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(54) Transducer arrays.

(57) A transducer for detecting an acoustic wave, the transducer comprising a panel member for affixing to the surface of the vessel, the panel member having an array of preformed apertures into which are inserted into a corresponding array of transducer elements, the configuring of the array being random or pseudo-random such as to produce a directionally uniform response for the array of transducer elements.

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TRANSDUCER ARRAY

This invention relates to an acoustic transducer. It relates particularly to a transducer capable of being used in a passive sonar system.

In certain modern passive sonar system, there is a requirement for large area (typically 15 cm sq) hydrophones which are physically thin (2.5 cm) and are formed as panels or tiles which can be affixed to hull of a vessel under water. There are various ways in which the design requirements for such panels can be met, but a major constraint is cost. If building a large area transducer by a conventional method, the matrix may be formed by a matrix of smaller elements of transducer material so as to create the whole area of continuous sensitive surface. The required area of sensitivity would be thus provided but with a higher constructional cost. One advantage of a transducer panel thus obtained is that it would be extremely effective in reducing the effects of unwanted noise by spatial integration over the large area of the transducer panel.

In our co-pending application 8611573 (F13438) we claim a transducer for detecting a transducer wave, the transducer comprising an array of transducer elements, each transducer element having a spatial transducer response and a working aperture for receiving the acoustic wave, at least one transducer element of the array having a non-uniform spatial filter response across its working aperture thereby to attenuate the response of the transducer to spatial noise lying outside the spectrum of an acoustic wave to be detected by the transducer. As preferred the array is rectangular in form and the transducer elements elliptical in shape, with elements closer to the centre of the array being larger in size. Such an array is preferred in order to reject noise arising from water flow in the horizontal direction while being highly sensitive to acoustic signals in directions other than horizontal.

Whilst such an arrangement has been found to be effective in operation, a problem has been found in that the elliptical transducer elements may be difficult to construct from the ceramic material which is normally used for such elements (PZT ceramic is commonly used). Furthermore the different sizes of elements required produce further difficulties in fabrication and assembly. Use of a simpler shape of transducer element, such as circular or rectangular would bring about a significant savings in cost of fabrication and assembly. However, such transducer being of a simple shape would not be suitable in a rectangular array of elements, since the response of the array to acoustic signals would be similar to that of a diffraction grating, being highly sensitive to certain wavenumbers ($\underline{k}$, having magnitude and direction) and relatively insensitive to other wavenumbers.

A further problem which has been found with an arrangement as claimed in our copending application 8611573 (F13438) is that a hydrophone formed in the shape of a tile to be affixed to the hull of as vessel may have any orientation, particularly when a large array of tiles are to be affixed to a hull. A tile having a highly directional sensitivity is therefore disadvantageous if it is not possible to affix the tile in its intended orientation for use.

In accordance with the invention, these problems are overcome in a transducer for detecting an acoustic wave, the transducer being in the form of a tile and comprising a flexible panel memeber for affixing to the hull of a vessel, the panel member having an array of apertures into which are inserted an array of transducer elements, the array being wholly or partially random, or pseudo-random in regard to the spacing and relative direction between the elements so as to provide a response of intensity v. wavenumber which is generally uniform or not significantly non-uniform for acoustic waves received from any direction.

Thus in accordance with the invention the desired filter reponse is provided by introducing a degree of randomness or psseudorandomness is in the spacing and relative directions of the transducer elements. A directionally uniform response will enable the tile to be positioned in any orientation on a vessel hull without affecting the intended filter response.

As preferred the shape of each transducer element may be circular or rectangular for simplicity in production.

Although a completely random array would be preferred this is impossible to achieve given the requirement for a relatively large number of transucer elements within a small surface area of tile. It is therefore necessary to effect a compromise between the various factors involved so as to generate a degree of randomness which provides the desired uniformity of direcitonal response, whilst maintining a sufficient aperture, sensitivity etc. The precise configuration may be determined on a trial-and-error basis and/or by application of computer modelling techniques. A preferred configuration is to provide the transucer elements in a series of concentric rings which are circular or polygonal but the elements being so disposed so as to create the appearance of randomness to received acoustic waves.

A preferred embodiment of the invention will

now be described with reference to the accompanied drawings wherein:-

Fig 1 is a plan view of a transducer in accordance with the invention:

Fig 2 is a view of the transducer in Fig 1 showing the wiring pattern to the transducer elements of the array: and

Figs 3, 4 and 5 are graphs of the response of the transducer for various directions.

Referring now to the drawings there is shown a sheet of polyurethane 2 into which is punched a series of holes 4 whose accuracy is controlled by a computer generated template. A ceramic thin disc of lead titanate is cemented into each aperture, leaving the flat surfaces flush with the polyurethane sheet. The ceramic discs have one terminal on each flat face, which are electrically connected to a matrix of wires 8 (See Figure 2), each side being treated separately, with a flying lead being brought from each side to electronics module 10a, 10b, 10c, 10d. As shown in Figure 2, the matrix of wires are arranged in a series of rings 8′ with diagonal wires 8″. This permits two wires connected to each terminal extending in opposite directions around the array for safety in case one group of wores is cut. The modules 10a-d are mounted on PCBs on the edge of the sheet and include signal processing and filter circuits (these are not relevant to the present invention and will not be described). The electronics modules are encapsulated in a suitable plastics material and are clipped by means of lugs 12 to the edge of the polythene sheet, the flying leads from the ceramic disc being soldered to posts on sections 14a-d of the printed circuit board protruding from the encapsulation.

A main cable 16 is attached to the posts on the printed circuit board and the whole assembly is located in a mould tool with suitable spacers to enable a uniform thickness of polyurethane overmoulding to be maintained. The main cable is clamped in position in the mould tool sides during the encapsulation process.

The ceramic elements 6 are circular in shape and therefore have individually a directionally uniform filter response.

The entire array of transducer elements produces a response which is shown in Figres 3, 4 and 5 as intensity vs. wavenumber for various directions of incoming acoustic waves. As shown in Figure 1 the precise array chosen comprises a series of rings having a common centre, a transducer 6 a being located at the centre. An inner ring is formed of 5 transducer elements 6b located approximately in a circle, a central ring is provided by ceramic elements 6c arranged in a ring having the approximate shape of a hexagon, and an outer ring comprising elements 6 d is formed in the approximate shape of an octagon. Nevertheless the overall configuration of elements has a large degree of randomness of spacing and direction between the individual elements. It has been found through experiment that such a configuration provides a desired spatial filter response.

Claims

1. A transducer for detecting an acoustic wave, the transducer being in the form of a tile and comprising a flexible panel member for affixing to the hull of a vessel, the panel member having an array of apertures into which are inserted an array of transducer elements, the array being wholly or partially random or pseudo-random in regard to the spacing and relative direction between the elements so as to provide a response of intensity v. wavenumber which is generally uniform or not significantly non-uniform for acoustic waves received from any direction.

2. A transducer as claimed in claim 1 wherein the transducer elements are circular or rectangular in form.

3. A transducer as claimed in claim 2 wherein the transducer elements are configured in the form in the form of a series of rings having a common centre.

4. A transducer as claimed in claim 3 wherin an inner ring of transducer elements is circular in form, a central ring of the transduce element is approximately hexagonal in form, and an outer ring of transducer elements is approximately octagonal in form.

5. A transducer as claimed in any preceding claim wherein the panel member is formed of flexible polyurethane material.

6. A transducer as claimed in any preceding claim wherein the transducer elements are each formed of lead titanate.

7. A transducer as claimed in any preceding claim wherein leads are connected between each transducer element and one or more electronics modules attached to the panel member, the electronics modules including filter circuits for producing a desired frequency response of the transducer.

8. A transducer a claimed in any preceding claim wherein the whole assembly is encapsulated in a polyurethane overmoulding.

9. A transducer substantially as described herein with reference to the accompanying drawings.

Neu eingereicht / Newly filed
Nouvellement déposé

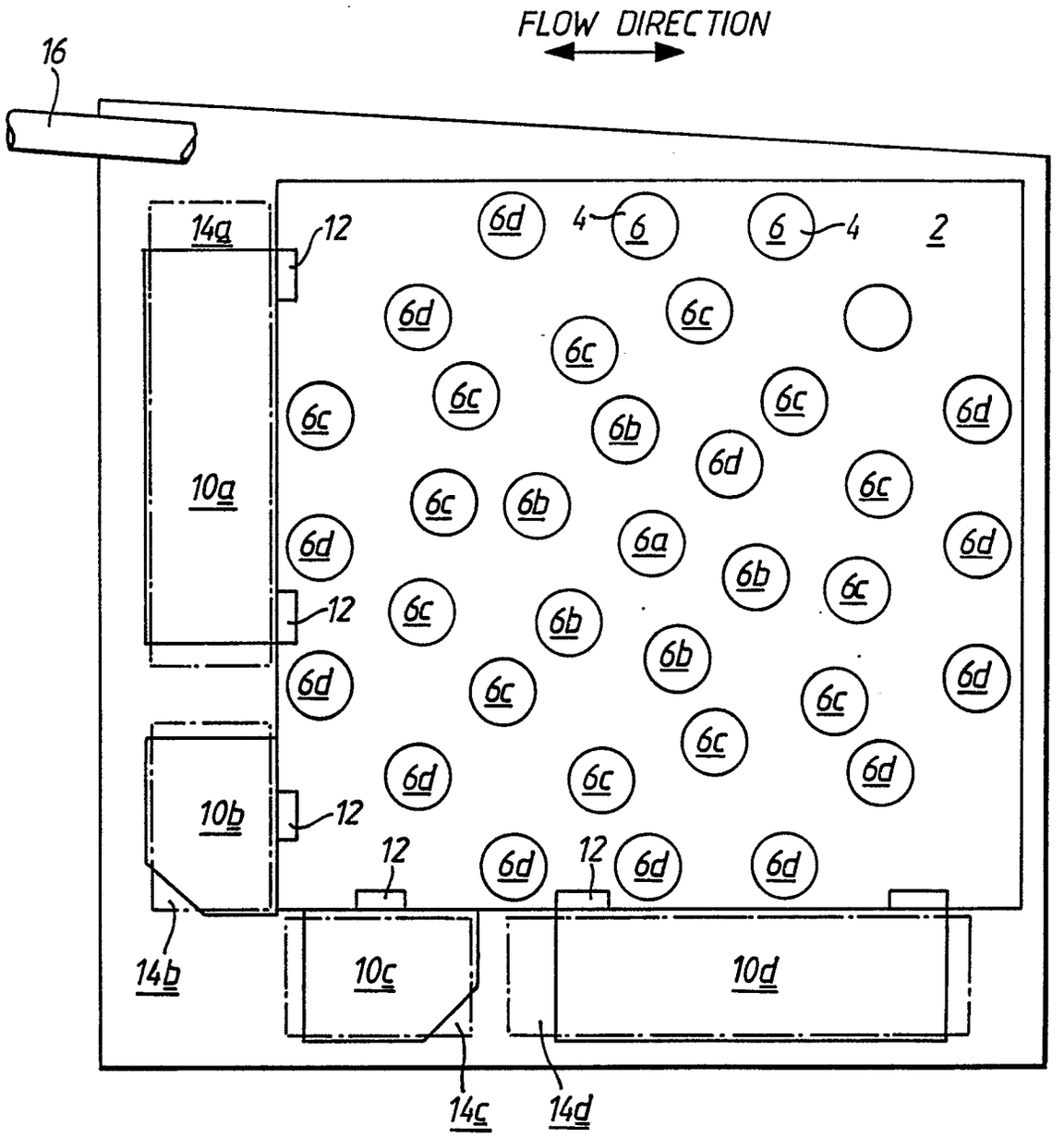

FIG. 1.

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Nouvellement déposé

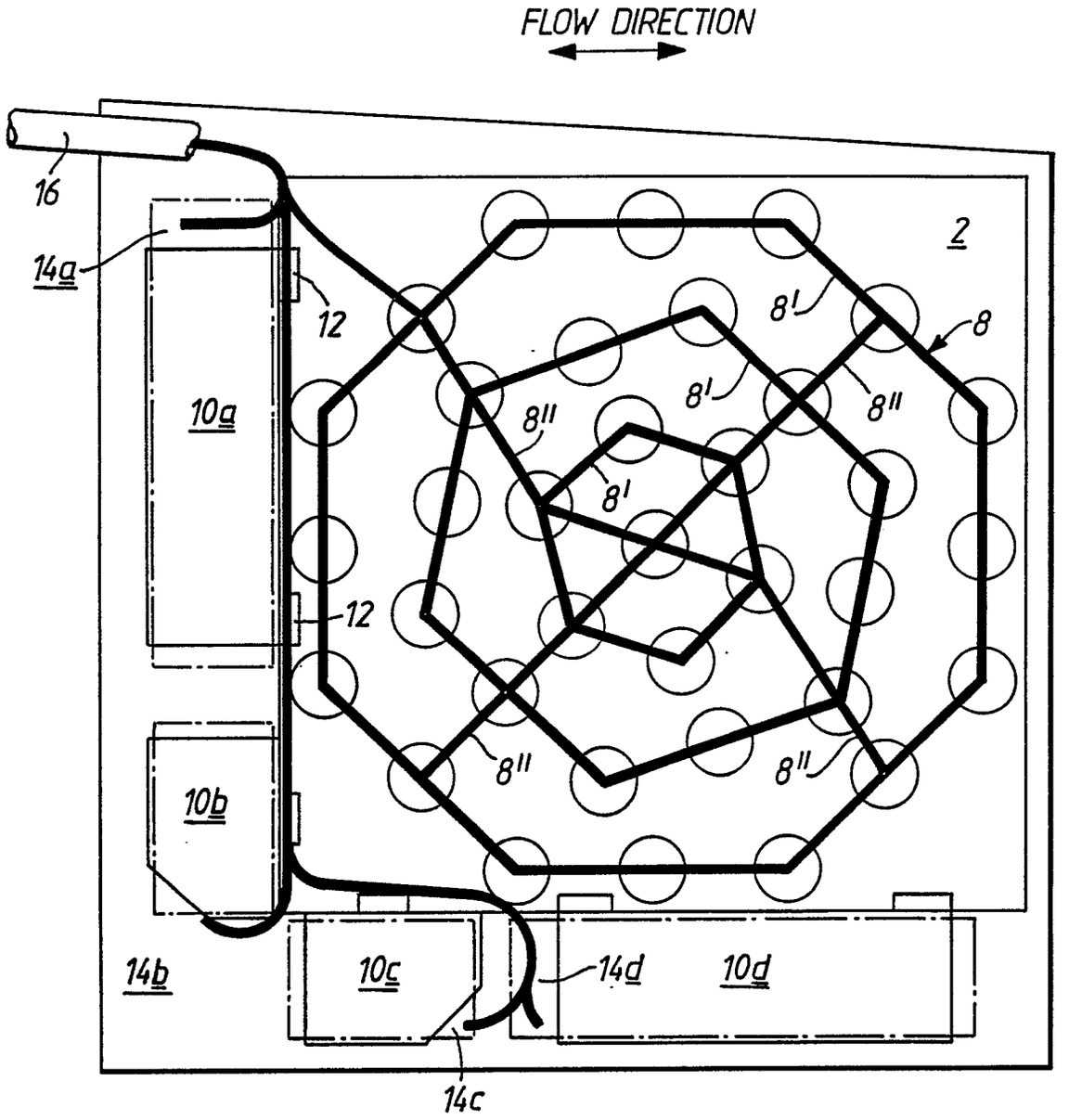

FIG. 2.

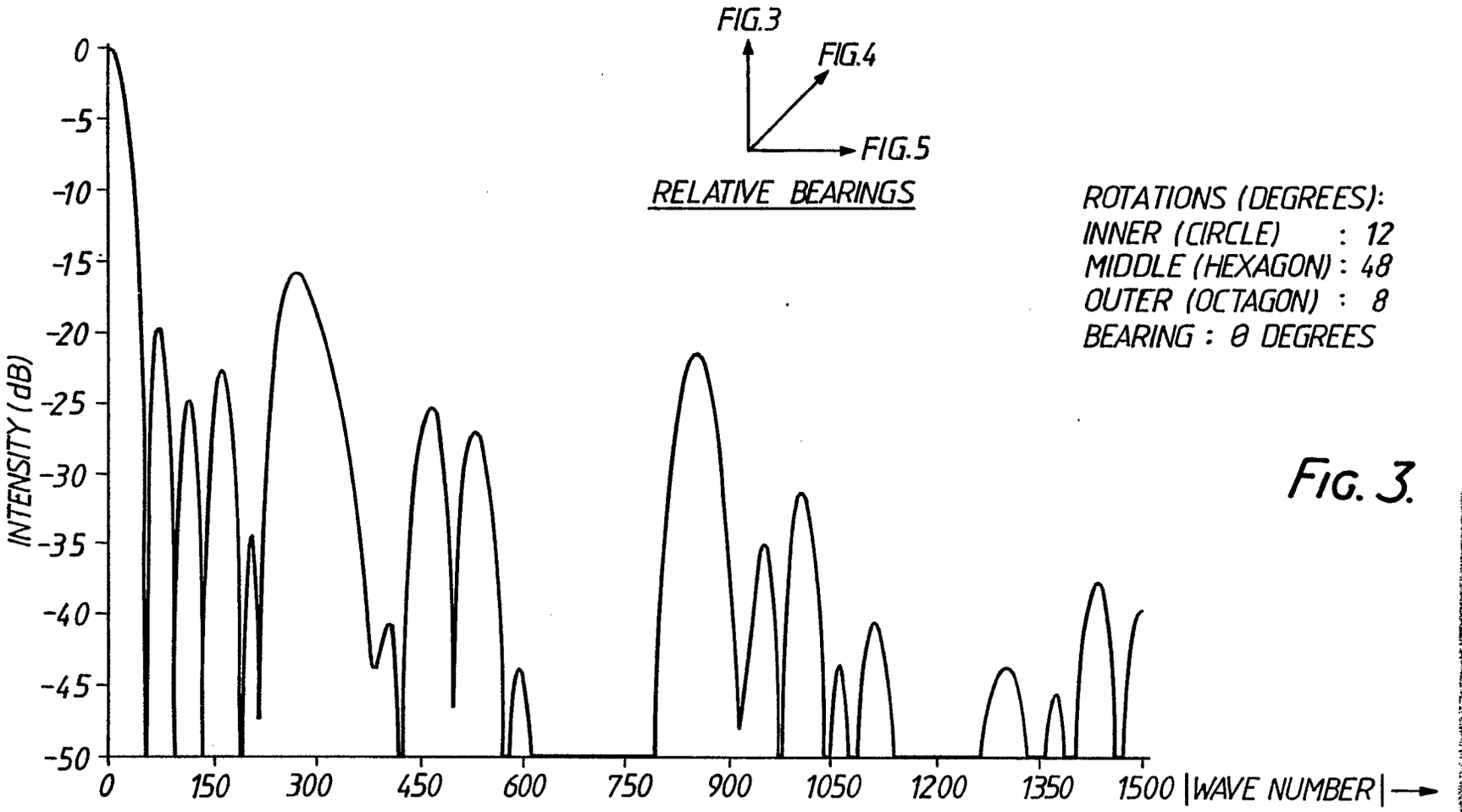

FIG. 3.

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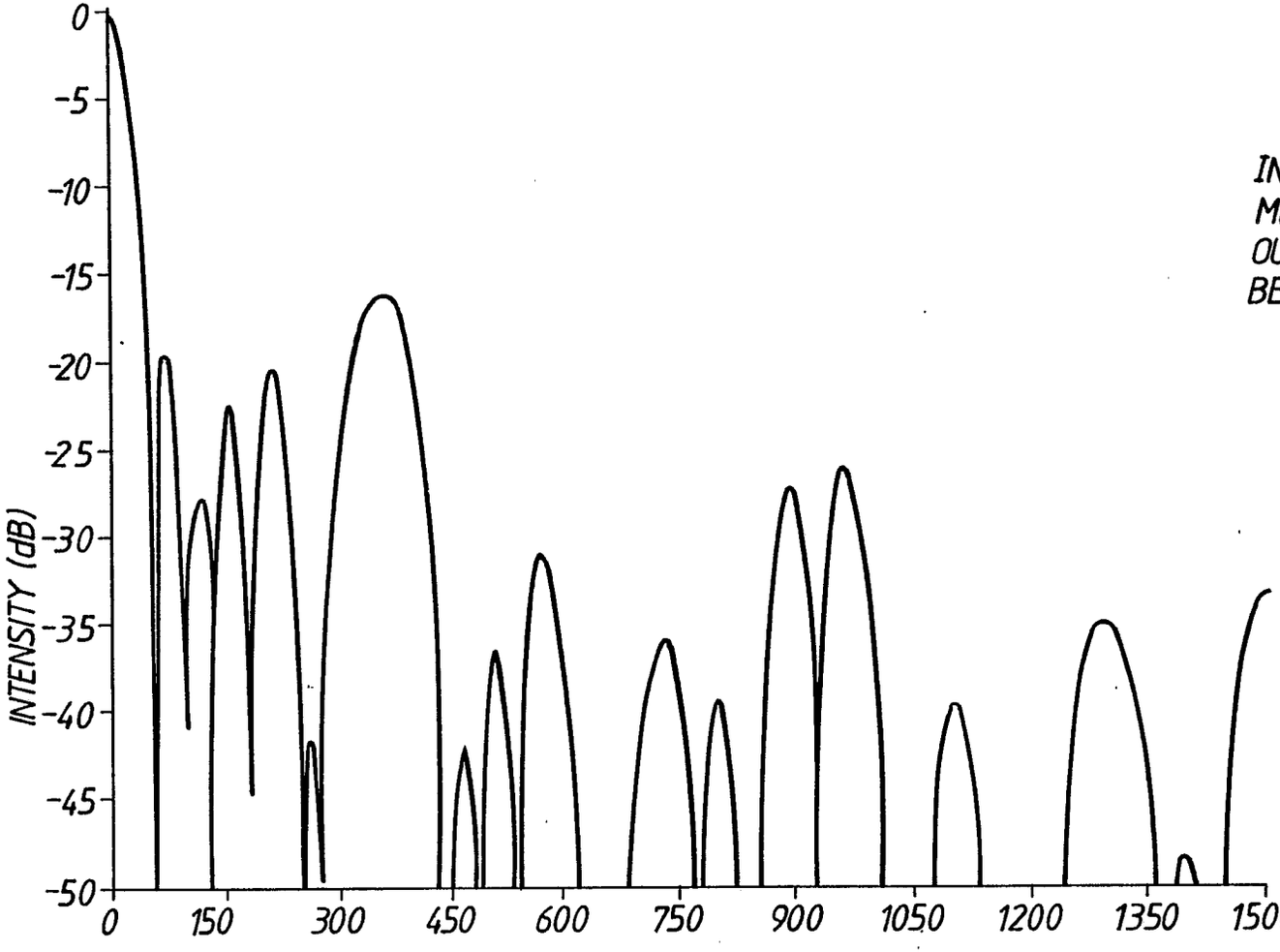

INNER (6) : 12
MIDDLE (12) : 48
OUTER (16) : 8
BEARING = 44 DEGS.

FIG. 4.

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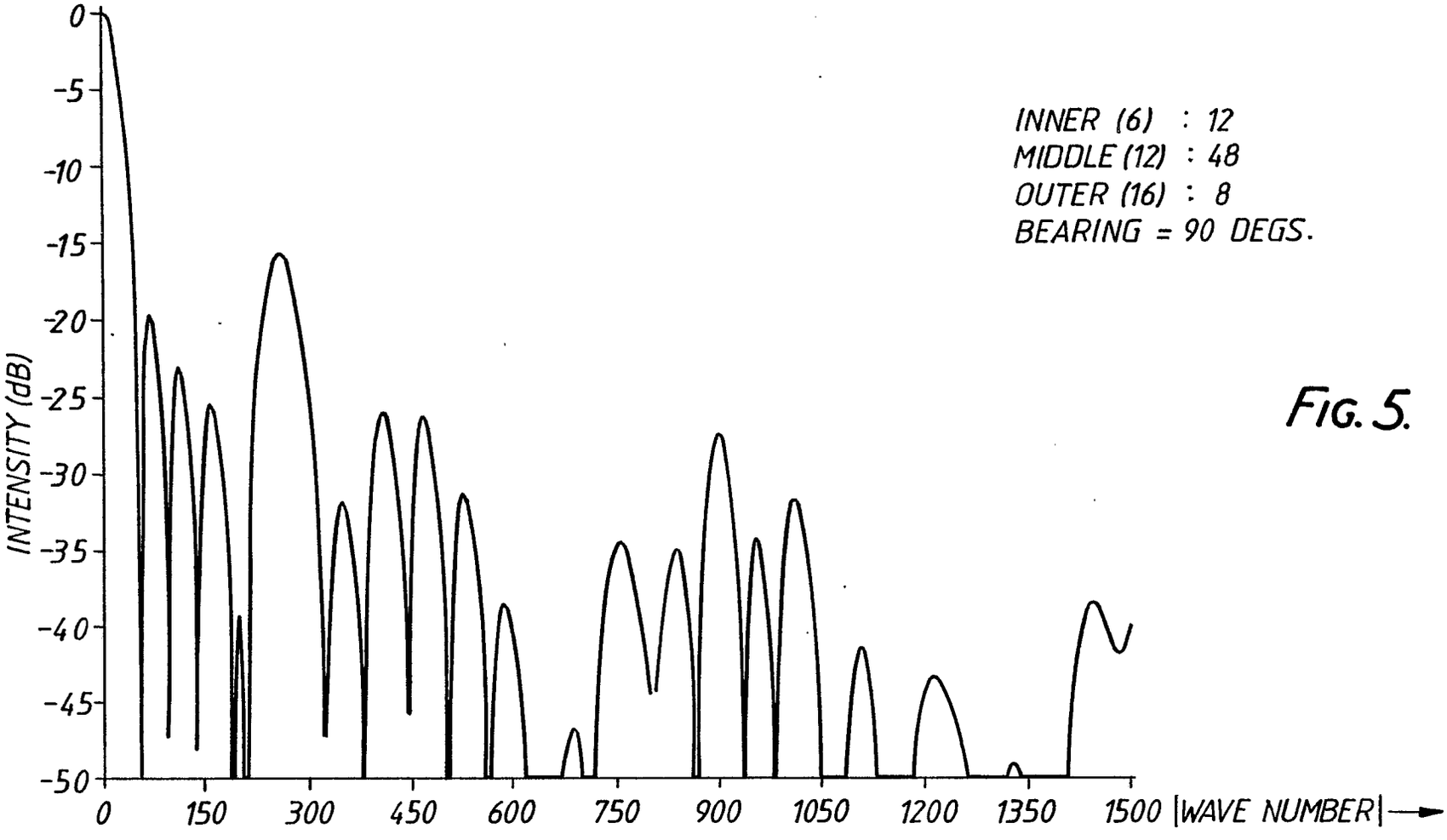

FIG. 5.

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