

obtain the overall system dynamic range. Consequently in the worst case on the highest gain level (when the seismic input signal has fallen below 61 microvolts), the system dynamic range is 140 db.

The dynamic range at the digitizer, calculated from noise levels, is from 4 to 28 db less than the digital resolution expressed in decibels. Each 6 db of dynamic range below the resolution represents the loss of one bit of resolution. For example, on gain level 0 (gain of 10), the last bit of the fifteen bits is below the rms noise level. At gain level 12, the last three bits are lost; and at gain level 14, more than four bits are below the rms noise level.

In most applications, digitizing below the system noise level would be of little value. In the seismic application, however, the additional resolution capability is valuable. The reason is that computer procedures such as filtering, cross-correlation, and convolution can retrieve data from noise. Stacking procedures, too, can attenuate the noise in relation to the wanted signal. There are reports of data being extracted from noise as much as 35 db greater than the data. In order for noise removal procedures to function effectively, the digital resolution capability must extend below the noise level. As computer procedures are improved and become more widely used, 14-bit-plus-sign resolution will become more and more useful.

Automatic Gain Selection and Recording

The selection of one of the 15 gain levels is entirely automatic, except for the early gain setting which will be discussed in the next section. The Model 72 amplifier optimizes gain solely on the basis of signal amplitude, thereby eliminating operator judgment in this matter.

The output of the AGR amplifier is ordinarily held between one-quarter and one-half of digitizer full scale. The upper setpoint was selected so that a seismic signal could double and still remain within the digitizer scale. Thus, a burst-out increasing at the rate of

6 db/ms can be digitized and recorded. Yet, as the signal peaks gradually fall below quarter scale (as the seismic signal declines), these small signals can be very precisely digitized, as 12 out of the 14 magnitude bits are still in use at these levels. In effect, the selection of the setpoints strikes a tradeoff between the ability to record burst-outs and the ability to resolve signals below the lower setpoint.

The selection of the appropriate gain level is the function of the gain control unit. This unit consists essentially of logic elements which compare the digital output of the digitizer with the upper and lower set points and a 4-bit up/down counter which stores the 4-bit binary gain code currently in use. As the seismic signal decreases and falls below one-quarter scale, the counter is incremented up one gain level. If the signal increases and exceeds half scale, the counter is decremented by one. The output of the counter is decoded to control the two post-amplifiers, the amplifier output selector, and the buffer amplifier--all the switchable elements of the automatic gain-ranging amplifier. The counter output is also recorded on the magnetic tape periodically.

To accommodate variations in field conditions, the user may specify the number of gain control units per system. If one unit is used, it is responsive to all seismic inputs, and the signal with the highest input amplitude dictates the gain of all channels. This is called "ganged gain" control.

If a gain control unit is connected to a group of inputs, say four, then each independently controls the gain of its group. Again, the signal with the highest input amplitude sets the gain of all channels within the group. This is called "group gain" control. If a unit is connected to each channel, it is responsive only to the amplitude of that channel. This is called "individual gain" control. With this arrangement, the gain of the one channel is optimal at all times.

Generally, where prospecting will be confined to shallow spreads, inter-channel amplitude variations with