

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) Publication number:

0 373 188 B1

(12)

EUROPEAN PATENT SPECIFICATION(45) Date of publication of patent specification: **01.12.93** (51) Int. Cl.⁵: **F01N 1/06**(21) Application number: **89902911.0**(22) Date of filing: **17.02.89**(86) International application number:
PCT/US89/00665(87) International publication number:
WO 89/07701 (24.08.89 89/20)(54) **EXHAUST GAS MUFFLER ARRANGEMENT FOR COMBUSTION ENGINE.**(30) Priority: **19.02.88 US 158883**(43) Date of publication of application:
20.06.90 Bulletin 90/25(45) Publication of the grant of the patent:
01.12.93 Bulletin 93/48(84) Designated Contracting States:
DE FR GB IT SE

(56) References cited:

FR-A- 1 190 317	JP-A- 0 214 613
SU-A- 0 836 652	US-A- 3 712 412
US-A- 3 826 870	US-A- 4 122 303
US-A- 4 177 874	US-A- 4 489 441
US-A- 4 527 282	

PATENT ABSTRACTS OF JAPAN vol. 9, no.
142 (M-388)(1865) 18 June 1985, & JP-A-60
22010 (NISSAN JIDOSHA) 04 February 1985

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MOTORSHIP vol. 68, no. 806, September 1987, LONDON GB page 47 "ELECTRONICS CANCEL NOISE AND VIBRATION AT SOURCE"

ELECTRONIC DESIGN vol. 36, no. 19, 25 August 1988, HASBROUCK HEIGHTS, N page 30
RICHARD NASS:
"MICROPROCESSOR-BASED ANTINOISE SYSTEM ELIMINATES SOUND"

PATENT ABSTRACTS OF JAPAN vol. 11, no. 235 (M-612)(2682) 31 July 1987, & JP-A-62 048911 (NIPPON SOKEN) 03 March 1987

Description

The invention is related to an exhaust gas muffler arrangement according to the introductory part of claim 1.

5 Numerous passive systems for suppressing noise at the intake and/or exhaust of gas movement systems have been proposed previously. Such passive systems use sound insulating material and/or baffles to suppress sound waves before they reach the surrounding atmosphere. These so-called "passive systems", such as conventional automotive exhaust gas mufflers, inherently restrict the exhaust gas flow, thereby resulting in energy losses with reductions in the efficiency of operation of the vehicle combustion
10 engines. It is well known to those skilled in the art of internal combustion engines that reduction or removal of the exhaust gas restriction back pressure substantially improves the performance of the engine. However, permitting such "straight pipe" operation of automotive vehicles results in sound patterns in public places that are not only unpleasant, they are unhealthy. For these reasons, virtually every industrialized nation has restrictions on the level of noise propagation that can be generated by automotive vehicles and other
15 machinery operating in public places. To date, in order to satisfy these noise abatement restrictions, virtually all automotive vehicles have relied on the passive muffler systems with consequent reduction in engine efficiency. Coupled with the reduction in engine efficiency there is of course inherent increased pollution due to increased hydrocarbon fuel consumption.

So-called "active" noise-cancellation systems have been proposed in the past and adapted to certain
20 environments on a small scale, usually environments involving relatively constant frequency sound generation pattern of the type that might be experienced in a fixed combustion engine constant velocity operating for a generator station or the like. U.S. Patents 4,122,303; 4,489,441; and 4,527,282 to Chaplin et al. disclose various aspects of active noise cancellation systems. French Patent 1,190,317 to Sherrer; U.S. Patents 4,677,676 and 4,677,677 to Eriksson, and U.S. Patent 4,473,906 to Wannaka disclose additional
25 methods for active noise cancellation in building system air ducts or exhaust pipes in which the cancelling noise generator (speaker) is required to be exposed directly to the exhaust gas stream. Those systems requiring placement of the speakers in the exhaust gas stream generating the undesirable sound to be cancelled place the speakers in such a harsh chemical and heat environment that they cannot operate over an extended period of time, at least not without inordinate costs for insulating the speaker and/or designing
30 them to withstand the loud environment. Further, such placement restricts the flow of exhaust gases to some extent, thereby resulting in the above-mentioned disadvantages regarding the back pressure on the combustion engine. Furthermore, those prior art systems that have been utilized in exhaust environments do not exhibit the compactness to facilitate commercialization and use on automotive and marine passenger vehicles and also do not have control systems that are responsive to the varying noise spectrum generated
35 during the normal driving of such vehicles, with acceleration and deceleration over a wide range of vehicle engine speeds.

An improved active noise cancellation system is known from 306 The Motor Ship 68 (1987) Sept., No. 806, Sutton, Surrey, Great Britain, which is compatible with the operating condition of motor vehicle, combustion engine exhaust systems. In that only schematically disclosed system loudspeakers are
40 controlled by a digital controller which has inputs from a synchronizing sensor monitoring the engine rotational speed and from a residual noise sensing microphone which picks up the sound at the outlet of the exhaust pipe. The loudspeakers are arranged in an anti-noise chamber which asymmetrically surrounds the exhaust pipe and extends beyond the outlet opening of the exhaust pipe. The loudspeaker means are mounted on a radial wall of the anti-noise chamber.

45 A further active noise cancellation system compatible with the operating condition of a motor vehicle combustion engine is known from JP-A 60-22010. The anti-speaker means is controlled by means of a control unit which processes a signal depending on the rotational speed of the engine only. The exhaust pipe for communicating exhaust gases to the atmosphere is surrounded by an anti-noise chamber opening to the atmosphere at a position substantially in the same plane as the exhaust pipe outlet opening. The anti-
50 noise speaker means for generating anti-noise sound waves is mounted within the vehicle body and coupled to the anti-noise chamber by a heat resistant rubber bellows. The bellows is intended to compensate relative movements between the vehicle body and the anti-noise chamber fixed to the exhaust pipe. Such compensation of movements will cause the bellows to flex and to elongate and to contract its length. This change of length of the bellows changes the acoustic impedance of the system and thus also
55 the tuning frequency and the efficiency of the transfer of the cancelling signal.

It is object of the present invention to provide an exhaust gas muffler arrangement for active noise cancellation systems of combustion engines which is compact and economical to manufacture and which can be incorporated into mass production vehicles with a consequent substantial reduction of the overall

costs of operating such vehicles as compared with vehicles having conventional passive muffler systems.

This object is achieved by the features of claim 1.

The anti-noise speaker means open into the anti-noise chamber which is totally isolated from the exhaust pipe and thereby the speakers are not subjected to the harsh chemical and heat environment of the exhaust gases. Also, the acoustic impedance of the system is constant.

Although the preferred embodiments described involve vehicle combustion engine exhaust systems, preferred embodiments of the invention are also contemplated for engine intake systems, for compressors and pumps with undesirable sound waves propagated in a pipe exhausting to atmosphere, and the like.

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

Figure 1 is a schematic side view of a passenger vehicle depicting the location of the engine exhaust system and a digital muffler system;

Figure 2 is a schematic bottom view of the vehicle of Figure 1 depicting the vehicle exhaust system and active digital muffler system;

Figure 3 is a side schematic view of a motor boat equipped with an active digital muffler system;

Figure 4 is a schematic view showing the engine, exhaust system and active digital muffler system for use with the boat of Figure 3;

Figure 5 is a schematic perspective view of an exhaust muffler arrangement constructed according to a preferred embodiment of the present invention;

Figure 6 is a longitudinal section view of the muffler arrangement of Figure 5;

Figure 7 is an end view taken from the right side of Figure 6;

Figure 8 is a view similar to Figure 6, showing an alternative of the exhaust muffler arrangement of the present invention, having an intermediate exhaust gas low pressure cooling chamber;

Figure 9 is an end view from the right side of Figure 8;

Figure 10 is a schematic depiction of a complete active digital muffler system constructed according to a preferred embodiment of the present invention;

Figure 11 is a schematic depiction of a complete active digital muffler system constructed according to another preferred embodiment of the present invention;

Figure 12 is a graph comparing test results on a vehicle with a diesel engine, showing the sound spectrum at the exhaust with and without noise attenuation using the system of the present invention.

Figures 1 and 2 schematically depict respective side views and bottom views of a passenger motor vehicle having an active digital muffler system constructed according to preferred embodiments of the present invention. The system depicted in Figures 1 and 2 corresponds to the Figure 10 embodiment of the overall system (described in more detail below). The passenger vehicle 1 includes a multi-cylinder/piston internal combustion engine 2, the exhaust of which is transported by exhaust pipe system 3 to the exhaust outlet 4 at the rear of the vehicle. The rear portion of the exhaust pipe system 3, is depicted as a single exhaust pipe in the following description, although similar duplicate arrangements can be provided for dual exhaust pipe systems, is provided at its rear end with a surrounding anti-noise chamber arrangement 5, which includes anti-noise speakers driven by a power amplifier 6 and digital controller 7. The digital controller 7 has input signals from a residual sensing microphone 8 adjacent the exhaust outlet 4 and a synchronization sensor 9, such as a tachometer at the drive shaft of the engine 2.

Figures 3 and 4 schematically depict a preferred embodiment of an active digital muffler system according to the invention installed on a motor boat 1A, which, in a similar manner as the passenger motor vehicle of Figures 1 and 2, includes a reciprocating piston multi-cylinder internal combustion engine 2A, an exhaust pipe system 3A with an outlet 4A. An anti-noise chamber arrangement 5A is provided adjacent the downstream end of the exhaust pipe system 3 and includes speakers driven by a power amplifier 6A and controlled by a digital controller 7A. The digital controller 7A is in turn supplied with input signals from a residual sensor microphone 8A, the exhaust outlet of the boat motor and a synchronization sensor 9A of the output drive shaft of the boat motor engine 2. Certain embodiments for use with boats will include water supplied exhaust system cooling arrangements, such as water flow directly into the exhaust pipe and water flow in an annular jacket surrounding the exhaust such cooling arrangement being well known in the motor boat industry.

The following description of the details of the anti-noise chamber arrangement surrounding the exhaust pipe and the controller circuit for controlling the same is similar for the embodiments for both the over the road passenger motor vehicles of Figures 1 and 2 and the motor boat of Figures 3 and 4. It will be understood by those skilled in the art that certain components in the motor boat environment need to be "marine" qualified to withstand salt sea air and the like.

Figures 5-7 Schematically depict a first preferred embodiment of an anti-noise chamber arrangement 5 and exhaust pipe. Chamber 5 of Figures 6-7 is constructed as an intergal sheet metal structure and includes a centrally disposed cylindrical exhaust pipe 10 which is connected to the exhaust pipe system 3, 3A (compare Figures 1 to 4). The left hand end of the exhaust pipe section 10 is preferably configured so as to be insertable into an existing exhaust pipe of an engine exhaust system 3,3A, with an appropriate sealing clamping connection being provided.

An anti-noise chamber 11 is provided in annular surrounding relationship to the exhaust pipe 10. The anti-noise-chamber 11 is defined by first cylindrical section 12 of a large diameter and an adjoining smaller diameter section 13. The left hand end of the large diameter section 12 is closed off by an annular end plate 14 which is supported at the outer surface of the exhaust pipe 10 by welding connection. The opposite end of the anti-noise chamber 11 is supported by radially extending support plates 15 attached by welding at the exhaust pipe 10 and by welding at the section 13 of the anti-noise chamber 11. A pair of cylindrical speaker support sections 17 are connected by a welding connection 18 to the cylindrical section 12 at a position adjacent the end cap 14. In the illustrated embodiment the cylindrical speaker support sections 17 have a slightly smaller diameter than the diameter of the section 12 of the anti-noise chamber and are there joined by welding seams 18. These anti-noise speaker support cylinder sections 17 are disposed symmetrically with respect to the longitudinal axis of the exhaust pipe 10 and anti-noise chamber 11. Anti-noise speakers 19 are mounted in each of the respective support section 17 and are disposed to generate sound waves emanating into the anti-noise chamber 11. The anti-noise chamber 11 is concentric and separate from the exhaust pipe 10, with the anti-noise sound waves generated by the speaker 19 and propagated along the length of the chamber 11 opening into the atmosphere at the same exit plane 4B as the exhaust gases from the exhaust pipe 10.

By arranging the speakers 19 to be symmetrical with the longitudinal axis of the exhaust pipe 10 and by providing the anti-noise chamber 11 as an annular chamber surrounding the pipe 10, the manufacture of the anti-noise muffler chamber arrangement is quite simple and it can be constructed as a unit that can be added on to an existing exhaust system 3 merely by connecting the left hand end of the pipe section 10 to the exhaust pipe of a vehicle. In especially preferred embodiments, the exhaust pipe 10 and the cylindrical sections 12, 13 making up the anti-noise chamber 11 and the speaker supports 17 are all constructed of metal that can be easily welded together, thus further simplifying the manufacturing operation. Embodiments are also contemplated with a heat insulating connection at the exhaust pipe 10 such as an annular heat insulating material ring surrounding the pipe 10 which limits the transfer of heat to the components. Since the speakers 19 are disposed symmetrically with respect to the noise generating exhaust pipe 10, an especially efficient utilization of space and cancellation of noise is provided since there is symmetrical disposition of the anti-noise waves around the annular space at the outlet end plane 4B of the muffler pipe arrangement. Since the noise cancelling sound waves emanate in substantially the same plane 4B of the exhaust gases, the anti-sound wave propagation is symmetrical with the sound wave propagation from the exhaust pipe outlet, thereby simplifying the construction and operation. The speakers 19 are also isolated by chamber 11 from the exhaust gases and thereby do not have to withstand the highly corrosive hot gases in the exhaust stream.

Other preferred embodiments are contemplated which utilize only a single speaker opening into the acoustically tuned chamber 11, the annular outlet at plane 4B effectively providing an appropriate effective common point source for the cancelling and undesired sound. The additional speakers of the preferred embodiments illustrated facilitate the use of smaller speakers for the same output, thus economizing space.

In an especially preferred practical embodiment, the dimensions are as follows referring to Figure 6:

- diameter 2D of the exhaust pipe 10 is 5,715 cm (2.250 inches) inside diameter,
- the length 71 between end plate 14 and the left end of the pipe 10 is 5,08 cm (2 inches),
- the radial width 11R of the chamber section 12 outside of the pipe 10 is 4,45 cm (1.75 inches),
- the radial width 15R between the outside of the pipe 10 and the outer wall of cylindrical section 13 is 1,9 cm (0.75 inches),
- the radial length 17R of the speaker support sections 17 is 6,35 cm (2.5 inches),
- the diameter 17D of the cylindrical sections 17 is 12,7 cm (5 inches),
- the distance 12L between the edge of the sections 17 and the end of chamber section 12 is 12,07 cm (4.75 inches),
- and the length 13L of the section 13 is 12,7 cm (5 inches).

The embodiment of Figures 8 and 9 is the same as the embodiment of Figures 5 through 7 described above, except for the addition of an intermediate low pressure cooling exhaust gas chamber 20 between the anti-noise chamber 11A and the exhaust pipe. In Figures 8 and 9, like reference numerals with a suffix A will be included to designate corresponding structure from the embodiment of Figures 5 through 8. These

structures are described only to the extent that they function differently from the corresponding structure embodiment of Figures 5 and 8. The annular intermediate chamber 20 is communicated with the exhaust pipe 10A by eight radially extending 1/8 inch diameter holes 21 in the pipe 10A. The holes 21 are disposed at the upstream end of the anti-noise chamber 11 and allow a small amount of cooling air to be sucked in by the exhaust gas flow through the opening at end plane 4B so cooling air flows in chamber 20 counter to the direction of flow of the exhaust gases and then into the exhaust pipe. The radially extending reinforcing plates 15 extend also through the end portion of this chamber 20 and support the respective concentric pipes forming same. The cooling air flow communicated to the exhaust pipe through openings 21 also aid in reducing the turbulence of the exhaust gases that exit from the exhaust pipe 10A and thereby further reduce over all noise levels.

Figure 10 schematically depicts a first embodiment of a control system for the active digital muffler system of the present invention. A synchronization sensor such as an engine tachometer 9 provides synchronization signal inputs to a digital controller 7 which is also supplied by a residual sensor microphone 8 which picks up the actual sound wave pattern downstream of the outlet plane 4B of the exhaust pipe 10 and the anti-noise chamber 11 the controller 7 controls power amplifier 6 which in turn drives the speakers 19 to generate the noise-cancelling waves in the chamber 11, which then travel to the outlet plane 4B of the exhaust pipe 10 and effect cancellation of the sound waves emanating from the pipe outlet. In especially preferred embodiments, the audio power amplifier 6 is integrated with the digital electronic controller 7. The digital controller can utilize a frequency domain algorithm as described in U.S. Patent 4,490,841 by Chaplin. Alternatively, the digital controller can utilize a time domain algorithm as described in co-inventor Eldon Ziegler, Jr.'s pending U.S. Patent Application Serial No. 238,188 filed on August 30, 1988.

A practical speaker and microphone usable with a configuration as in Figures 5-7 or 8 and 9 has the following characteristics.

SPEAKER

MAGNET FLUX DENSITY 11,000 GAUSS
 TOTAL FLUX - 58,000 MAXWELLS
 SENSITIVITY 96dB spc@ 1m, 11.2 v RMS
 THEIL-SMALL PARAMETERS
 $S_D = 92 \text{ cm}^2$
 $M_D = 9.8 \text{ gm}$
 $X_D = 6 \text{ mm peak to peak}$
 $f_s = 37 \text{ HZ}$
 $R_{ms} = 1 \Omega$
 $C_{ms} = 1.8 \times 10^{-3} \text{ M/N}$
 VAS = 23.6 liters
 QM = 2.44
 QE = 0.38
 QT = 0.33
 IMPEDANCE 8Ω
 RANGE 55 Hz to 3,500 Hz
 NET WEIGHT 1.13 kg.

MICROPHONE

FREQ. RESPONSE	20 - 13,000 HZ
IMPEDANCE	600
SENSITIVITY	-71dB $\pm$ 5dB (REF OJB = 1v/ μ bar, 1KHZ)
POWER	1.5 VDC to 20 VDC-

A second control system for the active digital muffler system is schematically depicted in Figure 11. Since the Figure 11 system only differs from the Figure 10 system in the utilization of an upstream sensor microphone 22, in lieu of the tachometer synchronizing sensor 9, the remaining structure is depicted by similar reference numerals as in Figure 10. Similarly to the Figure 10 embodiment, either of a frequency domain algorithm controller or a time domain algorithm controller can be utilized. The difference between

the Figure 10 and 11 embodiment being that the input from microphone 22 is utilized instead of the input from a tachometer sensor 9 as in Figure 10.

It is further noted that a controller corresponding to the NCT 20C0 controller marketed by Noise Cancellation Technologies Inc., can be used to serve as controller 7.

Figure 12 is a graphical comparison showing a dramatic reduction in noise levels utilizing the active digital muffler system on a diesel engine, as compared with operating the same diesel engine without cancellation. In Figure 12 the upper graph shows the noise levels without cancellation and the lower graph shows the noise levels with cancellation. The following is a Table of the experimental results shown on the Figure 12 graph.

MARK	LIST X	Y(U)	Y(L)
0	90.000	-18.0	-44.5
1	104.99	-45.3	-51.8
2	120.00	-45.9	-53.4
3	135.00	-41.8	-59.7
4	150.00	-38.3	-60.3
5	165.00	-45.9	-56.0
6	180.00	-24.8	-49.4
7	240.00	-36.1	-58.2
8	270.00	-40.8	-58.2
9	360.00	-46.1	-52.2

From the Table and the graph, one can see substantial noise level reductions, e.g. 26 decibels at mark 0 at 90 HZ frequency with the engine exhaust noise silenced by the sound attenuation system by the present invention, the passive muffler can be deleted from the vehicle exhaust pipe system. Deletion of the passive muffler (so-called "straight pipe" operations) results in remarkable increases in engine efficiency and power, as is known to those skilled in the art of automotive internal combustion engines.

Claims

- Exhaust gas muffler arrangement for combustion engines (2, 2A) having
exhaust pipe means (10, 10A) for communicating engine exhaust gases to surrounding ambient atmosphere at an exhaust pipe outlet opening means,
anti-noise chamber means (11, 11A) at least partly surrounding the exhaust pipe means and opening to the atmosphere via anti-noise exhaust gas opening means at a position substantially in the same plane (4B) as the exhaust pipe outlet opening means,
and anti-noise speaker means (19, 19A) for generating anti-noise sound waves in the anti-noise chamber means such that the anti-noise sound waves and original noise sound waves in the exhaust pipe means cancel the effect of one another at the region of the exhaust pipe outlet opening means to reduce the overall noise level of the arrangement,
characterized in that said anti-noise speaker means (19, 19A) is supported by a speaker section (17, 17A) rigidly connected to a chamber (11, 11A) extending from an end plate (14) to the outlet opening means and being mounted concentrically on the pipe (10, 10A).
- An arrangement according to claim 1, wherein said anti-noise chamber means (11) is acoustically tuned and includes a large diameter section (12) joined by a smaller diameter section (13), said anti-noise speaker means (19, 19A) being mounted at the large diameter section, said smaller diameter section extending to the outlet plane (4B).
- An arrangement according to claim 1 or 2 wherein said anti-noise speaker means includes a plurality of speaker means (19, 19A) disposed symmetrically with respect to one another at opposite sides of the longitudinal axis.
- An arrangement according to anyone of claims 1 to 3 comprising an intermediate chamber (20) disposed between the exhaust pipe means (10A) and the anti-noise chamber means (11A) for accommodating cooling air flow to cool the exhaust pipe means, said cooling air flow in bypassing relation to the exhaust pipe and the anti-noise chamber means in a direction opposite the exhaust gas

flow, said intermediate chamber opening to atmosphere substantially in the plane (4B) of the exhaust pipe outlet means.

- 5 5. An arrangement according to claim 4, wherein cooling air flow openings (21) open from the exhaust pipe means (10A) to the intermediate chamber (20) and are symmetrically disposed about the circumference of the exhaust pipe means.
6. An arrangement according to claim 4 or 5, wherein said cooling air flow openings (21) include at least four separate radial openings through the exhaust pipe means (10A).
- 10 7. An arrangement according to claim 4 or 5, wherein said cooling air flow openings (21) include eight separate radial openings through the exhaust pipe means (10A).

Patentansprüche

- 15 1. Abgasschalldämpferanlage für Brennkraftmaschinen (2, 2a),
die Auspuffrohrmittel (10, 10A), um Maschinenauspuffgase bei einem Öffnungsmittel des Auspuffrohr-
auslasses der einschließenden Umgebungsatmosphäre mitzuteilen,
20 Kammermittel zur Geräuschkämpfung (11, 11A), die die Auspuffrohrmittel wenigstens teilweise umge-
ben und sich in die Atmosphäre über Öffnungsmittel zur Geräuschkämpfung des Auspuffgases in einer
Position öffnen, die im wesentlichen in der Ebene (4B) liegt wie die Öffnungsmittel des Auspuffrohr-
auslasses
und Lautsprechermittel zur Geräuschkämpfung (19, 19a) enthält, um Schallwellen zur Geräuschkämp-
25 fung in den Kammermitteln zur Geräuschkämpfung zu erzeugen, so daß die Schallwellen zur Ge-
räuschkämpfung und die ursprünglichen Geräuschkwellen in den Auspuffrohrmitteln ihre Wirkung
gegenseitig in dem Bereich der Öffnungsmittel des Auspuffrohrauslasses aufheben, um den gesamten
Geräuschkpegel der Anlage zu verringern,
dadurch gekennzeichnet, daß das Lautsprechermittel (19, 19A) zur Geräuschkämpfung durch einen
30 Lautsprecherabschnitt (17, 17A) getragen ist, der starr mit einer Kammer (11, 11A) verbunden ist, die
sich von einer Endplatte (14) zu den Öffnungsmitteln des Auslasses erstreckt und konzentrisch an dem
Rohr (10, 10A) angebracht ist.
2. Anlage nach Anspruch 1, worin das Kammermittel zur Geräuschkämpfung (11) akustisch abgestimmt
ist und einen Abschnitt (12) großen Durchmessers einschließt, der mit einem Abschnitt (13) kleineren
35 Durchmessers verbunden ist und die Lautsprechermittel (19, 19A) zur Geräuschkämpfung an dem
Abschnitt größeren Durchmessers angebracht sind und der Abschnitt kleineren Durchmessers sich zu
der Auslaßebene (4b) erstreckt.
3. Anlage nach Anspruch 1 oder 2, worin das Lautsprechermittel zur Geräuschkämpfung eine Mehrzahl
40 von Lautsprechermitteln (19, 19A) enthält, die symmetrisch in bezug zueinander an gegenüberliegen-
den Seiten der Längsachse angeordnet sind.
4. Anlage nach einem der Ansprüche 1 bis 3, die eine Zwischenkammer (20) enthält, die zwischen den
Auspuffrohrmitteln (10A) und den Kammermitteln zur Geräuschkämpfung (11A) angeordnet ist, um
45 einen Kühlluftstrom einzubringen, um die Auspuffrohrmittel zu kühlen und der Kühlluftstrom das
Auspuffrohr und die Kammermittel zur Geräuschkämpfung in einer Richtung entgegen dem Auspuff-
gasstrom umgeht und sich die Zwischenkammer im wesentlichen in der Ebene (4B) der Auspuffrohr-
auslaßmittel in die Atmosphäre öffnet.
- 50 5. Anlage nach Anspruch 4, worin Kühlluftstromöffnungen 21 sich von den Auspuffrohrmitteln (10A) in die
Zwischenkammer (20) öffnen und symmetrisch am Umfang der Auspuffrohrmittel angeordnet sind.
6. Anlage nach Anspruch 4 oder 5, worin die Kühlluftstromöffnungen (21) wenigstens vier getrennte
radiale Öffnungen durch die Auspuffrohrmittel (10A) einschließen.
- 55 7. Anlage nach Anspruch 4 oder 5, worin die Kühlluftstromöffnungen (21) acht getrennte radiale Öffnun-
gen durch die Auspuffrohrmittel (10a) einschließen.

Revendications

1. Dispositif de silencieux de gaz d'échappement pour moteurs à combustion interne (2, 2A), comprenant des moyens formant tuyau d'échappement (10, 10A) destinés à transmettre les gaz d'échappement du moteur à l'atmosphère ambiante, au droit de moyens d'ouverture de sortie du tuyau d'échappement ;
des moyens (11, 11A) formant chambre anti-bruit, qui entourent au moins partiellement les moyens formant tuyau d'échappement et s'ouvrent sur l'atmosphère à travers des moyens d'ouverture de gaz d'échappement anti-bruit, dans une position située sensiblement dans le même plan (4B) que les moyens d'ouverture de sortie du tuyau d'échappement, et
des moyens (19, 19A) formant haut-parleur anti-bruit destinés à engendrer des ondes sonores anti-bruit dans les moyens formant chambre anti-bruit de manière que les ondes sonores anti-bruit et les ondes sonores du bruit d'origine qui se propagent dans les moyens formant tuyau d'échappement annulent mutuellement leurs effets dans la région des moyens d'ouverture de sortie du tuyau d'échappement pour réduire le niveau de bruit global du dispositif,
caractérisé en ce que lesdits moyens (19, 19A) formant haut-parleur anti-bruit sont supportés par une partie haut-parleur (17, 17A) reliée rigidement à une chambre (11, 11A) qui s'étend d'une plaque d'extrémité (14) aux moyens d'ouverture de sortie et est montée concentriquement sur le tuyau (10, 10A).
2. Dispositif selon la revendication 1, dans lequel lesdits moyens (11) formant chambre anti-bruit sont accordés acoustiquement et comprennent une partie (12) de grand diamètre réunie à une partie (13) de petit diamètre, lesdits moyens (19, 19A) formant haut-parleur anti-bruit étant montés au droit de la partie de grand diamètre, ladite partie de petit diamètre s'étendant jusqu'au plan de sortie (4B).
3. Dispositif selon la revendication 1 ou 2, dans lequel lesdits moyens formant haut-parleur anti-bruit comprennent une pluralité de haut-parleurs (19, 19A) disposés symétriquement les uns par rapport aux autres de part et d'autre de l'axe longitudinal.
4. Dispositif selon une quelconque des revendications 1 à 3, comprenant une chambre intermédiaire (20) disposée entre les moyens (10A) formant tuyau d'échappement et les moyens (11A) formant chambre anti-bruit pour recevoir un flux d'air de refroidissement pour refroidir les moyens formant tuyau d'échappement, ledit flux d'air de refroidissement étant en relation de bypass par rapport au tuyau d'échappement et aux moyens formant chambre anti-bruit dans le sens inverse du flux de gaz d'échappement, ladite chambre intermédiaire s'ouvrant sur l'atmosphère sensiblement dans le plan (4B) des moyens de sortie du tuyau d'échappement.
5. Dispositif selon la revendication 4, dans lequel les ouvertures (21) du flux d'air de refroidissement s'ouvrent des moyens (10A) formant tuyau d'échappement sur la chambre intermédiaire (20) et sont disposés symétriquement autour de la circonférence des moyens formant tuyau d'échappement.
6. Dispositif selon la revendication 4 ou 5, dans lequel lesdites ouvertures (21) du flux d'air de refroidissement comprennent au moins quatre ouvertures radiales séparées qui traversent les moyens (10A) formant tuyau d'échappement.
7. Dispositif selon la revendication 4 ou 5, dans lequel lesdites ouvertures (21) de flux d'air de refroidissement comprennent huit ouvertures radiales séparées ménagées au travers lesdits moyens (10A) formant tuyau d'échappement.

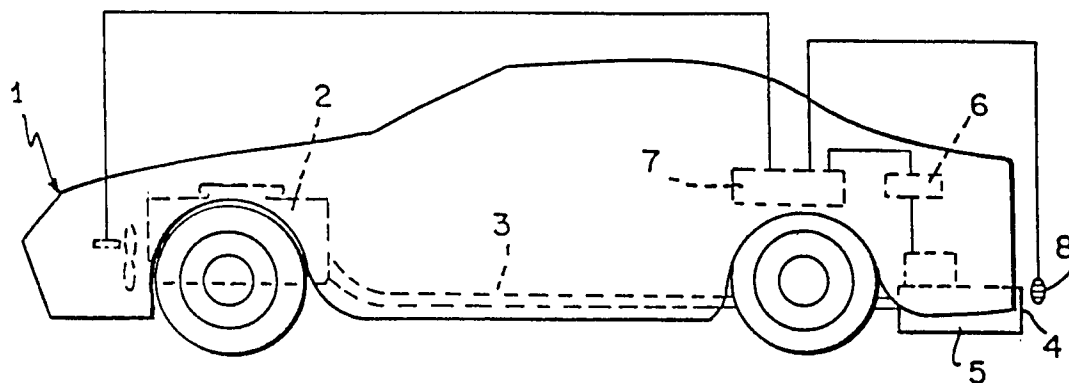


FIG. 1

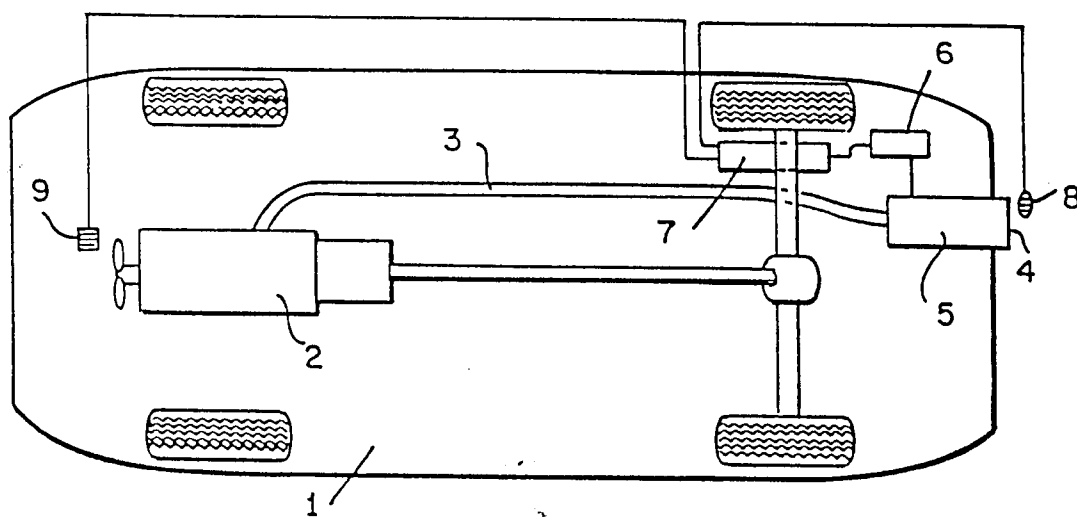


FIG. 2

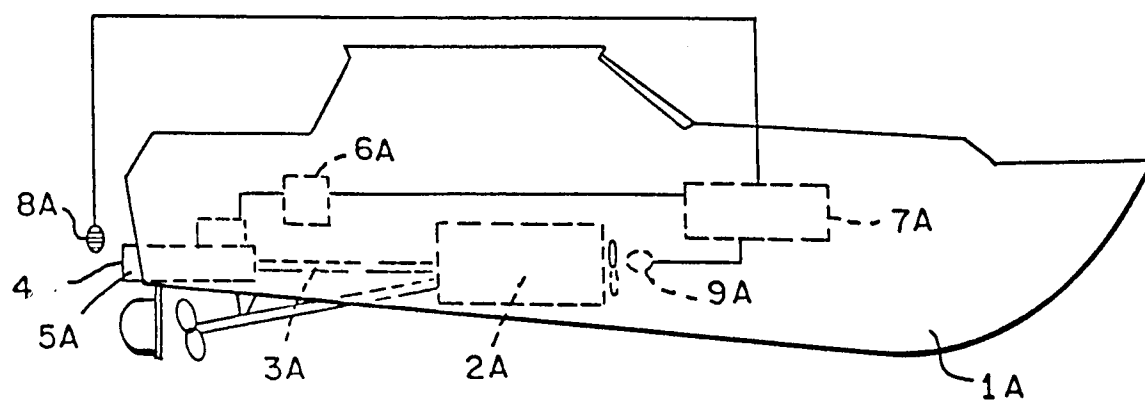


FIG. 3

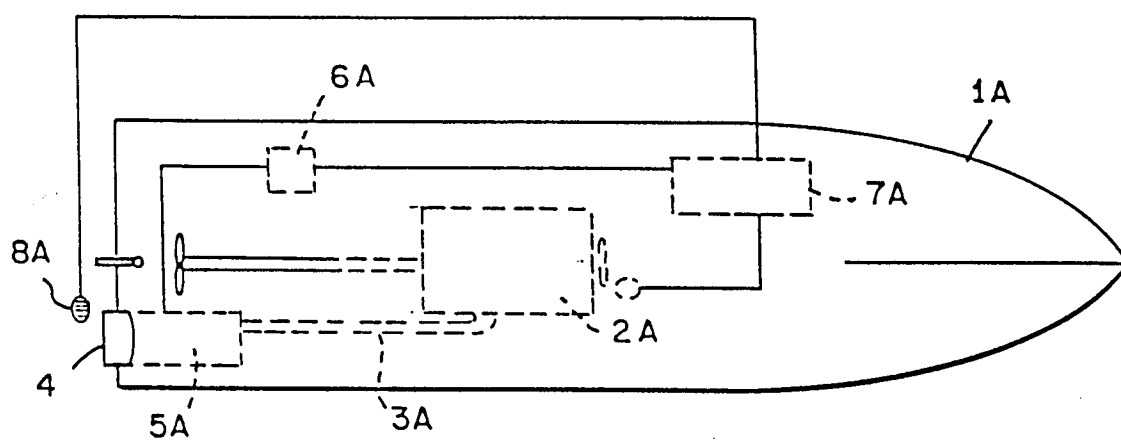


FIG. 4

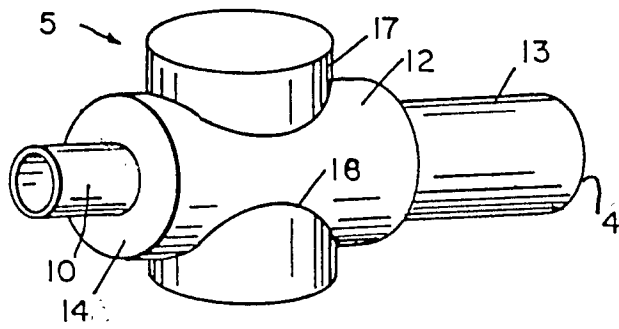


FIG. 5

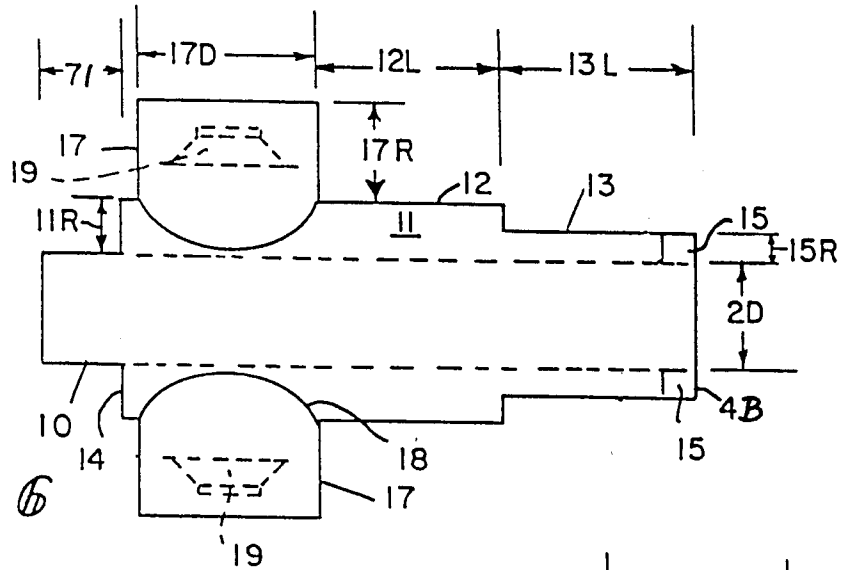


FIG. 6

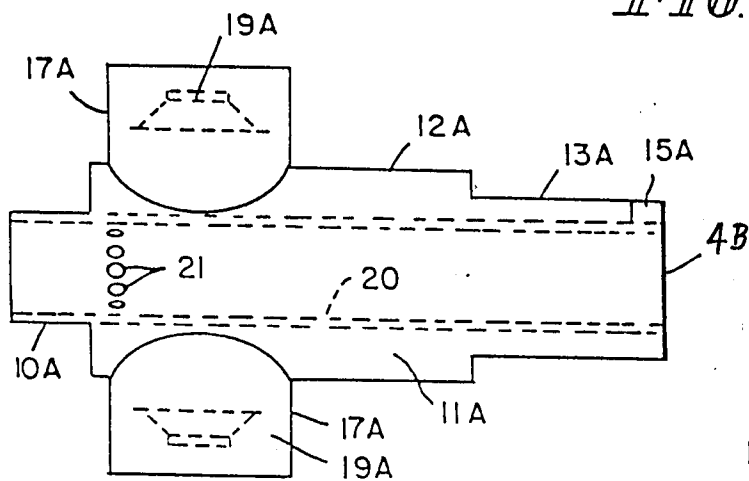


FIG. 8

FIG. 7

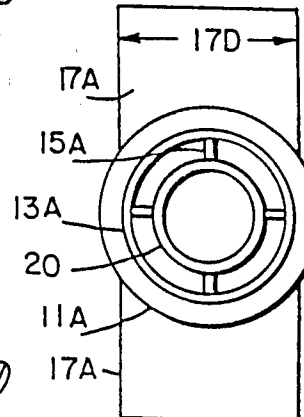
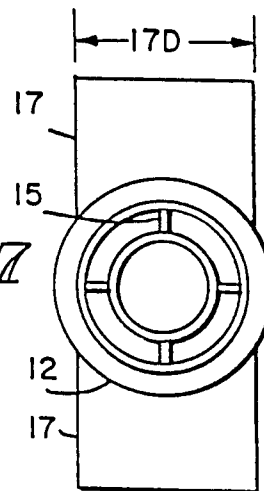


FIG. 9

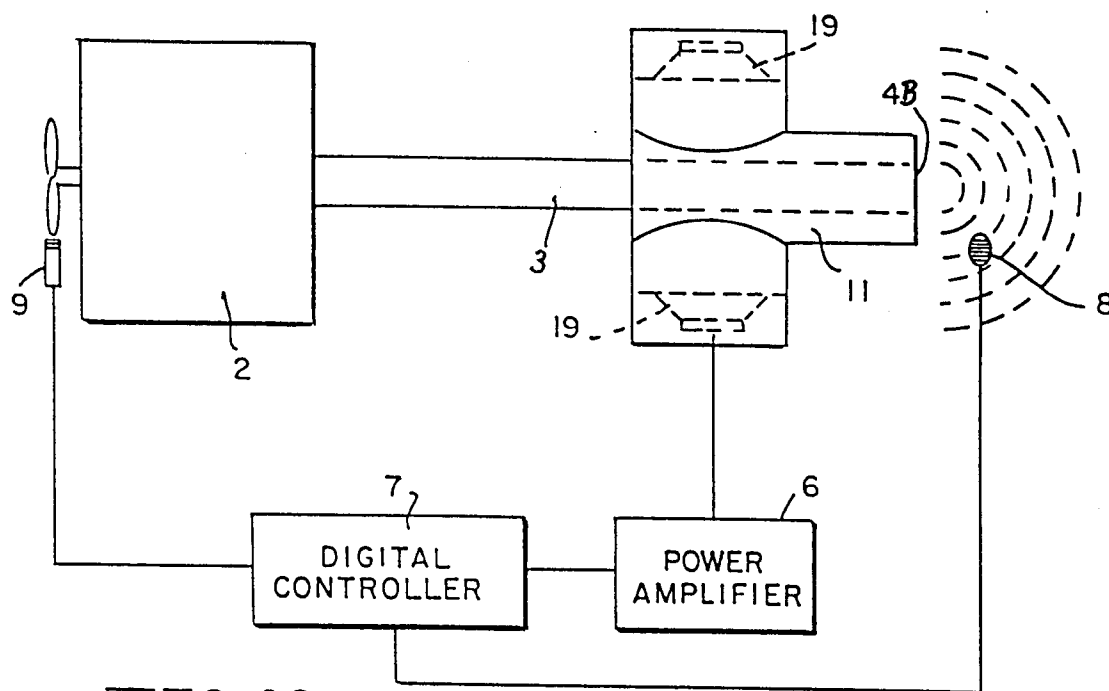


FIG 10

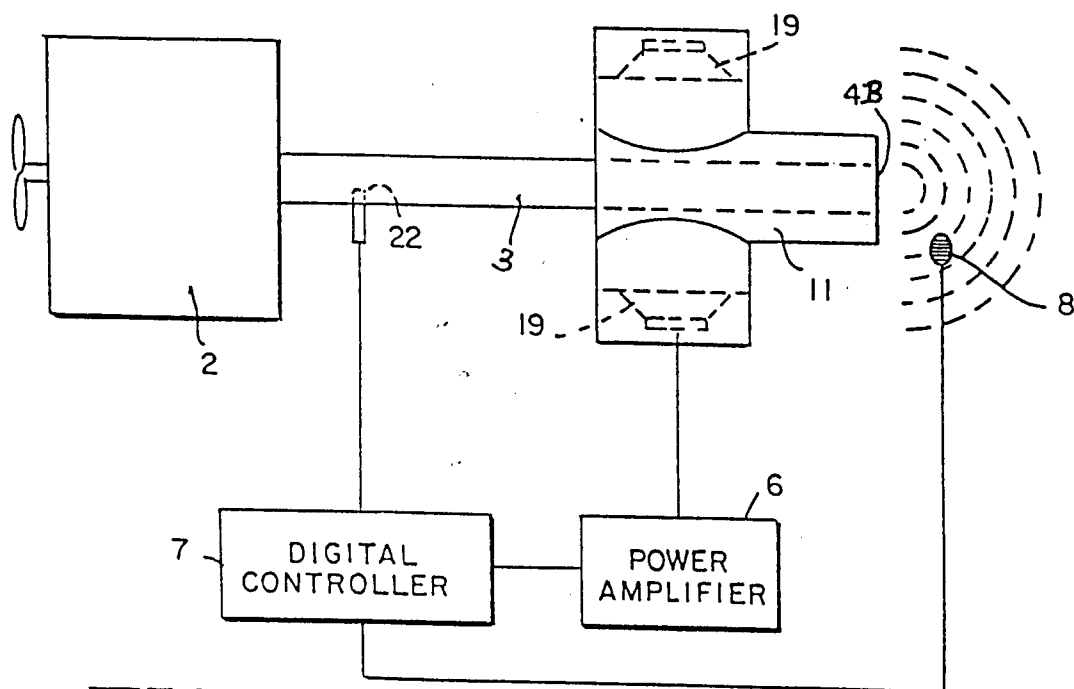


FIG 11

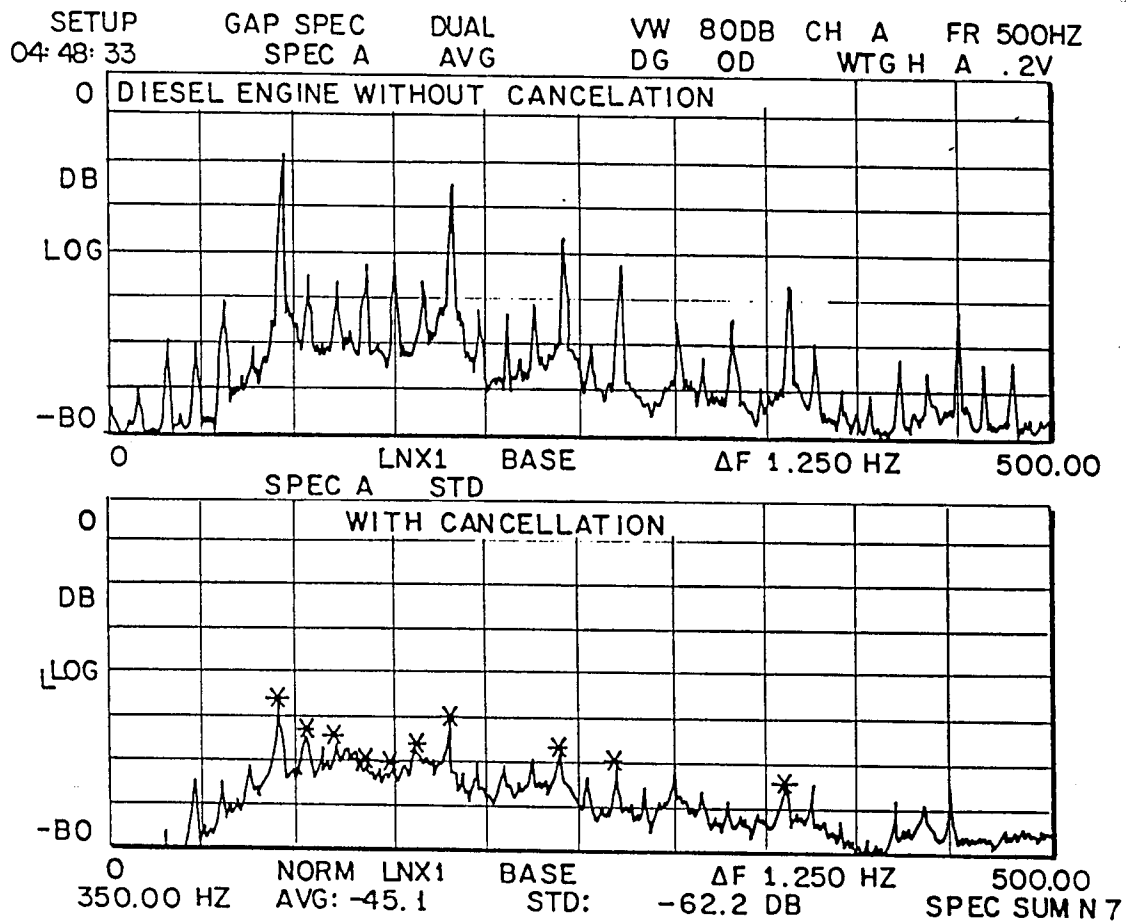


FIG. 12