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SLEEVE GUNS AND WIDE TOW

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Introduction

With the increased emphasis over recent years on achieving higher spatial and temporal resolution from seismic data, many improvements to the acquisition and processing systems—both hardware and software—have been made.

Field recording systems have long been capable of collecting data with very high temporal resolution, and the introduction of digital streamers with large numbers of closely spaced, short groups has provided a significant improvement in spatial resolution. Wavelet processing techniques and wave equation consistent migration have also contributed to the improvement in resolution, during the data processing phase.

In spite of these improvements, limitations are placed on the maximum resolution achievable by the relatively narrow and biased bandwidths of conventional sources.

A further obstacle to achieving the high resolution goal is the presence of scattered noise in the recorded data. This may be caused by a number of phenomena including underwater obstacles, shallow reefs and irregular water bottom profiles. Unfortunately, this type of noise may be difficult or impossible to remove using traditional techniques such as F-K filtering or array simulation.

This paper discusses solutions to these two main problems—the source bandwidth and the scattered noise.

The External Sleeve Gun

The first problem has been greatly diminished by the advent of an airgun whose design is a radical departure from that of the traditional airgun. In the external sleeve gun (Fig. 1), a rigid steel member forms a central backbone to the gun. High pressure air is stored in a concentric chamber about the lower half of the unit and contained by an external sleeve—hence the name of the gun. When the gun is fired, the sleeve slides up over the top part of the gun exposing the stored air over a full 360 degree span. This generates a more nearly spherical bubble than its conventional counterpart and, consequently, makes more efficient use of the energy produced. The result is a dramatic improvement in bandwidth.

Evidence of this improved efficiency is seen in Fig. 2 which shows the far field signature of a 0.655 litre (40 cu. in.) sleeve gun compared with that of a 1.31 litre (80 cu. in.) conventional airgun obtained under identical conditions. The two signatures are very similar in amplitude and bubble oscillation implying

FIGURE 1
External sleeve air gun.

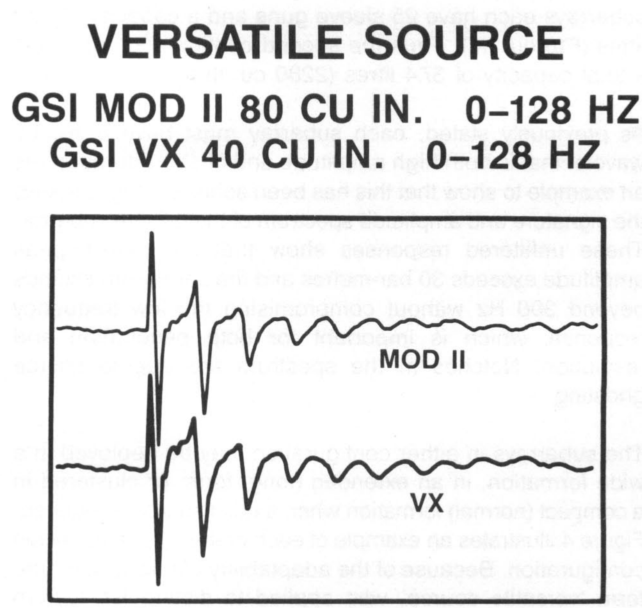

FIGURE 2
Comparison of far field signatures of a 0.655 litre (40 cu. in.) sleeve gun (labelled VX) and a 1.31 litre (80 cu. in.) conventional gun (labelled MOD II).

that the 0.655 litre sleeve gun gives the equivalent output of a 1.31 litre conventional gun.

Two further features of the sleeve gun are that it requires about half the number of components of a conventional airgun, and that it is practically impossible for it to autofire. These suggest (and indeed exhaustive testing has shown) that the sleeve gun is a much more reliable unit.

Wide Tow Arrays

As a consequence of this greater efficiency and reliability, it is now practical to deploy wide and areal arrays in the marine situation. These may be used to alleviate the second problem outlined above—scattered noise.

The first important requirement of an airgun array is that it is 'tuned' with guns of different sizes so that the source wavelet is a high amplitude signal of short duration and that the subsequent bubbles are attenuated. Thus, an ideal areal array would have to consist of several 'subarrays', each individually tuned. In order to achieve this, two different configurations were designed. One configuration, for fitting to large vessels, uses 9.1 metre (30 foot) long Paracats to deploy the subarrays. A second configuration uses the smaller, and much more easily managed, paravanes for deployment of the subarrays.

The Paracat configuration consists of 6 identical subarrays. Each basic subarray is composed of 17 sleeve guns in a highly tuned formation. The total capacity of each subarray is only 6.2 litres (380 cu. in.), giving a total capacity of 37.4 litres (2280 cu. in.) for the full array.

The paravane configuration is made up of 4 subarrays. The outer string subarrays each consist of 26 sleeve guns with a total capacity of 8.7 litres (530 cu. in.). The two inner string subarrays each have 25 sleeve guns and a capacity of 10.0 litres (610 cu. in.). Thus the second configuration also has a total capacity of 37.4 litres (2280 cu. in.).

As previously stated, each subarray must have a source wavelet that is both high amplitude and of short duration. As an example to show that this has been achieved, Fig. 3 shows the signature and amplitude spectrum of the 6.2 litre subarray. These unfiltered responses show that the peak-to-peak amplitude exceeds 30 bar-metres and the bandwidth extends beyond 300 Hz without compromising the low frequency response, which is important for both penetration and resolution. Notches in the spectrum are due to source ghosting.

The subarrays in either configuration may be deployed in a wide formation, in an extended (long) form, or clustered in a compact (normal) formation when a point source is required. Figure 4 illustrates an example of each of these for a paravane configuration. Because of the adaptability of this system, the term 'versatile source', was applied to distinguish it from conventional arrays.

During development, many different array patterns were tested. Some had good inline and crossline responses but

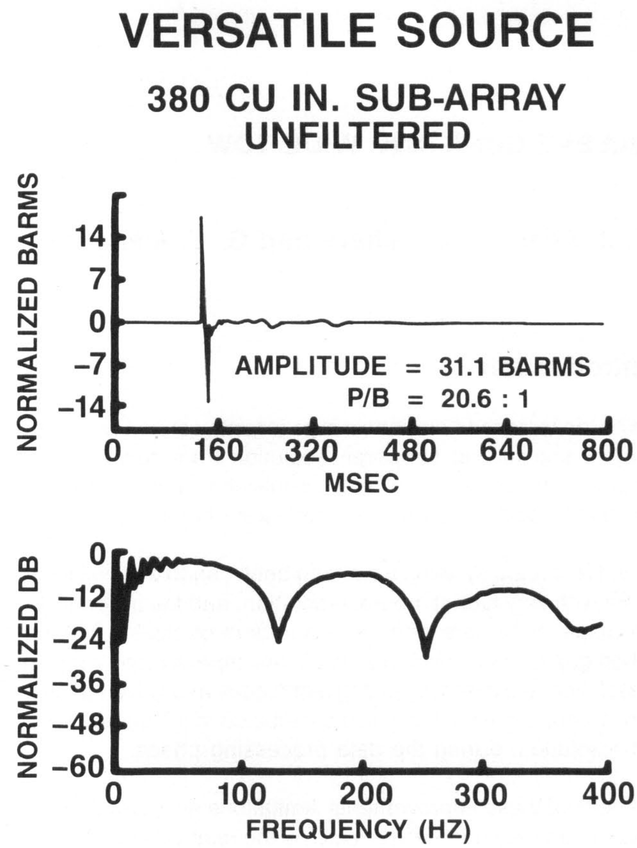

FIGURE 3
Signature and amplitude response of a 6.2 litre (380 cu. in.) subarray composed of 17 sleeve guns.

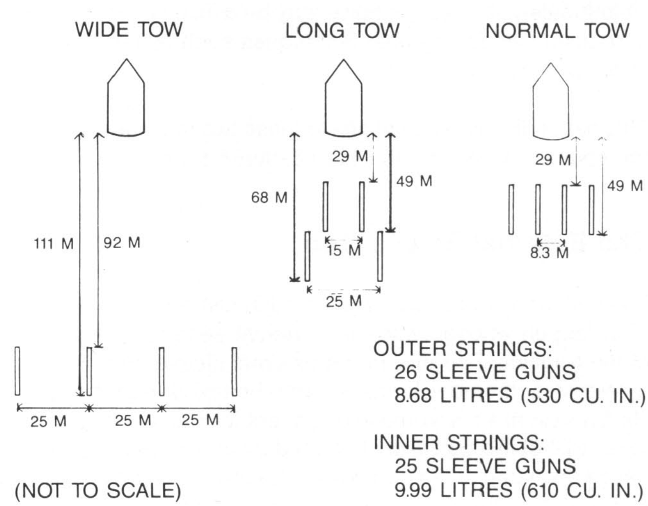

FIGURE 4
Typical tow formations for a 4 subarray 'versatile source'.

suffered severe sidelobe leakage in the diagonal direction. Others sacrificed either inline or crossline response in order to give better broadside noise attenuation. The array responses of several of these patterns will be shown and discussed during the presentation.

Data Example

To demonstrate the superiority of the wide-tow sleeve gun array, a line was recorded twice along a traverse in the Carnarvon Basin offshore Western Australia. The first recording used a conventional airgun array, whilst the second recording used the new external sleeve guns configured in a wide-tow array.

Both lines were processed using identical parameters. The filtered and scaled stack of the conventional data is shown in Fig. 5, and that of the 'versatile source' shown in Fig. 6. The new data reveals a much higher frequency content and resolution level both in the shallow zone and at depth. Many of the details revealed on the new data are masked by a low frequency reverberation on the conventional airgun array stack. In addition, much of the noise apparent on the conventional data, particularly above 1.5 seconds, has been attenuated by the wide-tow array.

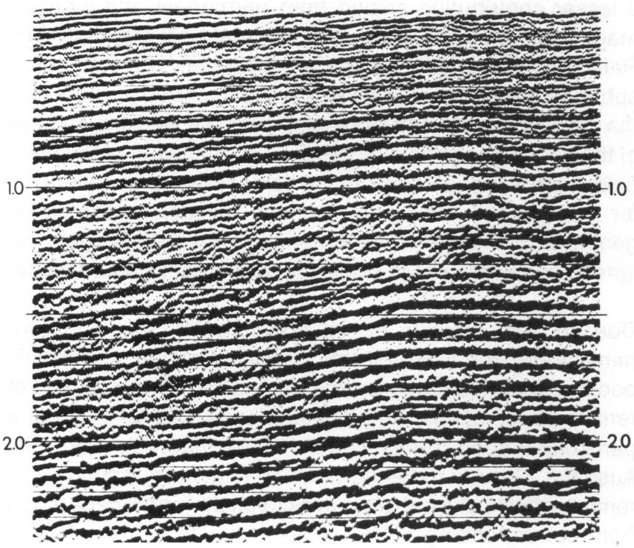

FIGURE 5
Filtered and scaled stack data shot using conventional airgun array.

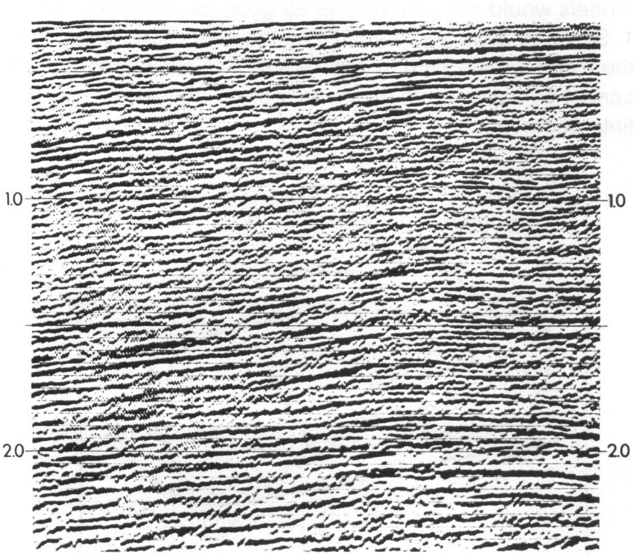

FIGURE 6
Filtered and scaled stack data shot using wide-tow sleeve gun array.

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AIRBORNE RAPID RECONNAISSANCE FOR OIL AND GAS

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Oil and gas fields and productive regions rich in mature source rocks are associated with the widespread leakage to the surface of trace amounts of hydrocarbons. In oil prone areas, these micro-seeps include liquid phase C10+ hydrocarbons which penetrate not only to the sea floor in offshore areas, but also to land surfaces.

In offshore exploration, gas leakage from the sea floor generates bubbles that are very effective carriers of interfacial films of crude oil. Such bubbles on reaching the ocean surface inject oil coated aerosols into the atmosphere and simultaneously deposit traces of oil on the sea surface. An airborne system known as AIRTRACE[R] has been developed to detect the aerosol phenomenon at high sensitivity. The equipment is operated in a low flying, twin-engine, STOL aircraft that carries a nose-mounted collection system capable of concentrating the atmospheric aerosol content by more than one million times. Hydrocarbons are desorbed and analyzed from this aerosol on a continuous stream basis and the concentrations are recorded digitally forty times per second and also displayed in analog profile form. Simultaneous recordings are made of position using Loran C and GPS systems as well as measurements of humidity, air temperature, sea surface temperature, air speed and turbulence, sea surface optical characteristics, terrain clearance and magnetic field strength. Post-flight maps are produced in the field at the aircraft base using micro computers to facilitate interactive control of operations. Production rates vary between 400–1000 line kilometres a day where good weather prevails and ferry distances are not more than 200 km.

A second airborne system is currently under development that employs laser technology for the remote sensing of