PIPELINE SURVEYING ON THE DUTCH SHELF

by ir H.R. vanderWal
Dutch Public Works Department
North Sea Directorate
Nijverheidsstraat 1
Rijswijk Holland

C.M. 1977 / B:11

Paper to be presented at the 65th Statuory Meeting of ICES
(International Council for the Exploration of the Sea).

26 September to 5 October 1977
Reykjavik, Iceland.

Summary

In 1974, the first gas pipeline was placed on the Dutch part of the Continental Shelf.
Although the number of pipelines has remained limited since then, much research has been done into the development of equipment with which and the means upon which the position of the pipelines could be controlled.
For different reasons, the Dutch Government has drawn up certain requirements regarding the ground-covering to which the lay of these gas pipelines should confirm.
In order to be able to control as to how fas these requirements have been or are being with, the "Rijkswaterstaat, directie Noordzee" carries out control surveys periodically.
In this paper I will enter into more details about the way upon which these surveys are being done and on the specific equipment that is being used.

Résumé

En 1974 on a posé le premier conduit de gaz marine dans la partie néerlandaise du Plat Continentale.
Malgré le fait que la nombre de conduits de gaz est resté limitée depuis ce temps-là, beaucoup de recherches ont été faites sur l'outillage avec laquelle et la manière dont on pourrait controler la position du conduit.
Les autorités néerlandaises ont, pour plusiers raisons, rédigé certaines exigences, par rapport à la converture des conduits de gaz. Afin de controler à quel point on satisfait ou a satisfait à ces exigences, le "Rijkswaterstaat, directie Noordzee", effectue régulièrement des mesurages de controle.
Dans ce rapport on donnera de nouvelles informations sur la manière dont on fait ces mesurages et sur l'outillage special avec lequel ces traveaux ont lieu.

I. Introduction

In the Dutch Sector of the Continental Shelf there are at present two marine gas pipelines.
They are the gas pipeline from block L-10 to Uithuizermedum with a length of about 165 km and a diameter of 36", and the pipeline running from block K-13 to Callantsoog, which is some 120 km in length and 36" in diameter (see also appendix I).
In view of the fact that the Netherlands Government has stipulated special requirements relating, among other things, to burial depths and ground covering, which have to be satisfied, it is necessary for the locations of the two pipelines to be checked at regular intervals.
The need to stipulate certain requirements in regard to burial depths arises from the following facts:

- the pipelines cross major shipping lanes (penetration depth of ships' anchors)
- the pipelines lie in intensively fished areas (penetration depth of seabed fishing gear)
- the pipelines lie in areas where the location of the seabed is subject to fairly marked change (mega ripples).

Damage to a pipeline, possibly followed by fracture, due to the above-mentioned causes may present serious hazards to the environment, navigation, fisheries etc.
In order to ascertain whether the requirement of ground covering of the pipelines has been and is being satisfied, and/or to enable any dangerous situations to be detected at an early stage, random testing is essential.
The methods and equipment used in performing tests of this kind have undergone considerable changes of late. One of the reasons for these changes is the development in electronics; developments that have been greatly accelerated by the rapid increase in the costs of offshore operations.
In the following paragraphs I shall deal more fully with the equipment with which and the methods by which the Public Works Department's North Sea Directorate now checks the location of the pipelines on the Dutch Sector of the Continental Shelf.

II. Equipment

The equipment with which the pipeline surveys in the Dutch Sector of the Continental Shelf are performed by the Ministry of Works may conveniently be divided into:

- basic equipment : (a) subbottom profiling system
- additional equipment : (a) locating system
  - (b) echo sounder
  - (c) side scan sonar
  - (d) magnetometer
  - (e) underwater television.

In addition to the above equipment, the vessels carry apparatus with which the collected measuring data can be automatically recorded (e.g. mini computers, analogeous/digital converters, magnetic tape recorders, etc.).

Basic equipment

(a) Subbottom profiling system

Subbottom profiling systems, otherwise known as penetrating echo sounders, are systems that enable us to determine up to certain depths the various structures in the subbottom of the seabed. Closely resembling in action the echo sounder on the one hand, and seismic systems on the other, these systems have now been modified by various manufacturers to such an extent that they are also suitable for determining the location of wholly or partly buried wrecks, telephone cables, pipelines etc.

A subbottom profiling system consists of three elementary parts, viz.: (see appendix II)

- the source of sound: This may be built-in in a vessel or in a stable, fish-like body, which is towed behind the vessel, on or below the surface of the sea.
  This source of sound transmits acoustical signals to the seabed.
- the receiver, which receives the signals reflected via reflecting layers/objects in the seabed and converts these into electrical signals.

- a recorder, in which the electrical signals are processed and of which a graphic display is then presented in the form of blackings.

  In this manner a continuous reflection profile of the subbottom of the seabed is registered.

  The sources of sound are electro-acoustical transducers (electrical energy being converted into acoustical energy), and are distinguishable by the way in which the necessary acoustical energy is generated (see appendix III).

  This is possible by using piezo-electrical transducers, in which high alternating current generates the acoustical energy by oscillating quartz crystals.

  The systems that operate on this principle are known as pingers.

  The acoustical energy can also be obtained from electrical energy stored in a large number of condensers.

  The boomer (in which the discharge of a coil causes an aluminium plate to be vigorously repelled by it), and the sparker (in which the energy is discharged through a pair of electrodes suspended in the sea) both operate on this principle.

  Since the electro-acoustical effect in piezo-electrical transducers is reversible (which means that these transducers can re-convert acoustical energy into electrical energy: the acoustical-electro effect), these transducers can also function as receivers.

  By contrast, the sparker and the boomer need to use a separate receiver (hydrophone) or several of them positioned in line (streamer).

  Because of the relatively low frequencies and relatively high power with which the acoustical energy is transmitted, the sparkers, boomers and pingers are capable of detecting stratifications and objects in the seabed.

  Not all sound waves reflected from the seabed and seabed strata are received direct by the transducer (hydrophone); a large number of them pass the receiver, rebound against the surface of the sea and are then reflected for the second time by the seabed or the subbottom.

This process may repeat itself several times, until the energy of the sound waves is exhausted by reflection losses, absorption, etc.
Each time the sound waves pass the receiver they are registered by the recorder (multiple reflection), which is a very disturbing effect and whereby the maximum seabed penetration is determined.

(b) Additional equipment

For performing each survey, including a pipeline survey, an adequate locating system and echo-sounding equipment must obviously be available.
We will not go into the details of the principle of these systems here.

For the operations described here frequent use is made nowadays of side scan sonar equipment, magnetometers and, occasionally, underwater television.
With a side scan sonar it is possible to inspect a relatively large area of the seabed surface.
The recordings obtained with this system may supply information regarding the possible presence of a trench and/or whether or not the pipeline is covered in.
The side scan sonar transmits acoustical signals with a frequency of about 100 KHZ and shaped like a fan. The reflected signals are converted in the recorder into blackings on the recording paper, after these signals have been amplified by a time-base amplification factor.
In this way an acoustical reflection image is produced of the seabed and the objects upon it (e.g. wrecks, pipelines, mega ripples, etc.).
With a magnetometer the presence of a pipeline/telephone cable can be detected. This sytem, which can only be used in combination with other equipment, registers changes in the strength of the earth's magnetic field. Such changes may indicate the presence of cables, pipelines, etc.

For obtaining precise information about the extent to which pipelines are exposed or damage has occurred, the use of underwater television is indispensable.

In principle there are three ways of using underwater television, viz.:

- with the aid of divers. The drawback here is that the system can only be used for a few hours a day.
- built-in, in a remote controlled vehicle. This method also has its drawbacks. In areas with strong tidal currents continuous use of this equipment will be difficult.
- built-in, in a submersible. This is the most efficient, but also the costliest method of inspecting the seabed.

The Public Works Department's North Sea Directorate occasionally employs divers during pipeline surveys.
It is being investigated whether one of the other two systems could also be used for other kinds of work (appendix IV gives a diagrammatic survey of the equipment used for inspecting pipelines).

III. Method of scanning

In practice, the usual procedure for determining the horizontal and vertical position (ground covering) of a pipeline is to start with a side scan sonar view, especially if it is known that the pipeline is without ground covering in places. For this scanning, which is done in the longitudinal direction of the pipeline, one needs to have the use of a locating system with a high degree reproducibility (reproducibility in this context means the accuracy of the locating system with which one can return to points previously determined with it).

The survey can start with a rough magnetometer or subbottom profiling test. The recordings obtained should indicate the location of the pipeline.

After a side scan sonar shot it will be necessary to sail a zig-zag course over the pipeline, using a subbottom profiling system.

The distance between the different crossings of the pipeline depends on a number of factors, such as:

- purpose of the survey. It may be a routine survey, a spot check.
- the results of the scan sonar survey. If areas are detected where the pipeline has no ground covering, or there are doubts about the ground covering owing to the presence of a trench, the turn distance has to be shorter.
- composition and topography of the seabed. In a mega ripple area the distance between turns will be shorter than in an area where few changes, if any, occur in the seabed.

In practice, the Public Works Department's North Sea Directorate use a turn distance of 250 metres, while in areas where the pipeline has ground covering and/or the seabed undergoes marked changes the turn distance is reduced to 50 or 25 metres.

The transducer of the subbottom profiling system will have to have a relatively large aperture angle to enable the pipeline to be detected at an early stage, and relatively small penetration depth so as to prevent the echoes from the pipeline from being combined with bottom strata echoes, which would make interpretation of the

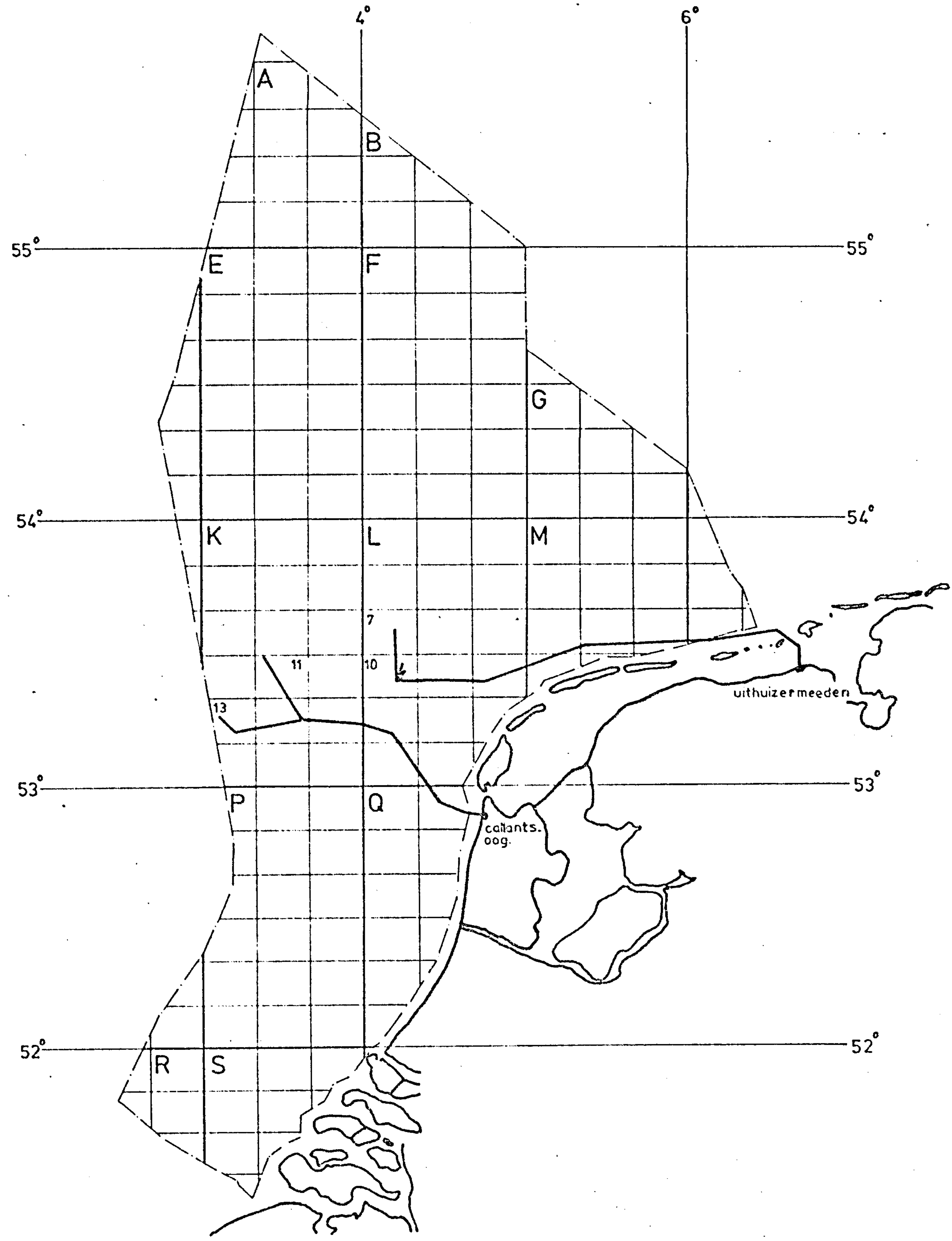
IV. Conclusion

In the foregoing I have outlined the way in which the Public Works Department's North Sea Directorate monitors the gas pipelines in the Dutch sector of the Continental Shelf.

Clearly, the method of scanning and the equipment with which this is done leave room for improvement.

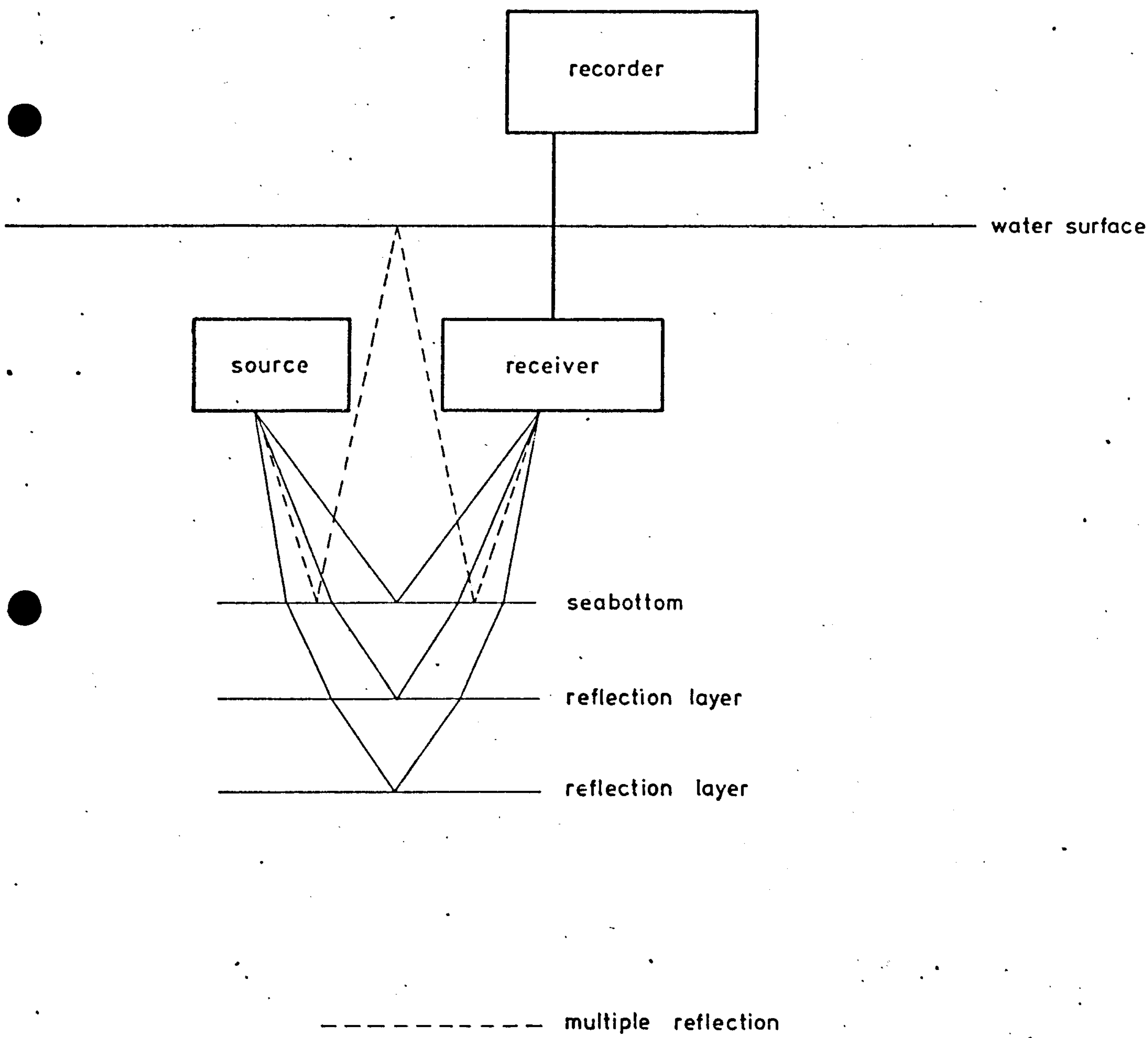
The ultimate result of these improvements will have to be that the location of pipelines, both in the horizontal and the vertical plane, can be determined with extreme accuracy and a high degree of reproducibility.

In this context mention should be made of the co-operation between the North Sea Board and the Exploration and Production Laboratory of Royal Dutch Shell, in the course of which considerable attention has been paid to encouraging manufacturers to develop systems which will make it possible to follow the pipelines in longitudinal direction and to make direct compensation in the registrations for the movement of the waves.



Two main Gaspipelines on the Netherlands Continental shelf.

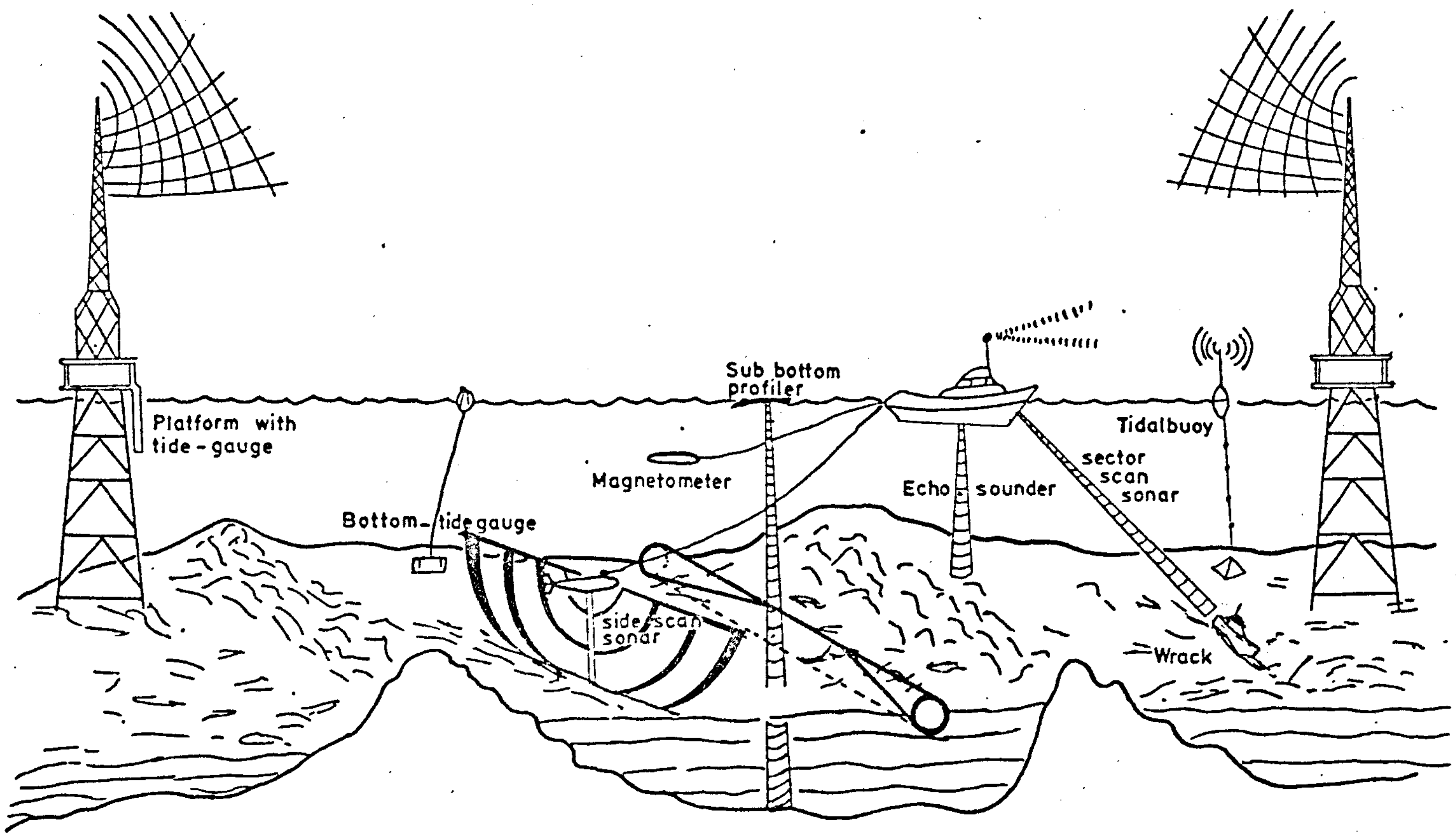
Schematic overview subbottom profiling system



Classification systems.

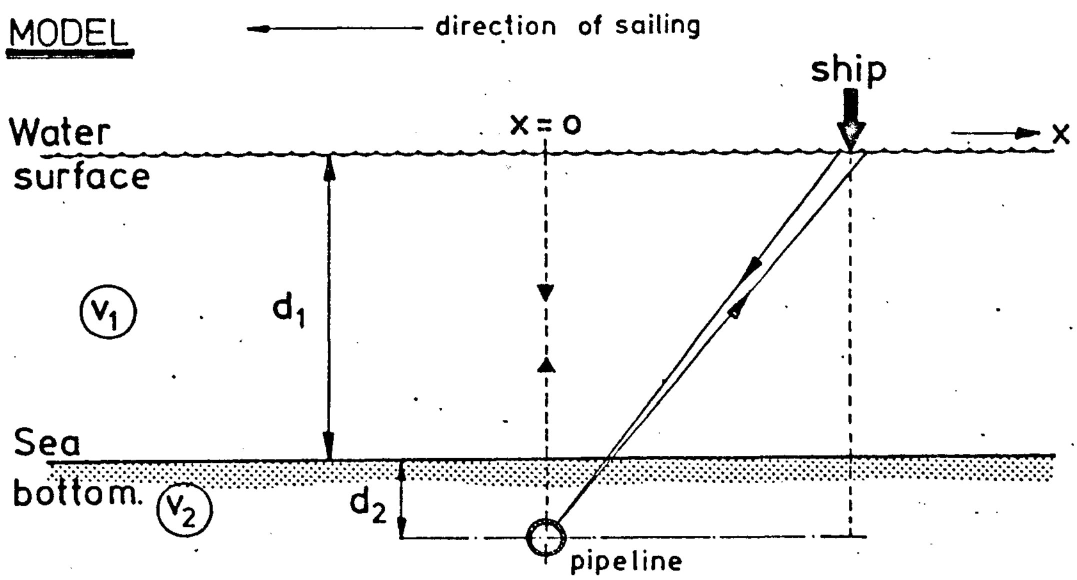
electro-acoustic transducers

- pingers : penetration_depth 20-50 m ; frequencyband 1 KHz - 12 KHz ; power 0,1 - 1 joule .
- sparkers : penetration_depth 50-500 m ; frequencyband 500 Hz -12 KHz ; power 200 - 8000 joule.
- boomers : penetration_depth 50 - 100 m ; frequency band 500 Hz - 10 KHz ; power 100 - 1000 joule.


Platform with
tide-gauge
Bottom-tide gauge
Magnetometer
Sub bottom
profiler
side-scan
sonar
Echo-sounder
sector
scan
sonar
Tidalbuoy
Wrack

Appendix IV

MODEL

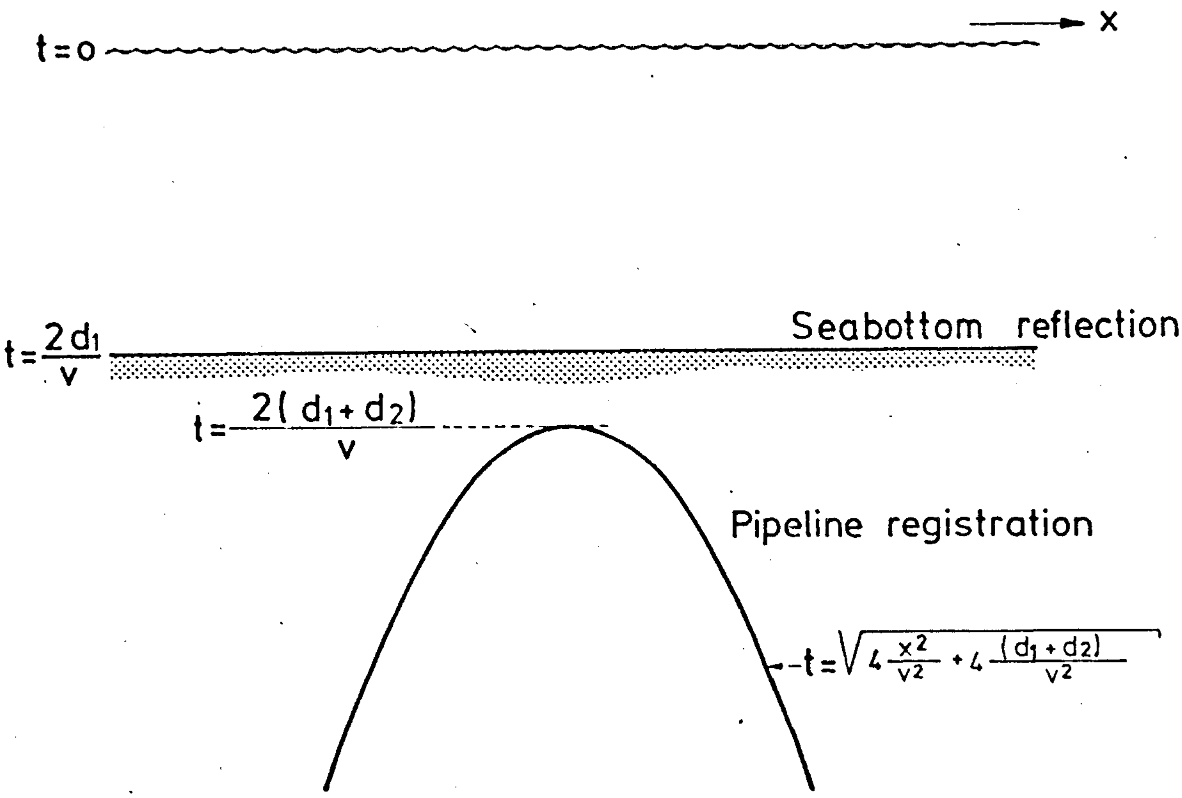


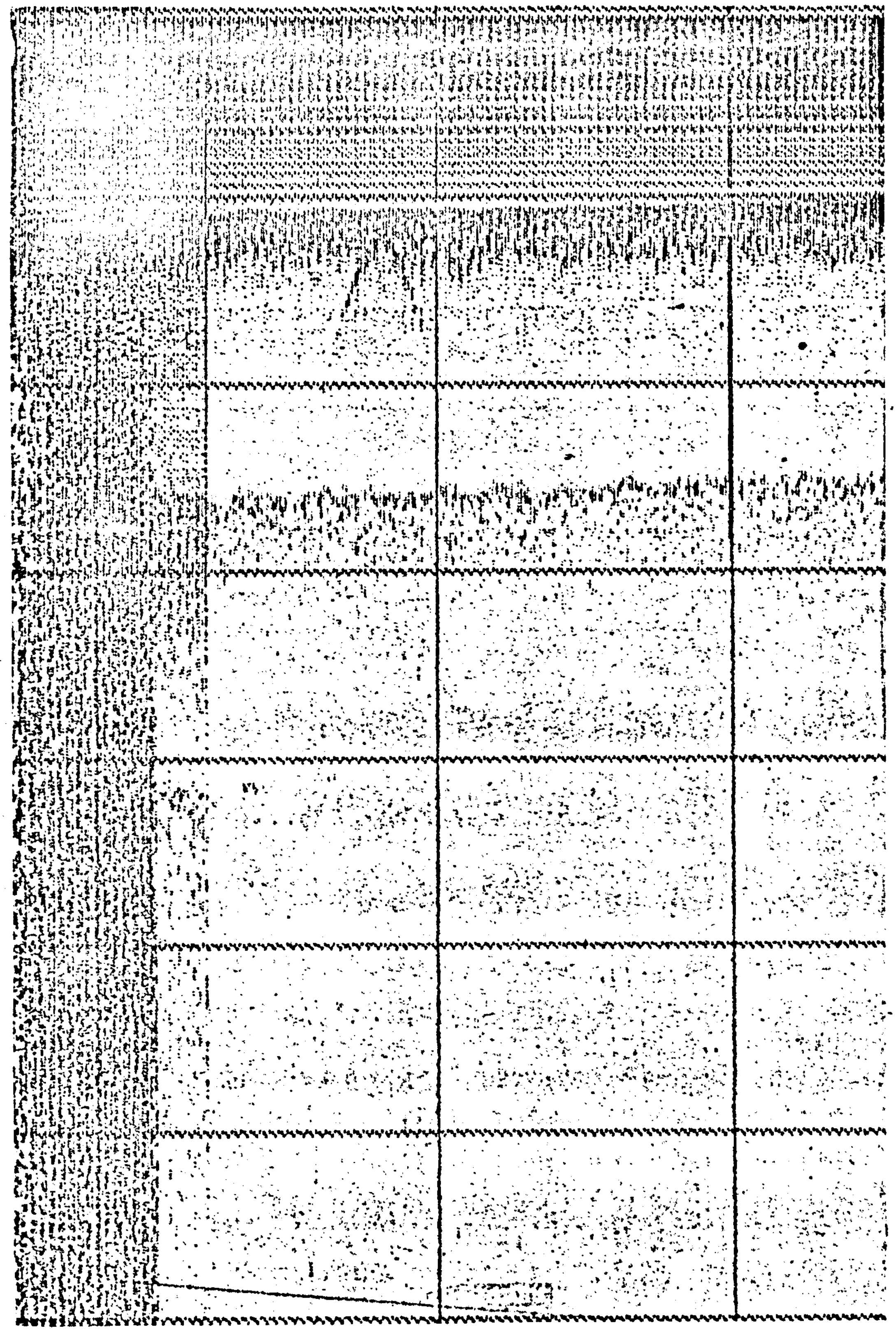
v = Sound velocity

Suppose: $v_1 = v_2 = v$

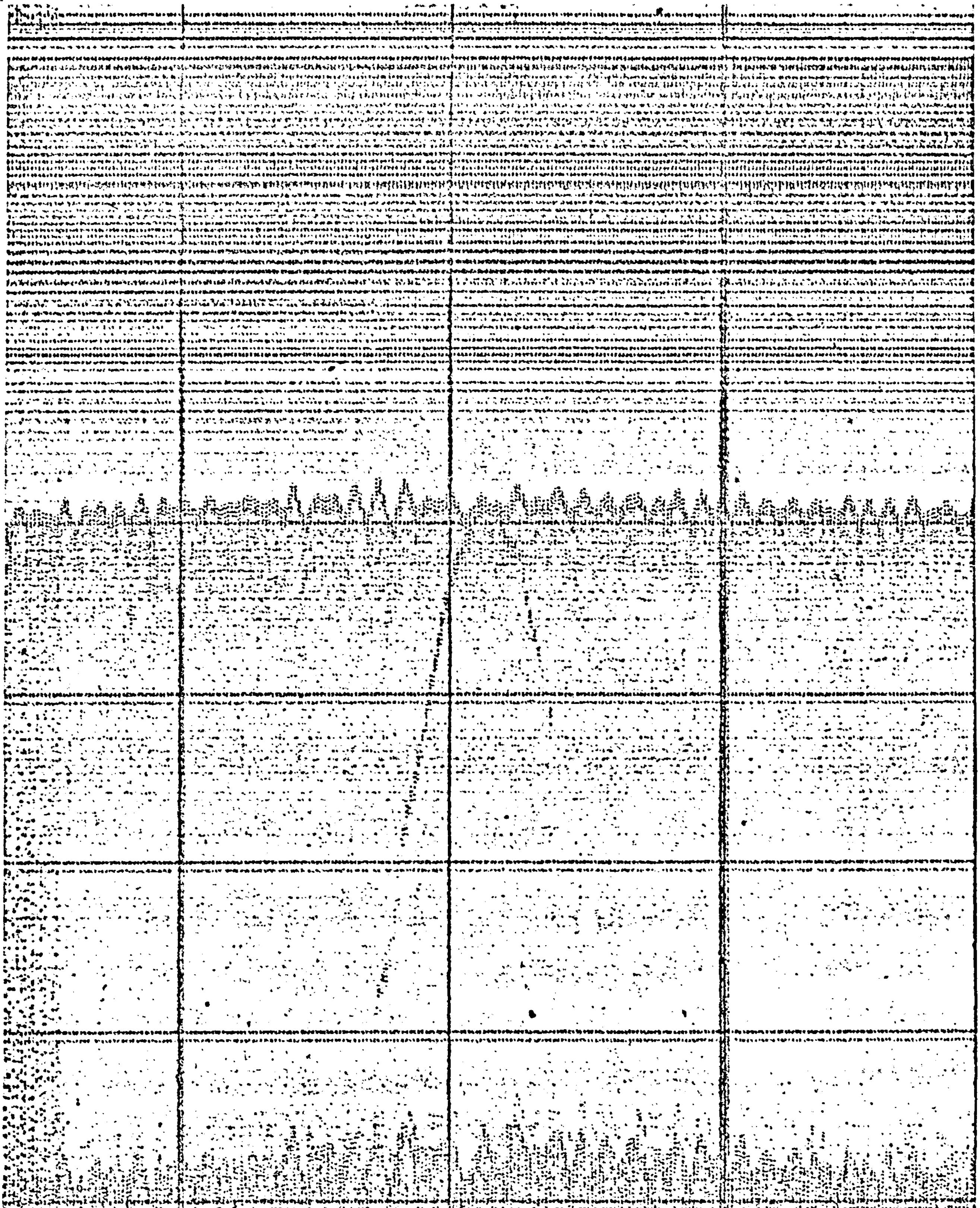
Traveltime: $$t^2 = 4\frac{x^2}{v^2} + 4\frac{(d_1+d_2)^2}{v^2}$$

SCHEMATIC SEISMOGRAM (Hyperbola)





"Subbottem-profiling" registration of a pipeline
(corrected for wave-movement: wave-compensation)



"Subbottom - profiling" registration of a pipeline
(not corrected for wave - movement)