Marine Vibrators: Part I
Early Developments and a Failure

If you want to find the secrets of the universe, think in terms of energy, frequency and vibration.
Nikola Tesla (1856–1943)

MARTIN LANDRØ and LASSE AMUNDSEN

In 1966 the marine seismic industry was blooming and acquiring a lot of seismic data by using a substantial quantity of dynamite. A combination of safety and environmental issues paved the way for a new source: the airgun, which was actually invented in 1960 by Stephen Chelminski, but came into practical commercial use 10 years later. Less well known is the fact that Conoco developed a marine seismic vibrator that was successfully tested in 1966 and also in later years. A marine seismic source competition developed during the late 1960s and the winner was the airgun: the marine vibrator lost.

Here we will explain how a marine seismic vibrator works, and why it might be getting closer to reality.

A Bit of History

In today's conventional acquisition two airgun sources, each defined by two or three sub-array elements spaced 6–8m apart, are fired sequentially at specified intervals, in a mode popularly called flip-flop shooting. After one source is fired, the reflected signals are recorded to the required time length for imaging the ground before the next shot can be acquired.

Before the airgun, dynamite was the common source for marine seismic operations, either placed on the seabed or directly into the water. Stephen Chelminski, who founded Bolt Technology in 1960, first acquired shallow seismic data using airguns in 1961 (Proffitt, 1991). In 1967 the concept of tuned airgun arrays – using airguns with different volumes – was introduced worldwide.

Today, a marine seismic source usually consists of between 20 and 50 airguns of different sizes. When the source is fired (i.e. the air is released), an acoustic signal is sent into the earth.

In the 1960s Conoco developed the first marine vibrator (Proffitt, 1991) and for a number of years there was competition between the two sources, marine vibrators and airguns. According to Proffitt, it was the safety, simplicity and reliability of the airgun that made it the winner of this competition. During the '80s improved design and new developments for hydraulic marine vibrators were made.

Vibroseis – the First Land Vibrator Source

The first seismic vibrator source was developed in the 1950s by Conoco in order to replace the use of dynamite as a source for seismic land acquisition. Crawford et al. (1960) published a paper entitled 'Continuous signal seismograph', where they described the development of the first seismic vibrator, which they called Vibroseis. The figure below is taken from this paper, in which the combined use of a continuous signal and cross-correlation is described in detail. Notice the delay drum device in the figure. Crawford, Doty and Lee received the Reginald Fessenden award for this work from SEG in 1967. John Crawford is known as the father of vibroseis. Field work was essential in his work, and one of his best-known quotes is: "What field work teaches you is never to ask a man to do something that you couldn't or wouldn't do yourself."

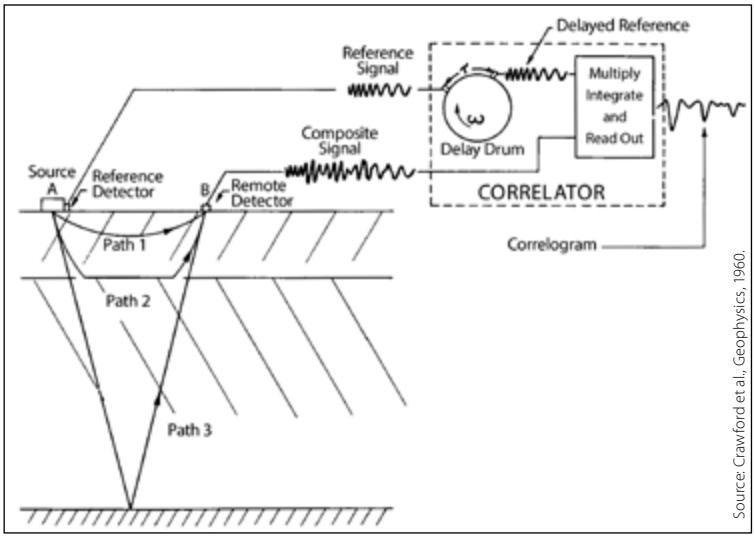
Launching Marine Vibrators…

In the late 1960s the marine vibrator sources were adaptations of land vibrators. Instead of generating a directive vertical force to the ground, marine vibrators were designed as a pulsating sphere (or similar shape) acting on water. In 1966 and for some years thereafter several marine vibrators were tested offshore, and demonstrated good results.

In 2002 Tyler Priest and Joseph Pratt interviewed Sam L. Evans about the competition between marine vibrators and airguns in this period. Sam states in this interview that the marine vibrator has a good signal but the vibrator signal length of 10–12 seconds followed by a listening period of 6–8 seconds makes the method slow and ineffective. When you tow seismic streamers you want the vessel speed to be around 4–6 knots (at least) to avoid drifting, so this lag makes the marine vibrator source less useful.

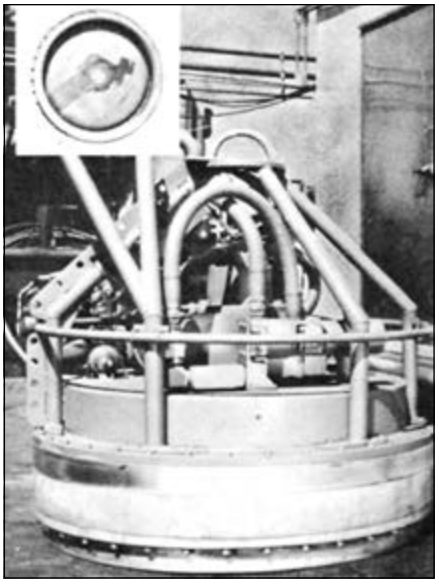
After the success of the vibroseis source onshore, Conoco spent several years finding ways to exploit this technology offshore. They cooperated with several companies including Olympic Geophysical and Ray Geophysical, and later Seiscom

Schematic view of the continuous energy method.



Delta. According to Evans, however, by 1972 or 1973 airguns had become the industry standard preferred marine seismic source.

From 1962 to 1970 SSC (Seismograph Services Corporation) and its subsidiaries (like, for instance, SSL) were the only service company that had the right (with a licence from Conoco) to operate the vibrator method on land (Lawyer, 2011). The figure on the right shows an old photo of the vibrator used by SSC in this period.



The Vibroseis high power transducer. (From Seismograph Services Corp., and Lugg, 1971.)

…And Losing the Battle

So why did the seismic vibrator win terrain for onshore applications in the late '60s, while the marine vibrator became a loser? The answer is probably complex and to some extent related to timing, random circumstances, but maybe mainly caused by the practical issues of a moving source emitting a long, randomised signal that required longer records for each shot and more processing efforts after acquisition.

Another reason could be that the mechanical life and long-term field reliability of the marine vibrator could not compete with the reliability of the airgun array. It was seen as an expensive, formidable engineering task to design a vibrator and its its associated rigging and handling gear for smooth, reliable operation in the harsh ocean environment..

So why are marine vibrators topical again today? First of all, there are offshore areas where the use of airgun arrays is not permitted, either seasonally or on a permanent basis. Environmental concerns related to noise pollution in the oceans are in focus, and hence there might be a need to develop sources with lower sound pressure level and sound exposure level than airguns. Research and development projects have been conducted by contractors and by industry consortia aiming to develop new marine vibrators that can compete with airgun arrays. We will discuss these developments in a series of articles. ■

References:

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