SUMMARY

Analog techniques for recording and analyzing seismic data have reached a limit of accuracy and dynamic range far short of newly developing requirements. To achieve new levels of performance, necessary to identify more complex and deeper geological structures, digital techniques must be employed.

These techniques include the digital computer which permits more sophisticated mathematical procedures to be applied to the seismic data; the digital recorder which freezes data accuracy in digital form at an early stage; and the seismic amplifier with digitally-switched gain levels.

The Model 72 Automatic Gain-Ranging Amplifier, developed by SDS Data Systems (patent applied for), provides a digital resolution of 84 db---15 gain levels each doubling the preceding gain. As part of the Series 1010 Geophysical Digital Recording System (capable of 15-bit resolution or 84-db dynamic range), overall system digital resolution totals 168 db.

Harmonic distortion of the amplifier is an order of magnitude better than most seismic amplifiers--less than 0.1%. Gain accuracy is 0.02% between levels on a single channel and 0.1% between channels. Gain linearity is held to 0.1%. Gain is recovered--for computation or playback--with digital precision, since each gain step is recorded on the digital tape in 4-bit code.

The new field recording system is a tool of unprecedented capability for geophysical exploration.

THE EXPLORATION TASK

The purpose of seismic data processing is to extract usable information about underground geological structures from a vast mass of detailed signals and noise. This assignment has always been a difficult one, and the exploration industry has typically employed the most advanced technology as an aid.

In recent years the search for oil has had to penetrate deeper into the earth and to delineate more complex oil-trapping structures. Offshore prospecting has introduced additional complications, as well as substantially increasing the sheer volume of data recorded. As a result of all these factors, the wanted signal is often smaller. It may lay below the noise level. The most effective way to recover these extremely low-level signals is by mathematical procedures in a digital computer. Furthermore, the computer brings great flexibility to the data reduction task; to change procedures, it is necessary only to revise the computer program--not redesign and re-arrange physical hardware.

INSTRUMENTATION REQUIREMENTS

The digital computer, unlike analog processing methods, can process seismic data with any desired degree of precision, depending on the number of binary bits employed. Consequently, the overall data acquisition and processing system is limited--not by the precision of computation, but by the capability of the analog input amplifiers or of the digitizing and recording units.

At the speed required by seismic work, 1000 samples per second per channel, modern electronic units are capable of digitizing and recording 15-bit samples (equivalent to 84 db dynamic range). This capability pushes the limiting element back to the seismic amplifiers.

Consequently, to take full advantage of the dynamic range of the digitizer and recorder, the seismic amplifier must be re-examined. As a first requirement, it should be capable of passing a dynamic range of at least 84 db, so that it does not degrade the performance of the rest of the system. If, by means of amplifier design, additional range could be added to the system, that would be a plus. Before considering the seismic amplifier in detail, however, the capability of current analog recording techniques will be reviewed.

ANALOG RECORDING TECHNIQUES

The dynamic range which may be achieved with analog recording devices extends from perhaps 35 to 40 db for recording oscillographs (cameras) up to 72 db for