Operator judgment: The determination of the times and amounts of programmed gain requires considerable judgment on the part of the operator. Moreover, one or more test shots may have to be made in each shooting location to enable the operator to determine when the gain changes should be made.

Also, in order to assure that the signal can be held within the limited bandwidth characteristics of typical AGC amplifiers, the operator may have to make a selection from ten, or so, low-cut filters and an equal number of high-cut filters. Furthermore, the selection of early gain requires more judgment on the part of the operator.

Operator attention: Analog recording requires a great deal of attention by the operator--to match and balance losser circuits, to adjust and trim circuits, and to make the repetitious manual adjustments necessary to change back and forth between record and playback.

Processing degradation: In addition to the initial inaccuracy of analog recordings, the signals are degraded further by every following analog processing step in contrast to digital processes where, once digitized, sample values remain the same, from an accuracy standpoint, through all further digital processing.

SEISMIC AMPLIFIER REQUIREMENTS

As computer processing forces the use of digital recording, the weak link in the chain of equipment, from geophone to computer, becomes the seismic amplifier. To meet the newly emerging needs, the seismic amplifier should fulfill the following requirements:

The dynamic range, as a minimum, should not constrain the digital recorder. Preferably, its range should add to that of the recorder.

Selection and recording of gain values should be fully automatic.

Signal amplitude, including gain steps, should be recovered with all the resolution that digital techniques make possible--at least an order of magnitude better than the best analog recording.

Time correlation, similarly, should be recoverable to digital standards of accuracy.

Furthermore, the amplifier design should embody the latest state-of-the-art with respect to linearity, stability, distortion, solid-state components, size, power, and environment. Operator adjustments should be minimized. Test and calibration capabilities should be complete and easy to use.

BLOCK DIAGRAM ANALYSIS

The Automatic Gain-Ranging (AGR) Amplifier, developed by SDS Data Systems to meet these geophysical exploration needs, is shown in simplified block diagram form in Figure 1. The unit accepts the signals normally provided by velocity pickups (geophones) with a source impedance of 500 ohms over twisted-pair lines, unshielded, with no particular restriction on the distance from the geophones to the amplifier. Variable resistance and capacitance are provided to balance the input lines in order to reject 60-cycle interference, improve common-mode rejection, and eliminate high-line noise.

The balanced input is transformer-coupled to a fixed-gain preamplifier. Filters limit the signals to the frequency range selected by the operator. Low-cut filters reject high-amplitude "ground roll," preventing it from masking data of interest. Aliasing filters prevent aliasing errors (or frequency foldover). High-cut filters reject other frequencies not desired in the recorded data.

Beyond this point in the AGR amplifier, the operations are controlled by a digital gain code derived from the digitizer. In general, when the values being digitized fall below one-quarter of digitizer full scale, the next higher gain code is originated by the gain control unit. Similarly, whenever the digital output exceeds one-half full scale, the next lower gain code is produced. The