

with a 5-to-1 burst-out at 50 cycles is approximately 0.15. With a more favorable "chance" occurrence of sample points, all of the samples in this example would be on scale. Even in the worst case, it is important to note that, following data sample 2, the system recovers (by reducing gain) and records all the remaining samples of the burst-out. The peak value of the burst-out signal is not clipped, as might occur in a programmed gain control configuration.

AMPLITUDE RECOVERY

With the 4-bit gain code and the 15-bit digitizer value, both recorded in binary form on magnetic tape, the amplitude of each signal can be readily recovered in either digital or analog form.

Digital Reconstruction

For digital use, signal amplitude can be reconstructed by a computer to a degree of precision unprecedented in seismic recording experience, as already discussed in the section on dynamic range. It may be noted further, however, that one of the advantages of doubling the gain each step is that the gain code, in binary form, is the same as the exponent in binary floating-point representation which is used in most computers. The 15-bit output of the digitizer represents the mantissa of the complete number. In this form, mantissa and exponent, the computer may use the data directly (except for format) in floating-point computations, or may easily reconstruct the exact-fixed point values of the samples.

Analog Playback

For analog use, the recorded digital values may be converted by a digital-to-analog converter. Since the limit of resolution of a recording oscillograph is only 0.5% (or 8 bits), there is no need to use all the bits available on the digital tape. Nine bits plus sign are ample. Using only these data bits, however--ignoring the gain code--the analog output suddenly steps up or down as the gain level is increased or decreased. Thus, the analog output remains within the relatively narrow

range of the oscillograph--but at the expense of sudden steps at each gain change point.

Smoothed Recovery

If the sudden steps caused by gain shifts are deemed objectionable, they may be entirely eliminated by the smoothed-recovery digital-to-analog converter (patent applied for). This unit, given a digital input in the form of a mantissa and an exponent, produces an analog output which simulates the signal provided by an analog recorder with automatic gain control. The smoothed-recovery unit, however, is capable of converting digital data of very great resolution into an output adapted to the limited resolution of an analog playback device. This output has a constant average amplitude, just as a conventional analog AGC seismic trace does. Rapid changes in output amplitude, or burst-outs, are reproduced in full fidelity, regardless of the particular amplifier-gain-level on which the event occurred. The digital input consists of two parts: One part is the 15 binary bits from the system analog-to-digital converter, and the other part is the 4 binary bits from the gain control unit. These two parts are equivalent to a mantissa and an exponent in binary floating-point representation; for example:

$$S.QQQQQQQQQQQQQQQ \times 2^{-GGGG}$$

where S is sign, Q represents a mantissa bit and G, a gain-code bit.

The nine most significant bits of the mantissa are placed in the central positions of the mantissa register and the 4-bit exponent in the exponent register, as shown in the simplified block diagram of the smoothed-recovery unit in Figure 8. The mantissa register has three positions, on both the left and right of the central positions, and a sign position, making 16 bits in all. By shifting the 9-bit mantissa to the left, burst-outs can be accommodated. Since each left shift doubles the value of the mantissa (in the binary number system), each shift represents a 6-db burst-out capability. With three left shifts available, total burst-out capability is 18 db. Each right shift, on the other hand, halves