The Eddy-SEIS: A new type of geophone

Ernest M. Hall, Jr

Introduction

Regular geophones, as used for the past 35 years, utilize a moving coil in a permanent magnet field. The coil serves as the inertial element and relative motion between the coil and case occurs when the geophone case is mechanically excited. Electrical connection to the moving coil is required in order to record the signal generated by the case motion.

The OYO Corporation has developed a new type of geophone, trade-named the Eddy-SEIS from 'eddy current seismometer'. The inertial element is a tubular sleeve of copper, which generates eddy currents as it moves in the permanent magnet field. The coil is fixed and is soldered directly to the terminals of the geophone. The eddy currents, which flow in the moving inertial element (tubular sleeve), induce a voltage in the stationary coil.

The Eddy-SEIS provides significant advantages over moving coil geophones. The frequency response curve shows a 6 db/octave enhancement of the higher frequencies, as compared to moving coil geophones. The low frequency ground roll attenuation is 18 db/octave, as compared to 12 db/octave in a moving coil geophone. Damping is unaffected by external loading. Field test results confirm that the Eddy-SEIS provides increased resolution and broadening of the frequency spectrum.

Theoretical basis

Whenever a magnetic flux passing through a conductor is made to vary either in position or magnitude, an e.m.f. is induced in the conductor. In the case of OYO's new geophone, the e.m.f. induced in the movable inertial element results from the relative motion between a conductor (the inertial element) and a magnetic field. In such a case, the induced e.m.f. is at right angles to the direction of the magnetic field and to the direction of the motion. The e.m.f. induced in the conductor causes current to flow in closed loops or 'eddies', generally referred to as eddy currents. It is this principle of eddy current generation which serves as the basis for the operation of OYO's new Eddy-SEIS.

The use of eddy currents in geophones is not new. Most moving coil geophones utilize eddy currents in the coil to provide a portion of the damping. In such geophones the eddy current serves no other useful function.

In the case of the Eddy-SEIS a tubular sleeve of non-magnetic, conductive material is caused to move in a permanent magnetic field, and such motion generates eddy currents in the moving conductive sleeve. The eddy currents so generated serve a dual function. One is to damp the motion of the sleeve, and the other is to provide a magnetic field for the purpose of signal generation. Since the magnetic field generated by the eddy currents flowing in the conductive sleeve is changing in both amplitude and position relative to the fixed coil, the signal generated in the geophone coil is proportional to acceleration, not velocity. Figure 1 shows the internal structure of the Eddy-SEIS.

Features of the geophone

Figure 2 shows the response of the Eddy-SEIS for a constant velocity excitation, and compares it to the response of a 10 Hz

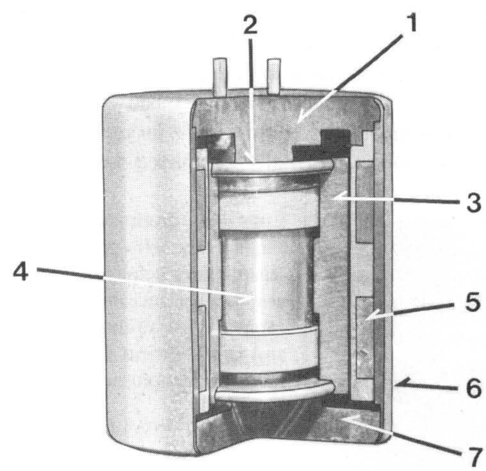


Fig 1 Pictorial of Eddy-SEIS structure. 1: Header with terminal pins. 2: Spring with retainer ring. 3: Inertial element (tubular copper sleeve). 4: Stationary magnet with inner pole piece. 5: Stationary coil with coilform. 6: Outer pole piece. 7: Bottom end cap.

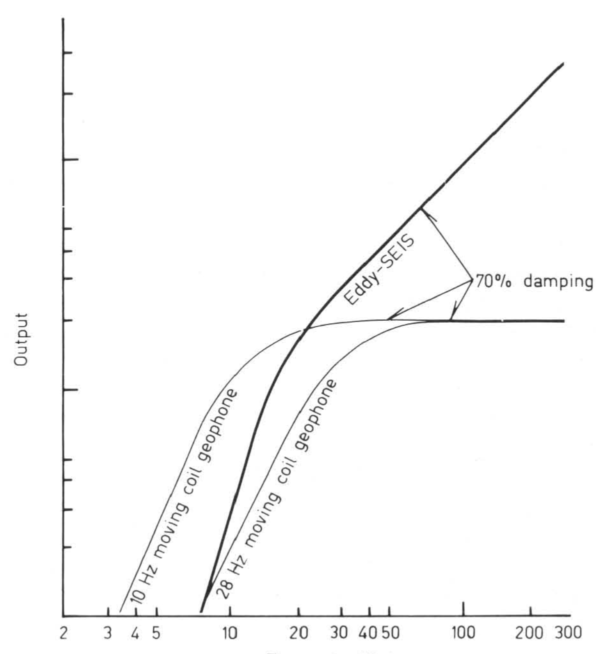


Fig 2 Frequency response curve comparison using constant velocity excitation.

and 28 Hz geophone, all units damped at 70%. One of the big advantages offered by the Eddy-SEIS is evident from the shape of the response curve. The sensitivity to higher frequencies is increased at a rate of approximately 6 db/octave, and this enhancement of high frequency sensitivity helps to offset the sharp attenuation of high frequencies by the earth.

The Eddy-SEIS also offers improved low cut filter action. The 6 db/octave enhancement of frequencies above the natural frequency is transformed into 6 db/octave of additional low cut filtering below the natural frequency when comparing the Eddy-SEIS to regular geophones. This means that when the geophysicist chooses to use the seismic detector as a low cut filter, the Eddy-SEIS is 50% more effective (18 db as compared to 12 db) than a regular geophone.

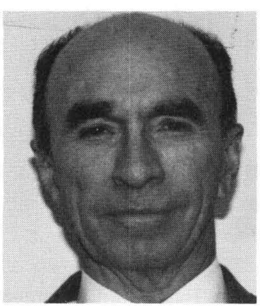
The damping of the inertial element (copper sleeve) is provided entirely by the eddy currents flowing in the copper sleeve. No damping resistor is required. The damping is further unaffected by loading the geophone coil.

Due to the unique utilization of basic eddy current principles, it is practical to accommodate a larger mass for the inertial element than is normally permitted in the design of a regular moving coil geophone. Not only is the basic unit substantially reduced in overall weight (45 g as compared to typically more than 70 g), but the mass of the inertial element is also increased by approximately 45% (16 g versus 11 g).

The simplicity of the Eddy-SEIS construction improves its reliability when compared to regular moving coil geophones. No electrical connection is required to any moving part since the geophone coil is stationary with respect to the header and frame of the geophone. The moving inertial element is a sturdy sleeve of copper alloy and free to rotate on the supporting springs, thus reducing stress on the springs.

Test results

Extensive field testing of the Eddy-SEIS is currently being conducted. Initial test results have been very encouraging. Improvements in ground roll rejection have been readily apparent on the field records, and the increased sensitivity to high frequencies has demonstrated increased resolution and a flattening of the frequency spectrum.



Ernie Hall graduated (1950) from the University of Texas at Austin with a BSc degree in Electrical Engineering. His professional experience has been in industry, working for companies manufacturing seismic data acquisition instruments. His specialty is geophones, a field in which he has more than 30 years' experience and is the holder of numerous patents. He has worked in an engineering or management capacity in several of the leading geophone companies and is currently employed as manager of Research and Development for OYO Corporation, USA in Houston, Texas. He has served as Treasurer of the Houston Geophysical Society and is currently an active member of the SEG.

E. M. Hall, OYO Corporation USA, 7334 N. Gessner Road, Houston, Texas 77040, USA.

A review of geophysical exploration methods for coal in Queensland

R. D. Huber

Introduction

The Geological Survey Division (GSD) has initiated numerous studies involving the application of geophysical techniques in the coal industry. An example of the early work is the combined Queensland Department of Mines/BMR seismic reflection survey near Moura (GSD/BMR 1970). This survey recorded clear reflections from coal seams as shallow as 91 m and detected faults with throws as small as 4.5 m. More unusual studies were reported by Koppe and Anderson (1974). They noted an empirical relationship between the variation along strike of coal rank and the Bouguer anomaly values at the northwest edge of the Bowen Basin. They concluded that the basement, through its influence on the geothermal gradient, was a determining factor of coal rank variation in this part of the Bowen Basin. More recently the suitability of microgravity and INPUT methods are being evaluated as indicators of structure on shallow seams, and the potential location of mini-coal basins respectively.

This diversity of application of geophysical methods to coal exploration has prompted this consideration of geophysical applications for the Coal Industry covered recent developments in wireline logging and in-seam seismic tech- the Macquarie University Centre for Geophysical Exploration Research in February 1985 on the subject of new geophysical applications for the Coal Industry covered recent developments in wireline logging and in-seam seismic techniques hence these will not be considered here. Instead the focus will be centred on surface applications of traditional geophysical techniques—gravity, magnetic, seismic and electrical methods. Examples are taken from the open file company reports library of the GSD and published case histories.

Gravity

The traditional exploration role for the gravity method has been as a regional technique providing structural information. The density contrast between the sedimentary coal environment and basement resulted in this method commonly being