(12) STANDARD PATENT (11) Application No. AU 2013211192 B2
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Method and device for processing water-borne sound signals

(51) International Patent Classification(s)
G01S 3/801 (2006.01)

(21) Application No: **2013211192** (22) Date of Filing: **2013.01.07**

(87) WIPO No: **WO13/107666**

(30) Priority Data

(31) Number	(32) Date	(33) Country
10 2012 000 788.4	**2012.01.17**	**DE**

(43) Publication Date: **2013.07.25**
(44) Accepted Journal Date: **2015.04.09**

(71) Applicant(s)
ATLAS ELEKTRONIK GmbH

(72) Inventor(s)
Haberlein, Boris

(74) Agent / Attorney
Watermark Patent and Trade Marks Attorneys, 302 Burwood Road, Hawthorn, VIC, 3122

(56) Related Art
WO 1999/026234 A1
EP 2009459 A1
DE 3520398 A1

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

(43) Internationales Veröffentlichungsdatum
25. Juli 2013 (25.07.2013)

WIPO | PCT

(10) Internationale Veröffentlichungsnummer
WO 2013/107666 A1

(51) Internationale Patentklassifikation:
G01S 3/801 (2006.01)

(21) Internationales Aktenzeichen: PCT/EP2013/050168

(22) Internationales Anmeldedatum:
7. Januar 2013 (07.01.2013)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
10 2012 000 788.4
17. Januar 2012 (17.01.2012) DE

(71) Anmelder: **ATLAS ELEKTRONIK GMBH** [DE/DE]; Sebaldsbrücker Heerstrasse 235, 28309 Bremen (DE).

(72) Erfinder: **HÄBERLEIN, Boris**; Großbeerenstraße 38, 28211 Bremen (DE).

(74) Anwalt: **LECOMTE & PARTNERS**; P.O. Box 1623, L-1016 Luxembourg (LU).

(81) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare nationale Schutzrechtsart)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare regionale Schutzrechtsart)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, KG, KZ, RU, TJ, TM), europäisches (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Fortsetzung auf der nächsten Seite]

(54) Title: METHOD AND DEVICE FOR PROCESSING WATER-BORNE SOUND SIGNALS

(54) Bezeichnung : VERFAHREN UND VORRICHTUNG ZUM VERARBEITEN VON WASSERSCHALLSIGNALEN

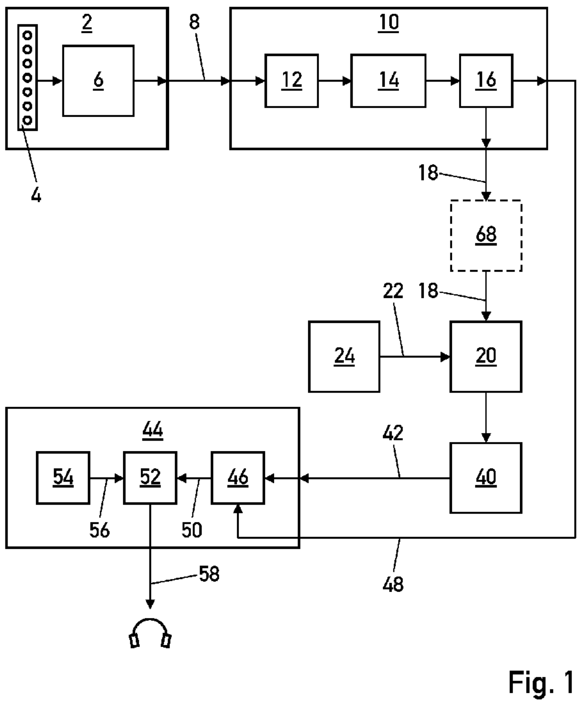

Fig. 1

(57) Abstract: The invention relates to a method for processing water-borne sound signals, in particular amplitude-modulated broadband noises, which are radiated or transmitted from vehicles. The broadband noises are received in a directionally selective manner as acoustic signals by means of a sonar system (2) and subjected to a spectral analysis (10), in particular a DEMON analysis (10). From the acoustic signals (8), the spectral analysis (10) then generates corresponding frequency spectra (18). At least one local maximum (36) is determined within the frequency spectrum (18), said local maxima (36) corresponding to individual frequency lines (38). On the basis of the determined frequency lines (18), a synthetic spectrum (42) is generated, which is subjected to a spectral synthesis (44), in particular a DEMON synthesis (44), which generates an associated synthetic time signal (50). From this time signal (50) and a carrier signal (56), a synthetic amplitude-modulated signal (58) corresponding to the spectral synthesis (44) is generated, said synthetic amplitude-modulated signal being output as an acoustic signal (58) to a user. The invention further relates to a device for performing the method according to the invention.

(57) Zusammenfassung:

[Fortsetzung auf der nächsten Seite]

WO 2013/107666 A1

Veröffentlicht:

— *mit internationalem Recherchenbericht (Artikel 21 Absatz 3)*

Die Erfindung betrifft ein Verfahren zum Verarbeiten von Wasserschallsignalen, insbesondere amplitudenmodulierte Breitbandgeräusche, welche von Fahrzeugen abgestrahlt oder gesendet werden. Die Breitbandgeräusche werden als akustische Signale mittels einer Sonaranlage (2) richtungsselektiv empfangen und einer Spektralanalyse (10), insbesondere einer DEMON-Analyse (10), unterzogen. Die Spektralanalyse (10) erzeugt dann aus den akustischen Signalen (8) entsprechende Frequenzspektren (18). Innerhalb des Frequenzspektrums (18) wird mindestens ein lokales Maxima (36) ermittelt, wobei die lokalen Maxima (36) einzelnen Frequenzlinien (38) entsprechen. Anhand der ermittelten Frequenzlinien (18) wird ein synthetisches Spektrum (42) erzeugt, welches einer Spektralsynthese (44), insbesondere einer DEMON-Synthese (44), unterzogen wird, die ein zugehöriges synthetisches Zeitsignal (50) erzeugt. Aus diesem Zeitsignal (50) und einem Trägersignal (56) wird entsprechend der Spektralsynthese (44) ein synthetisches amplitudenmoduliertes Signal (58) erzeugt, welches als akustisches Signal (58) einem Bediener ausgegeben wird. Ferner betrifft die Erfindung eine Vorrichtung zur Durchführung des erfindungsgemäßen Verfahrens.

ATLAS ELEKTRONIK GmbH
Sebaldsbrücker Heerstraße 235, 28309 Bremen

A method and device for processing underwater sound signals

The invention relates to a method for processing underwater sound signals according to the preamble of claim 1 and to a device for implementing the method according to the preamble of claim 8.

It is known both from airborne sound technology and underwater sound technology that bodies can be located, detected and classified by means of the operating noise that they emit. Thus, vehicles such as e.g. surface ships, manned or unmanned underwater vehicles as well as underwater running bodies produce an acoustic signature while travelling.

The operating noises of such vehicles are mainly caused by engines. While travelling for example, a ship produces operating noises, which have periodic loudness fluctuations in the range of a few hertz. These loudness fluctuations are comparable to an amplitude modulation of a noise carrier and are typical of each propeller-driven vehicle.

Above a certain propeller blade speed, cavitation noises occur. In the case of a propeller, cavitation occurs at the blade tip and on the blade surfaces when the negative pressure caused by the rotational movement is so high that the fluid is ruptured and the formation of gas bubbles occurs. The implosion of these gas bubbles produces short acoustic impulses with a high intensity. By rotating in the water, cavitating propeller blades thus produce an amplitude-modulated broadband noise. The modulation portions have a low frequency and correspond harmonically to the rotational frequency of the propeller. They provide information e.g. about the number of driving propellers, their rotation speed and the number of blades, from which the vehicle type can be deduced. In order to obtain the information contained in the envelope of the modulated signal, the DEMON (DEMON = Detection of Envelope Modulation on Noise) analysis method is customarily used. Such a method is described in DE 35 31 230 C2.

Since environmental conditions such as sea state, temperature, salinity of the water or currents influence the operating noise of the vehicle to be classified, the same type of ship can have a different noise signature under different conditions. However, via a listening channel, an operator of the sonar device is able to derive a lot of different information from subtle noise differences of an acoustic signal such as e.g. the ship category and its speed.

When detecting and classifying vehicles by means of sonar signals transmitted via a listening channel, it is important that the audio sonar signal is emitted with as little interference and interruption as possible. However, if the signal-to-noise ratio is relatively small, the operating noise to be detected is covered by the surrounding noise, e.g. because of the volume of the interfering noise or because the vehicle to be detected is far away. If two vehicles are detected at the same bearing, an acoustic classification by the operator may not be possible because the operating noises interfere with each other.

The problem underlying the invention is therefore to process or treat the received underwater sound signals in such a manner that an interpretation of the DEMON analysis is improved.

The invention solves the problem with the features of a method for processing underwater sound signals according to claim 1 as well as with a device with the features of claim 8.

Since, for the operator, the listening channel of a sonar device is an important part of the detection and classification of vehicles, the sonar signal is acoustically processed for the operator in accordance with the invention.

Underwater sound signals that have been emitted by bodies located on or in the water are received by way of a receiving antenna of a sonar device by means of a plurality of electro-acoustic and/or optoacoustic transducers. The underwater signals are preferably underwater sound signals with an amplitude modulation on a noise carrier.

Such a sonar device further has a direction finder in which the received signals generated in the transducers are processed into group signals of respectively one directional characteristic. To this end, the received signals of the transducers are time-delayed in such a manner that they are in-phase in relation to a main direction of the directional characteristic and are then added up for forming group signals.

In a subsequent DEMON-analysis, a group signal with respectively one directional characteristic is used. The sampled group signal is band-limited and demodulated with regard to its envelope in a known manner for the DEMON-analysis. A corresponding frequency spectrum and/or a spectrum derived from that frequency spectrum, more specifically an amplitude spectrum, is generated in an analysis unit.

A threshold value module determines at least one threshold value, wherein the determination can be carried out manually by an operator or automatically. A frequency line module then determines at least one local maximum within the frequency spectrum or within a spectrum derived from the frequency spectrum based on at least one of the predetermined threshold values, wherein the local maxima correspond to individual frequency lines.

Based on these frequency lines, a synthetic spectrum is generated by means of a spectrum-calculating unit, which is supplied to a spectral synthesis, more specifically a DEMON-synthesis, which uses it to generate a corresponding synthetic time signal. By using a modulation process, more specifically an amplitude modulation, a synthetic amplitude-modulated signal is then generated based on the synthetic time signal and a carrier signal in accordance with the spectral synthesis by means of a modulation module and is issued to the operator as an acoustic signal.

This is advantageous in that it results for the operator in a clearer auditory impression even for very noisy signals with only little modulation.

In a preferred embodiment of the invention, one, several or all determined frequency lines are selected and/or additional frequency lines are added for generating the synthetic spectrum by means of the frequency line module. Thereby, the auditory impression received by the operator can be advantageously improved by removing interfering frequency lines and/or adding frequency lines that are not encompassed by the threshold value. The selection or adding of the frequency lines is carried out manually by the operator or automatically, more specifically by means of stored frequency line patterns.

In another preferred embodiment of the invention, the synthetic spectrum is compared to known frequency line patterns from a database. If at least one frequency line pattern is recognized within the synthetic spectrum, a synthetic residual spectrum is generated by means of a difference unit, namely by extracting the determined frequency lines that belong to the frequency line pattern from the synthetic spectrum. A synthetic spectrum pattern, which is subsequently subjected to a spectral synthesis, is then generated based on the extracted frequency lines by means of the difference unit. The synthetic residual spectrum now corresponds to a new synthetic spectrum, which is also compared to known frequency line patterns in the database.

The previously mentioned steps are carried out until no more frequency line patterns are recognized in the synthetic spectrum. The synthetic spectrum is then transferred as a residual spectrum for spectral synthesis.

The advantage of dividing the spectrum into one residual spectrum and one or several spectrum patterns in case at least one frequency line pattern in the synthetic spectrum is recognised is that an acoustic separation of targets having the same bearing is possible. The amplitude-modulated signal of each target belonging to this signature is issued to the operator in an acoustically separate manner.

According to another embodiment of the invention, a carrier signal is selected among a multitude of available carrier signals by means of a carrier module. This selection can be carried out manually by the operator or automatically. This selected carrier signal is used for modulation with the synthetic time signal for generating a synthetic amplitude-modulated signal. Thereby, white noise or pink noise or typical sea noise for example can be used as carrier signals. Using a broadband-limited carrier signal that is adapted for human hearing is advantageous. Using a mono-frequency carrier signal is also advantageous, in order to make beat frequencies, which can result from a two-propeller drive, more audible to the operator.

In another preferred embodiment of the invention, the frequency spectrum generated by the spectral analysis or a spectrum derived from the frequency spectrum is stored by means of a storage module. By varying setting parameters, one or several different synthetic spectra are generated from the stored frequency spectrum, from which one or several synthetic time signals are generated in turn. This is advantageous in that the setting parameters can be varied until the best possible acoustic result, or rather the best possible auditory impression of the synthetic amplitude-modulated signal is achieved.

According to another preferred embodiment of the invention, the demodulated envelope of the group signal of the sonar device is transformed from the time domain into the frequency domain by means of a complex discrete Fourier transform. In accordance with the method according to the invention, the generated synthetic spectrum is then transformed from the spectral domain into the time domain by means of an inverse complex discrete Fourier-transform. A fast Fourier transform (FFT), respectively inverse fast Fourier transform (IFFT) is preferably used for transformation, because the Fourier transformation is accelerated by using symmetries. As a consequence, time as well as computing power is saved during processing of the underwater sound signals.

In another preferred embodiment of the invention, the sonar signal processed or treated according to the invention is issued to the operator by way of a sound reproducing system, more specifically headphones and/or speakers. This is advantageous in that the operator immediately receives an auditory impression of differently processed sonar signals, which are directly influenced by changing modifiable parameters of the method. The operator can thus advantageously directly influence the parameters and individually modify the auditory impression.

Other advantageous embodiments of the invention can be gathered from the dependent claims and from the exemplary embodiments described in more detail based on the drawings. In the drawings:

Fig. 1 shows a block diagram for explaining the method for processing underwater sound signals according to the invention,

Fig. 2 shows an example of a noise signal with a modulation,

Fig. 3 shows an example of a DEMON-spectrum,

Fig. 4 shows an example of a synthetic amplitude-modulated signal from the DEMON-synthesis,

Fig. 5 shows a block diagram of the method expanded to include a comparison module with a database and

Fig. 6 shows a block diagram for explaining the operation of the comparison module.

The invention is described in more detail with regard to using the method according to the invention with a sonar device in the context of underwater sound technology. However, the following explanations are also applicable to other methods, such as e.g. methods for processing signals in the context of airborne sound technology.

Fig. 1 shows a block diagram for explaining the method according to the invention for processing underwater sound signals, more specifically amplitude-modulated broadband sounds radiated or emitted by vehicles.

A sonar device 2 receives underwater sound signals by means of a plurality of electro-acoustic and/or opto-acoustic transducers 4. The sonar device further has means for signal processing 6 by means of which the electrical received signals of the transducers 4 are processed, sampled and digitized in a known direction-selective manner to form group signals of related directional characteristics and transmitted as digital signals 8 for further processing to the method according to the invention.

Fig. 2 exemplarily shows a noise signal with a modulation as provided by the sonar device 2. This signal is a very noisy signal with only little amplitude modulation, which makes it difficult for the operator to detect or classify the target. The amplitude of the signal 8 is shown on a vertical axis 7 relative to the time shown on a horizontal axis 9.

The digital signals 8 of the sonar device 2 are subjected to the DEMON-analysis 10, which has a band-pass filter 12, an envelope modulator 14 and an analysis unit 16.

The band-pass filter 12 serves to limit the received signals to the information-carrying frequency range. The band limits are preferably determined based on an elevated energy density in the signal, since this is probably where the most information is probably contained.

The DEMON-analysis 10 has an envelope modulator 14, preferably with a low-pass filter, at the output of which the time dependent course of the envelope of the band-limited sonar signal appears. Since the received underwater sound signals are amplitude-modulated broadband sounds, the amplitude of the carrier signals is converted into a variable amplitude by the useful signal. The useful signal is thus contained in the signal as an envelope of the carrier wave.

The downstream analysis unit 16 contains means for transforming the envelope of the band-pass filtered signal into the spectral domain and thus for generating DEMON-spectra 18. The transformation preferably occurs by means of complex discrete Fourier transforms. The DEMON-spectra 18 determined by the analysis unit 16 are thus frequency spectra that are preferably converted into a normalized amplitude spectrum or power spectrum by absolute-value generation and normalization. It could also be conceivable to determine other spectra derived from the DEMON-spectrum 18, such as e.g. energy spectra or a spectrum obtained by using a mathematical function such as a logarithm function and/or by adding and/or multiplying by a respective constant. However, here and in the following, only the amplitude spectrum will be taken into account as an example.

Frequency lines in the DEMON-spectrum 18 are determined in a frequency line module 20 by means of a threshold value 22 that is provided by a threshold value module 24. The determination of the threshold value 22 in the threshold value module 24 is carried out manually by the operator or automatically. The invention is not limited to one threshold value. In fact, any number of different threshold values can be transferred to the frequency line module 20.

Fig. 3 exemplarily shows a DEMON-spectrum 18 as determined by the DEMON-analysis 10 and as transferred to the frequency line module 20. Here, the frequency is plotted in Hertz on a horizontal axis 30 and the amplitude is plotted in Decibel on a vertical axis 32. The demon-spectrum 18 is composed of broadband components with an almost continuous frequency course and narrow band linear components.

Individual frequency ranges 34, in which the DEMON-spectrum 18 has an amplitude value that is greater or equal to the predetermined threshold value 22, are determined based on a predetermined threshold value 22. Respective local maxima 36, to which significant frequency lines 38 are assigned, are determined for these determined frequency ranges 34.

According to the method shown in fig. 2, a synthetic spectrum 42 is determined in a spectrum calculation unit 40 based on the frequency lines 38 determined in the frequency line module 20 and supplied to a spectral synthesis 44.

Since the spectral synthesis 44 reverses the processes of the DEMON-analysis 10, this spectral synthesis 44 will also be referred to as DEMON-synthesis 44 in the following.

In the DEMON-synthesis 44, the synthetic spectrum 42 is first transformed into the time domain in a synthesis device 46, wherein analysis parameter values 48 from the DEMON-analysis 10 can be taken into account.

Among the analysis parameters 48 are e.g. the used window width and window form for singling out a finite time sequence of the signal to be transformed, the used sampling frequency and/or the used number of samples. The transformation then preferably takes place by means of an inverse complex discrete Fourier transform, more specifically by means of an inverse fast Fourier transform (IFFT). A synthetic time signal 50 is thus generated, which is supplied to a modulation module 52 according to the DEMON-synthesis 44.

According to the invention, a carrier module 54 provides a carrier signal 56 to the method, the selection of the carrier signal 56 being carried out manually by the operator or automatically.

By means of an amplitude modulation, an amplitude-modulated, acoustic signal 58, which contains the basic characteristics of the original signal, is generated in accordance with the DEMON-synthesis 44 in the modulation module 52 based on the synthetic time signal 50 and the carrier signal 56. This signal is acoustically issued to the operator preferably via headphones or speakers.

Fig. 4 shows an exemplary amplitude-modulated, acoustic signal 58 as generated by the DEMON-synthesis 44. Here, the time is plotted in seconds on a horizontal axis 60 and the amplitude of the signal 58 on a vertical axis 62. This exemplary representation shows the result of the synthesis of the first detected frequency line from fig. 3.

In order to potentially provide the operator with a better auditory impression, different parameters can be varied in the method for processing the underwater sound signals.

The DEMON-spectrum 18 can be preferably stored by means of a storage module 68, in order to generate different synthetic spectra 42 as well as different synthetic time signals 50 based on this frequency spectrum 18 from the DEMON-analysis 10.

By determining several different threshold values 22 within the threshold value module 24, several synthetic spectra 42 with a respectively different threshold value 22, for example, can be generated based on the DEMON-spectrum 18. Thereby, several targets become distinguishable because the volumes of the operating noises of the targets may be different due to different distances and thus the levels or amplitudes of significant frequency ranges 34 of the DEMON-spectrum 18 may be different. The threshold values 22 can be modified manually by the operator or automatically at any time during the process.

Another modifiable parameter in the method for processing underwater sound signals is the selection of individual frequency lines 38 within the frequency line module 20. These frequency lines 38 can be faded in or out in a targeted manner for calculating the synthetic spectrum 42. This takes place e.g. by setting the frequency amplitude value of the frequency to be faded out or in to a value below or above the determined threshold value 22. Furthermore, it is conceivable to add additional frequency lines for calculating the synthetic spectrum 42.

An optional expansion of the invention provides comparing the frequency lines 38 of the DEMON-spectrum 18 with known frequency line patterns that are stored in a database.

Fig. 5 shows a block diagram of such an expansion of the method for processing underwater sound signals. Here, the previously described method is expanded to include a comparison module 70 with a database.

The DEMON-spectra 18 are transferred by the DEMON-analysis to the frequency module 20, which determines significant frequency lines 38 in the DEMON-spectrum 18 by means of a first threshold value 22. Based on this, the spectrum calculation unit 40 forms a synthetic spectrum 42 that is transferred to the comparison module 70.

The comparison module 70 has a database in which frequency line patterns of known DEMON spectra are stored, based on which known vehicles can be classified or identified. When comparing the synthetic spectrum 42 to the frequency line patterns of the database, the target speed of the sound source is taken into account, since a moving target causes speed-dependent spreads in the frequency line pattern. The comparison module 70 therefore has means for taking into account the speed of the target and, if necessary, for calculating a normalized synthetic spectrum 42, which is compared with the frequency line patterns of the database. The comparison module 70 is furthermore preferably configured in such a manner that it considers the variations of the characteristic spectrum caused by changes in the rotational speed.

Fig. 6 shows an explanation of the operation of the comparison module 70. If a frequency line pattern, that comes closest to the frequency lines 38 of the DEMON-spectrum, is recognized in a decision block 72 during a comparison of the synthetic spectrum 42 with known frequency line patterns of a database, a difference unit 76 is actuated via the branch 74. This unit generates a synthetic residual spectrum 78 by extracting the frequency line 38 that corresponds to the frequency line pattern from the synthetic spectrum 42. A spectrum pattern 80 is generated based on the extracted frequency lines 38 by means of the difference unit 76.

As shown in fig. 5, the residual spectrum 78 is transferred to the frequency line module 20, which identifies frequency lines 38 in the residual spectrum 78 based on the first or another threshold value 22, from which another synthetic spectrum 42 is generated. This synthetic spectrum 42 is also transferred to the comparison module 70 and the method is again implemented as described above by means of fig. 5.

However, if no frequency line pattern of the database is recognized in the DEMON-spectrum 18, the synthetic spectrum is transferred by the decision block 72 via a branch 82 to the DEMON-synthesis according to the method described above.

In this manner, depending on the number of recognized sound signatures, up to N different spectrum patterns 80_1 to 80_N as well as a synthetic spectrum 42 of the residual signal are generated, which are transferred to the DEMON-synthesis 44. The DEMON-synthesis 44 generates respectively one synthetic amplitude-modulated time signal for the spectrum patterns 80 and the synthetic spectrum 42 of the residual signal, which is separately issued acoustically to the operator in order to allow for an acoustic separation of targets with the same bearing.

Another modifiable parameter for processing underwater sound signals is the carrier signal 56 provided by the carrier module 54 and used during modulation of the synthetic time signal 50. Thus, it is possible to generate different synthetic amplitude-modulated acoustic signals 58 for one and the same synthetic time signal 50 and to issue them to the operator. Playing back the differently processed audio signals 58 makes it possible for the operator to choose the best sound result or to choose the best auditory impression of the selected signature.

Another modifiable parameter of the method according to the invention is a ratio between the amplitude change of the modulated carrier wave and the amplitude of the unmodulated carrier, referred to as modulation degree, wherein the modulation degree measures the intensity of the modulation. Since the synthetic time signals 50 determined based on a DEMON-spectrum 18 may have different amplitudes, the modulation degree in the modulation module 52 is changeable at any time. The modulation degree can be set manually by the operator or automatically by a computer or the like.

All the features mentioned in the above description of the figures, in the claims and in the introduction to the description are usable individually and in any combination of each other. Thus, the disclosure of the invention is not limited to the described or claimed feature combinations. Rather, all the feature combinations must be considered as disclosed.

Claims

1. A method for processing underwater sound signals, more specifically amplitude-modulated broadband sounds, which are radiated or emitted by vehicles, the broadband sounds being received as acoustic signals by means of a sonar device (2) and being subjected to a spectral analysis (10), more specifically a DEMON- analysis (10), which generates corresponding frequency spectra (18) based on the acoustic signals (8),
characterized in that
at least one local maximum (36) is determined within the frequency spectrum (18) or within a spectrum derived from the frequency spectrum (18) by means of at least one predetermined threshold value (22), the local maxima (36) corresponding to individual frequency lines (38) of the spectrum (18),
a synthetic spectrum (42) is generated by means of the determined frequency lines (38) and is subjected to a spectral synthesis (44), more specifically a DEMON-synthesis (44),
a corresponding synthetic time signal (50) is generated and a synthetic amplitude-modulated signal (58) is generated based on the synthetic time signal (50) and a carrier signal (56) by means of the spectral synthesis (44).

2. The method according to claim 1,
characterized in that
in order to generate the synthetic spectrum (42), one, several or all determined frequency lines (38) are selected and/or additional frequency lines are added.

3. The method according to claim 1 or 2,
characterized in that
the method additionally features the following steps:
   a) comparison of the synthetic spectrum (42) with known frequency line patterns of a database and

b) i) if at least one frequency line pattern in the synthetic spectrum (42) is recognized:
generation of a synthetic residual spectrum (78) by extracting that determined frequency line (38) from the synthetic spectrum (42) which corresponds to the frequency line pattern,
generation of a synthetic spectrum pattern (80) from the extracted frequency lines (38), which is transferred to spectral synthesis (44) and
continuation of the method with step a), wherein the residual spectrum (78) corresponds to a new synthetic spectrum (42).

ii) if no frequency line pattern in the synthetic spectrum (42) is recognized:
transfer of the synthetic spectrum (42) to spectral synthesis (44).

4. The method according to one of the afore-mentioned claims, characterized in that
a carrier signal (56) is selected from a multitude of available carrier signals and is used with the synthetic time signal (50) for modulation.

5. The method according to one of the afore-mentioned claims, characterized in that
the frequency spectrum (18) generated by spectral analysis (10) is stored and
one or several different synthetic spectra (42) are generated based on this frequency spectrum (18) by varying setting parameters and one or several synthetic time signals (50) are generated based on the synthetic spectra (42).

6. The method according to one of the afore-mentioned claims, characterized in that

the synthetic spectrum (42) is transformed from the frequency domain into the time domain by means of an inverse complex discrete Fourier transform, more specifically by means of an inverse fast Fourier transform.

7. The method according to one of the afore-mentioned claims, characterized in that
the synthetic amplitude-modulated signal (58) is output via a sound reproduction system, more specifically headphones and/or a speaker.

8. A device for processing underwater sound signals, more specifically amplitude-modulated broadband sounds, which are radiatable or emittable by vehicles, the broadband sounds being receivable as acoustic signals by means of a sonar device (2) and being subjectable to a spectral analysis (10), more specifically a DEMON- analysis (10), the spectral analysis (10) being designed so as to generated corresponding frequency spectra (18) based on the acoustic signals (8),
characterized by
a threshold value module (24), which is designed so as to define at least one threshold value (22),
a frequency line module (20), which is designed so as to determine at least one local maximum (36) within the frequency spectrum (18) or within a spectrum derived from the frequency spectrum by means of the predetermined threshold value (22), the local maxima (36) corresponding to the individual frequency lines (38),
a spectrum calculation unit (40), which is designed so as to generate a synthetic spectrum (42) by means of the determined frequency lines (38), the synthetic spectrum (42) being subjectable to a spectral synthesis (44), more specifically a DEMON-synthesis (44),
a synthesis device (56), which is designed so as to generate a corresponding synthetic time signal (50) from the synthetic spectrum (42) in accordance to the spectral synthesis (44) and
a modulation module (52), which is designed so as to generate a synthetic amplitude-modulated signal (58) from the synthetic time signal (50) and

from a carrier signal (56) provided by a carrier module (54) in accordance with the spectral synthesis (44).

9 The device according to claim 8,
characterized by
a further development of the frequency line module (20) so as to select one, several or all determined frequency lines (38) and/or to add additional frequency lines for generating the synthetic spectrum (42).

10 The device according to claims 8 to 9,
characterized by
a database with known frequency line patterns,
a comparison module (70), which is designed so as to compare the synthetic spectrum (42) with known frequency line patterns,
a difference unit (76), which is designed so as to generate a synthetic residual spectrum (78) by extracting such determined frequency lines (38) from the synthetic spectrum (42) as correspond to the frequency line pattern,
a further development of the difference unit (76) so as to generate a synthetic spectrum pattern (80) from the extracted frequency lines and to transfer it to the synthesis device (46).

11. The device according to one of the claims 8 to 10,
characterized by
a carrier module (54), which is designed so as to choose a carrier signal (56) from a multitude of available carrier signals, which is usable for modulation with the synthetic time signal (50).

12. The device according to one of the claims 8 to 11,
characterized by
a storage module (68), which is designed so as to store the frequency spectrum (18) generated by the spectral analysis (10) and

means for generating one or several different synthetic spectra (42) from the stored frequency spectrum (18), based on which one or several synthetic time signals (50) are generatable.

13. The device according to one of the claims 8 to 12,
characterized by
a design of the synthesis device (46) with means for transforming the synthetic spectrum (42) from the frequency domain into the time domain by means of an inverse complex discrete Fourier transform, more specifically an inverse fast Fourier transform.

14. The device according to one of the claims 8 to 13,
characterized by
a sound reproduction system, more specifically headphones and/or speakers, which are designed so as to issue the synthetic amplitude-modulated signal (58).

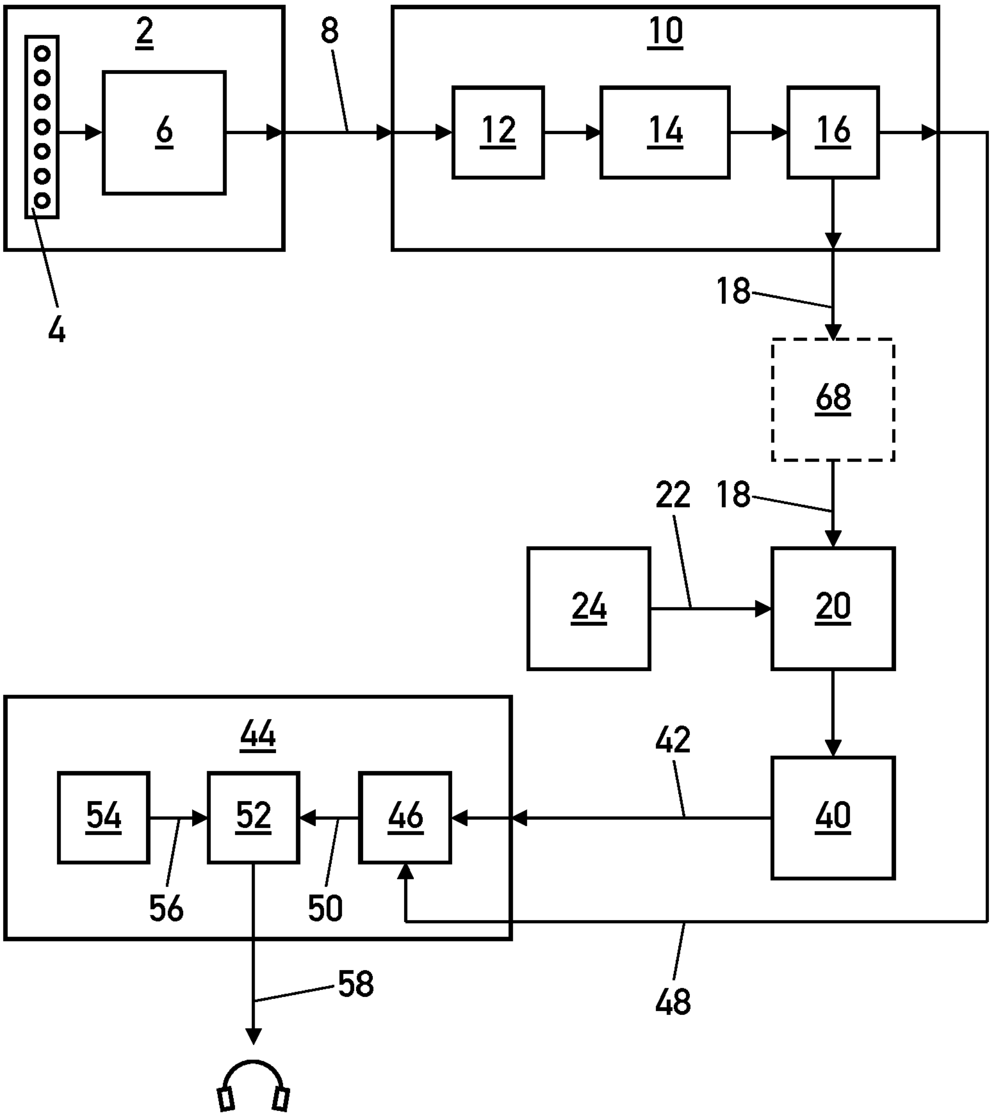

Fig. 1

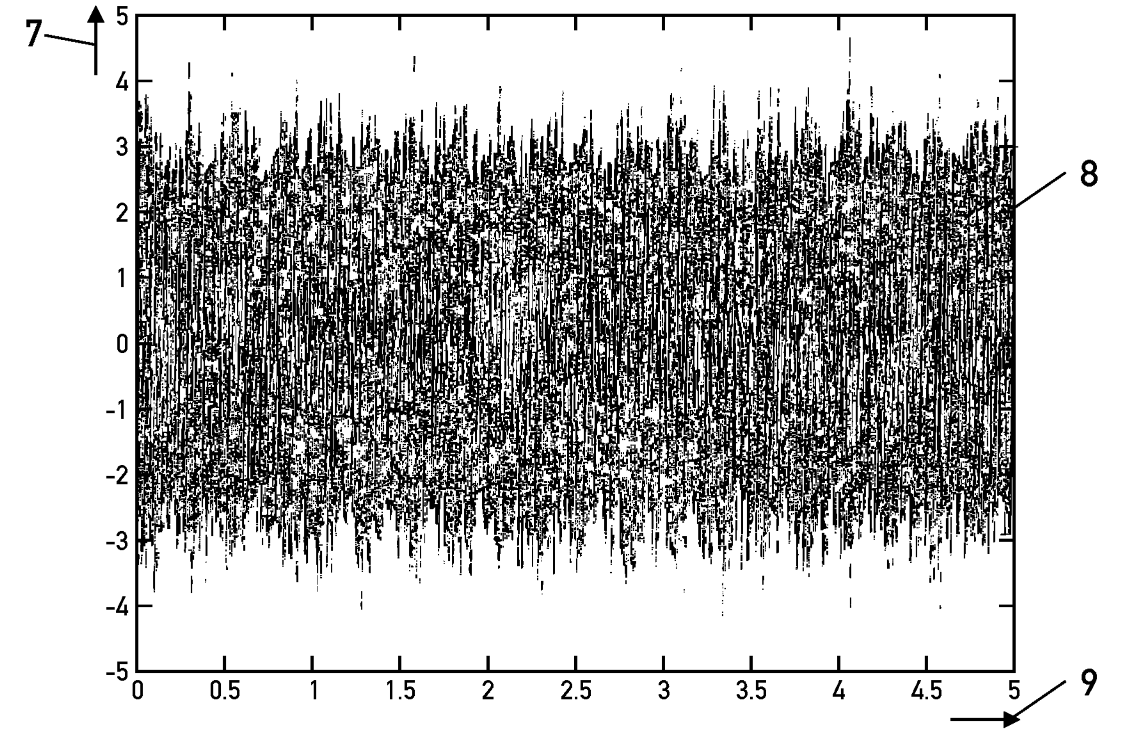
7
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
8
9

Fig. 2

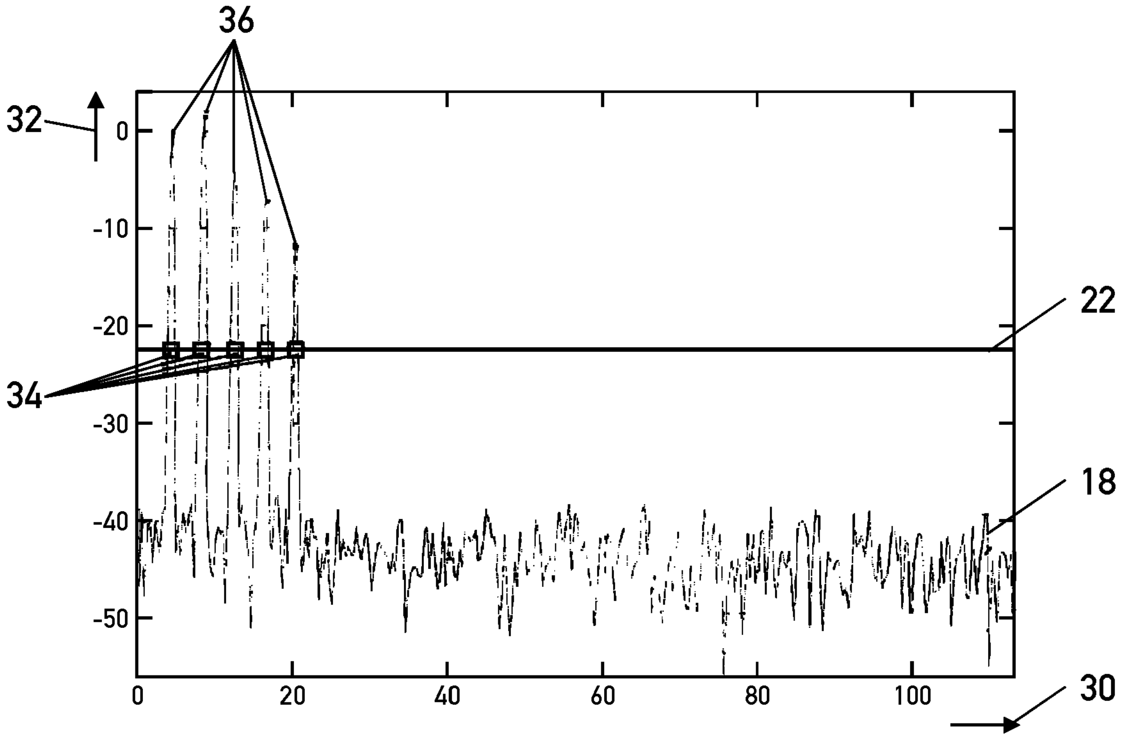
36
32
0
-10
-20
34
-30
-40
-50
0
20
40
60
80
100
22
18
30

Fig. 3

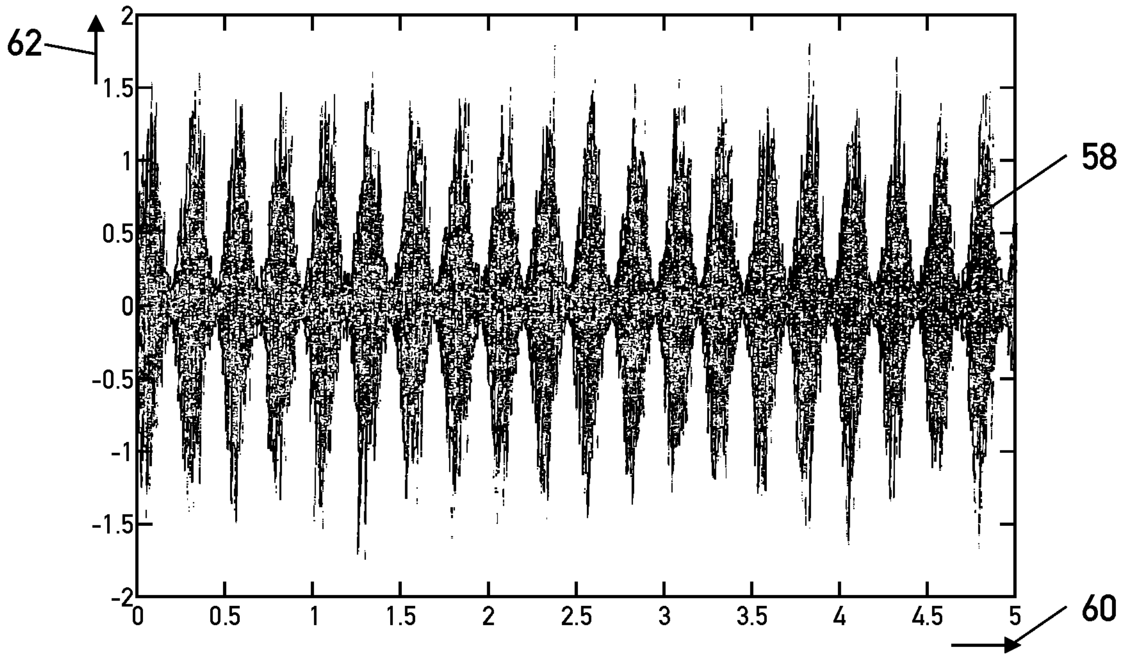
62
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
58
60

Fig. 4

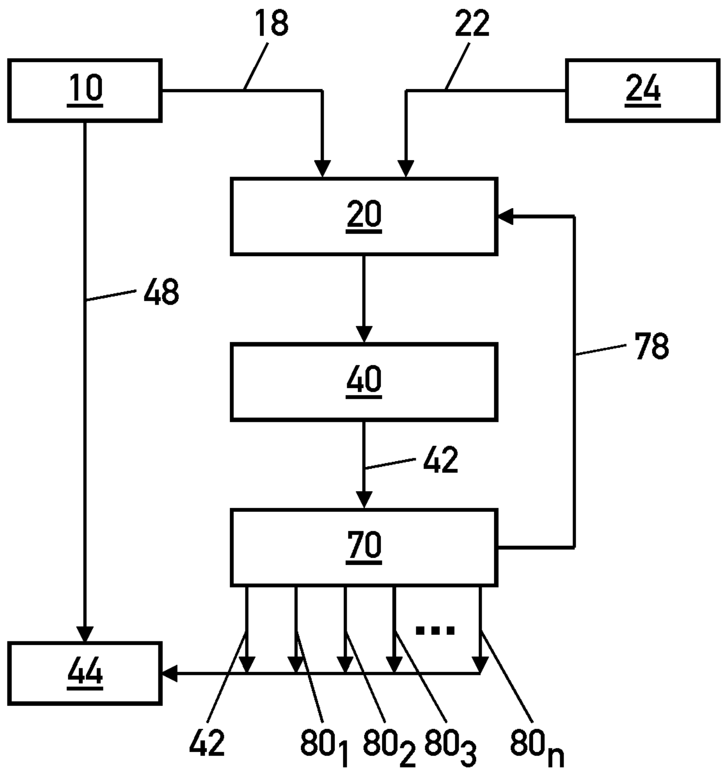
18
22
10
24
20
48
78
40
42
70
44
...
42
80₁
80₂
80₃
80ₙ

Fig. 5

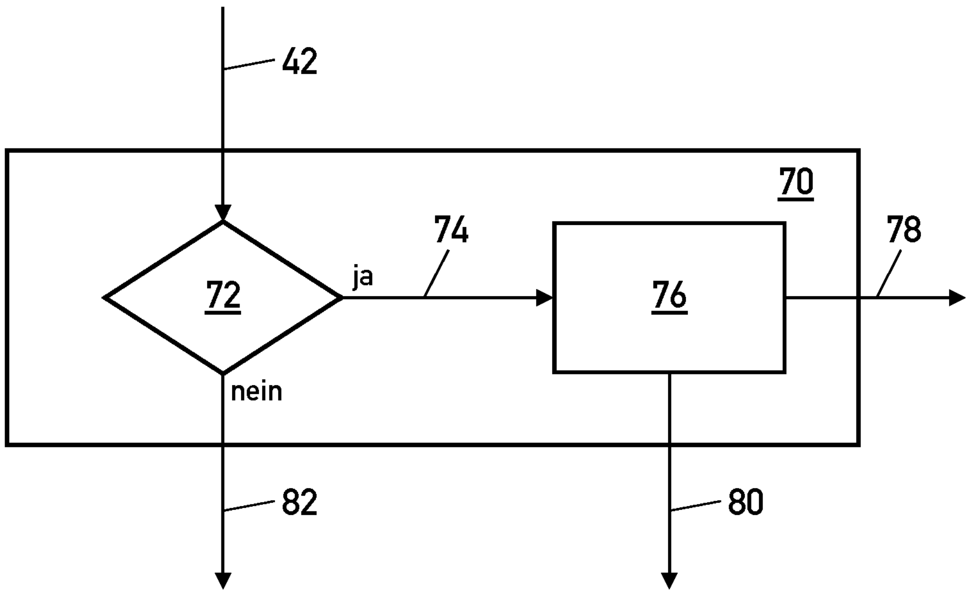

Fig. 6