Electromechanical horn with excitation of its acoustic diaphragm controlled electronically by sensors which measure its resonance frequency.

In this electromechanical horn, which is provided with an acoustic diaphragm able to undergo movements induced in it by variable magnetic fields generated by an electromagnet, the electromagnet which operates the diaphragm is excited by frequencies generated by an electronic oscillator which are based on the value of the maximum diaphragm resonance frequency measured by a specific sensor.
ELECTROMECHANICAL HORN WITH EXCITATION OF ITS ACOUSTIC DIAPHRAGM CONTROLLED ELECTRONICALLY BY SENSORS WHICH MEASURE ITS RESONANCE FREQUENCY

This invention relates to the field of electromechanical resonance devices for sound generation, and particularly to high-sounding horns for vehicles, trains and boats.

Sound generating devices of the electromechanical excitation type currently consist of:
- a resilient steel diaphragm carrying in its centre the mobile part of an electromagnet;
- an electric switch with a normally closed contact connected in series with the power feed to the electromagnet;
- an adjustment screw which determines the switch contact opening point;
- a diffuser which resonates at the same frequency as the metal diaphragm.

When the electromagnet is electrically fed, it attracts the mobile part rigid with the resilient diaphragm. When the diaphragm has nearly attained its maximum travel, the switch connected in series with the electromagnet coil is opened by a push rod operated by the mobile part of the electromagnet.

At this point, the mobile part of the electromagnet and the diaphragm on which it is fixed continue their travel by inertia until their kinetic energy has been completely absorbed elastically; beyond this point, the elastic energy accumulated by the diaphragm is restituted by reaction with the fixed structure to which it is connected, so that the diaphragm reverses its direction of movement. In this manner it again closes the switch which, again exciting the electromagnet, causes the diaphragm to commence a new oscillation cycle at a frequency equal to the resonance frequency of the electromechanical system.

These normal switch devices have considerable drawbacks, which can be summarised as follows:
- As the sound output of the horn depends on the time at which the switch operates, it is difficult to obtain maximum sound output because of the difficulty of fixing or adjusting the switch operation point;
- The sound output is subject to considerable fall-off with time due to the mechanical instability of the switch operation points;
- The switch contacts are subject to sparking which causes them to wear and lead to a variation in their time of operation;
- The contact sparking creates electromagnetic waves which can be troublesome to modern electronic systems currently in use, particularly in motor vehicles.

To obviate these drawbacks deriving from the switch, a different method of exciting the electromagnet has recently been conceived. More specifically, the magnetic vibration is obtained by electronic oscillators operating at a vibration frequency approximately equal to the resonance frequency of the electromagnetic system; with this method the oscillator output controls an electronic switch connected in series with the electromagnet coil, thus replacing the mechanically operated switch. However, even the use of this method has drawbacks which can be summarized as follows. Firstly, the generated frequency must be stabilised to make it independent of voltage variations; the generated frequency must also be acceptable to the variation in the diaphragm resonance frequency caused by variations in its temperature. A further serious drawback of this method is the cost involved in limiting the diaphragm production tolerances so that the resonance frequency of the diaphragms produced does not fall outside the limited tolerance range compatible with the constant frequency emitted by the electronic generator. This drawback is eloquently displayed by the reduction in sound output consequent on the variation in the mechanical vibration characteristics of the system, deriving from lengthy operation. Although when new the mechanical parts of the system have the same resonance frequency as the electronic oscillator, as they age they acquire a different frequency because of the fall-off in mechanical strength, the slack which occurs in the connections, the occurrence of wear and other reasons.

An object of the present invention is to provide a horn which dispenses with the mechanical switch, so obviating all the aforesaid drawbacks caused by it.

A further object is to provide a horn the sound of which derives from the generation of a diaphragm vibration induction frequency which is always the frequency creating maximum diaphragm resonance, independently of the variations in this latter deriving from any variation in the diaphragm dimensions, structure or fixing.

These and further objects which will be more apparent to experts of the art from a reading of the description and claims given hereinafter are attained by the following device:

An electromechanical horn provided with an acoustic diaphragm able to undergo movements induced in it by variable magnetic fields generated by an electromagnet, characterised in that the electromagnet which operates the diaphragm is excited...
by frequencies generated by an electronic oscillator which are based on the value of the maximum diaphragm resonance frequency measured by a specific sensor.

The invention is illustrated by way of non-limiting example on the accompanying drawings in which:

Figure 1 is a diagrammatic section showing the arrangement of the essential parts of the horn;

Figure 2 is an electrical schematic diagram showing the relationship between the essential parts;

Figure 3 is a block diagram showing the connection of the various parts.

With reference to the aforesaid figures, the metal container 1 forms the fixed part of the electromagnet, and carries fixed to the centre of its closed base 2 a ferromagnetic core 3 with the relative coil 4.

At the other end, this container is closed by a diaphragm 5 fixed in a particularly rigid manner about its entire edge, which is usually circular. The diaphragm 5 is usually of steel and has fixed to its central region a ferromagnetic core 6 forming the mobile part of the electromagnet.

The reference numeral 7 indicates a sensor for sensing the pressure variations induced in the air by the vibration of the overlying diaphragm 5.

This sensor, which in a certain sense could be called a "microphone", can obviously be of various types, as can normal microphones. It can thus, with suitable circuit modifications, be in the form of various types of electrical pressure transducers such as piezoresistive transducers, resistive transducers on an alumina substrate, or in the form of diaphragm position sensors such as Hall effect sensors and electromagnetic sensors.

Another possibility is to combine sensor elements and circuit elements into a single integrated circuit.

By way of example, the sensor could be of the piezo-ceramic type or capable of converting the occurring pressure variations into electrical potential variations.

The reference numeral 8 indicates the position of a power transformer, and 9 indicates the position of a power feed terminal. The reference numeral 10 indicates an insulating support for the electronic circuit and sensor.

On feeding the coil 4 from a voltage generator of variable frequency but constant amplitude, the mobile core 6 is caused to oscillate, as is the diaphragm rigid therewith, this having its maximum amplitude when the generated voltage has a frequency equal to the resonance frequency of the mobile resilient part 5, 6 of the device. The piezoelectric pressure sensor transforms the pressure variation generated in the air by the rapid movements of the diaphragm into variations in voltage, which is related directly to the amplitude, frequency and phase of its vibrations.

This sensor therefore assumes the electrical characteristics of a piezoceramic element resonating at the diaphragm frequency. When connected into the reaction circuit of an oscillator circuit, as shown in the schematic diagram of Figure 3, it generates a control signal for the coil 4 having a frequency equal to the resonance frequency of the sound-generating diaphragm 5.

If for the already listed reasons the diaphragm resonance frequency undergoes variation, this is automatically reflected in the frequency generated by the sensor 7 which in this manner can continue to cause the diaphragm to vibrate under maximum resonance conditions, ie maximum sound output. This therefore avoids the costly setting operations normally required by conventional horns.

With reference to the block diagram of Figure 3, A indicates a pressure sensor, B an oscillator circuit, C an impedance adaptor or a pulse width modifier circuit, D a pilot amplifier, E a solid state power switch, and F the control electromagnet for the acoustic diaphragm.

The electrical schematic diagram of Figure 3 shows the functions of the circuit elements to be used for constructionally optimising the invention.

The integrated circuit I.C.1 has a typical circuit configuration of a quartz-controlled oscillator. In place of this latter, the sensor 7 (piezoelectric transducer) is connected with the correct polarity for causing the oscillator circuit to resonate at the inherent resonance frequency of the sound-generating electromagnetic system.

The oscillator output is fed to the input of the impedance adaptor and current amplifier I.C.2 (in Figure 2), the output of which controls the final power circuit consisting of the transistors Q1 and Q2, to then control the horn coil 4 or solenoid. This particular transistor circuit configuration is provided to reduce the power dissipated by Q2 to a minimum, and at the same time to allow its heat dissipation. This is obtained by connecting the collector (in common with the cooling fin) directly to the metal container 1 of the horn T, which is provided with a resonant diffuser R (Figure 1).

In other circuit versions, I.C.2 can be replaced by a pulse width modulator, so as to obtain sound tone modulation.

**Claims**

1. An electromechanical horn (T) provided with an acoustic diaphragm (5) able to undergo movement induced in it by variable magnetic fields
generated by an electromagnet (3, 4, F), characterised in that the electromagnet which operates the diaphragm is excited by a frequency generated by an electronic oscillator (B) which is based on the value of the maximum resonance frequency of the diaphragm (5) measured by a specific sensor (7, A).

2. An electromechanical horn as claimed in the preceding claim, characterised by a circuit (I.C.2) connected between the sensor (A, 7) and the power circuit (Q1, Q2) for controlling the electromagnet, for the purpose of providing amplitude, phase and half-period modulation of the signal delivered by the sensor in order to obtain different sound tones from the diaphragm (5).

3. An electromechanical horn as claimed in the preceding claims, characterised by a configuration of the final electromagnet control circuit which allows the dissipation element of the final power transistor to be connected directly to the metal support for the diaphragm or horn body.