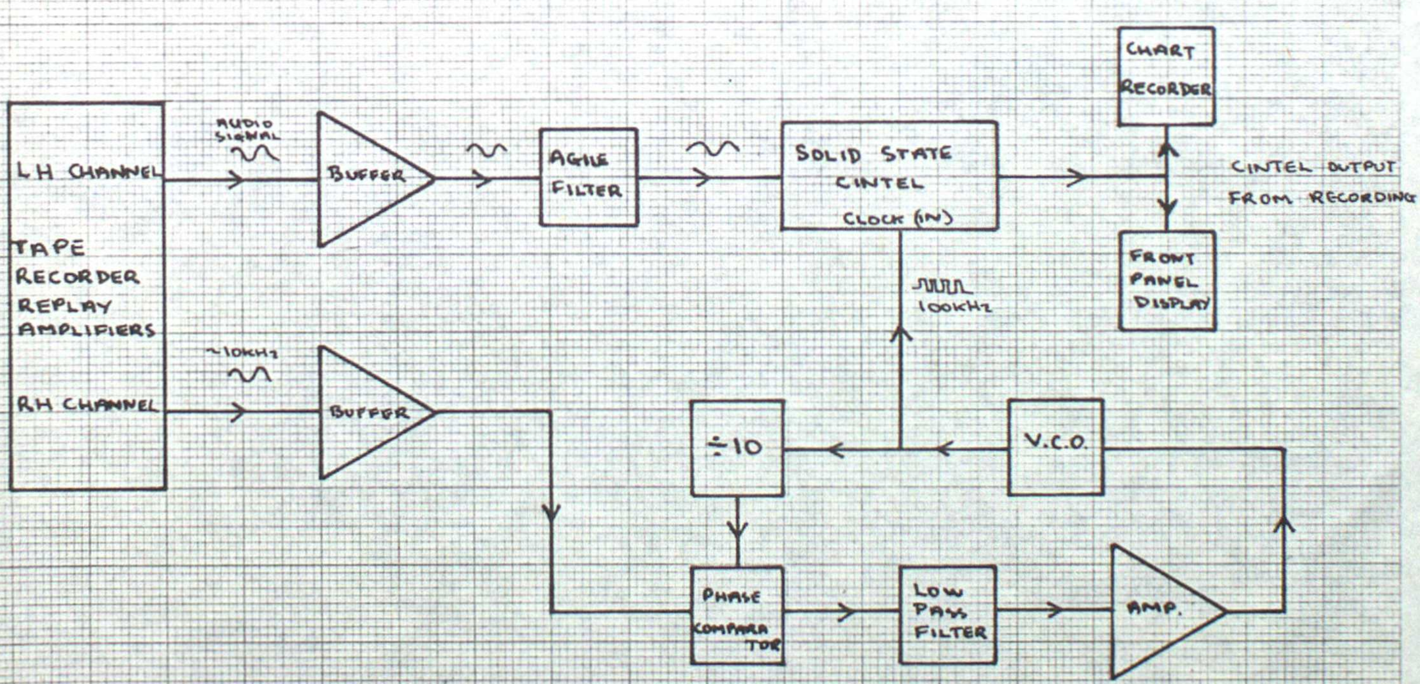


FIG. 2

FIG. 3 PART OF REAL TIME CINTEL TRACE FOR MSD2

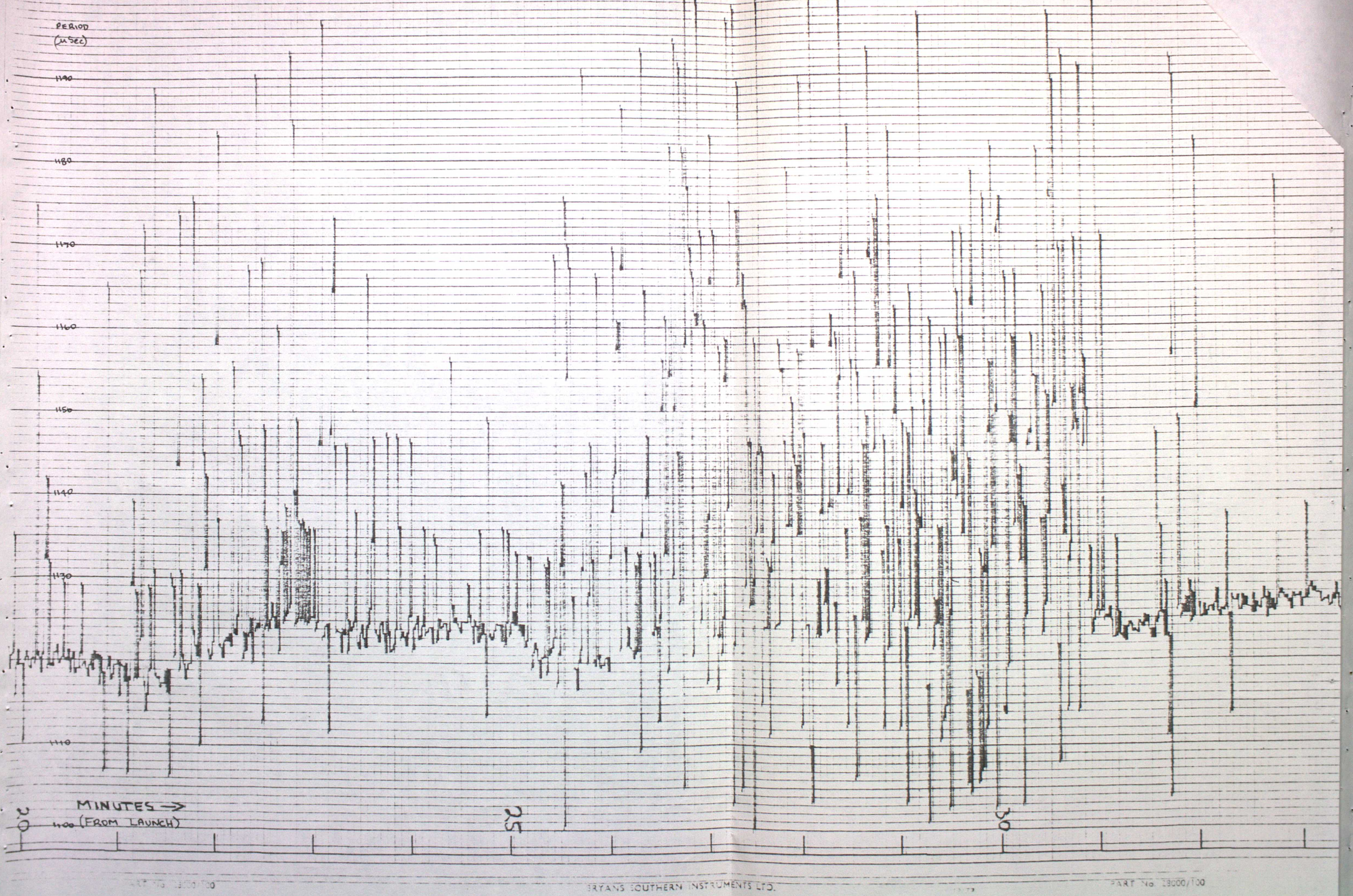


FIG. 4 PART OF CINTEL TRACE FROM REPLAY OF RECORDING OF M502