MICROPHONE COMBINATIONS OF THE KIND
COMPRISING A PLURALITY OF DIRECTIONAL
SOUND UNITS

Derk Kliks and Wilhelmina Hermans Iding, Emmasingel,
Eindhoven, Netherlands, assignors to North American
Phillips Company Inc., New York, N.Y., a corporation
of Delaware

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ABSTRACT OF THE DISCLOSURE

A microphone system in which the output of two
groups of microphones are combined with opposite
polarity in a frequency range below a predetermined fre-
cquency, and are combined with the same polarity in the
frequency range above the predetermined frequency.

The invention relates to a microphone combination
comprising a plurality of sound units arranged at a small
distance from each other each of the sound units being
connected through filter elements to a common output
and formed by one or more microphones.

It is known to obtain a given directional characteristi-
in a microphone by causing the sound field to act upon
both sides of the diaphragm, either directly with a time
difference determined by the dimensions of the micro-
phone and the direction of the incident sound (pressure
gradient microphone) or by providing, in addition, on
one side of the diaphragm an acoustical network
(cardioid microphone). The microphones of the last-
mentioned type may be considered to be a combination
of an omnidirectional pressure-gradient microphone and
a pressure gradient microphone with an eight-shaped di-
rectional characteristic. The directional characteristic
thus obtained is, in principle, independent of the fre-
cquency as long as the dimensions of the microphone are
small with respect to the wavelength.

It is furthermore known to obtain a sound receiver
with a given directional characteristic by choosing a
sound receiving surface which is larger than the wave-
length. Examples thereof are a microphone with a para-
bolic mirror, a microphone with an acoustic lens, a
microphone with a transit time tube and a combination
of microphones arranged in line with each other (micro-
phone column) or in one plane, said microphones co-
operating in phase. The directional characteristic of these
sound receivers depends upon the frequency and becomes
sharper with an increasing frequency. The directional
effect starts at the frequency, at which the wavelength
is of the same order as the dimensions of the receiver,
that is to say that such microphones, operating on the
interference principle, are not very effective for the low
tones as directional microphones, unless the dimensions
are very large.

Apart from said interference microphones there are
known difference microphones which are composed of
two or more microphone systems, which may be con-
ected with opposite polarities. Such a device is de-
scribed in American patent specification 2,301,744.

In contrast to interference microphones, which have
maximum sensitivity for that direction of the sound at
which the individual microphone systems receive the
sound in phase, the sensitivity of a difference microphone
will just be zero under these conditions.

For all further directions the difference microphone,
also termed higher-order microphone, exhibits a fre-
quency characteristic curve rising by 6 db/octave up to
that frequency at which half the wavelength is equal to
the distance between the microphones. With higher fre-
cquencies the frequency characteristic has a sequence
of peaks and valleys.

The invention is characterized in that by means of the
filter elements the microphone combination operates on
the interference principle above a separation frequency
\( f \) between high and low tones, whereas below said frequency
\( f \) it operates on the interference principle. The invention
has for its object to combine the advantages of the two
principles described above, so that with small dimensions
of the microphone combination a very satisfactory direc-
tional characteristic of linear course from low to high
notes can be obtained both for low frequencies and for
high frequencies.

In the microphone combination described in American
patent specification 2,301,744 separate microphones are
arranged one behind the other. The frequency characteris-
tic for high notes exhibits a wave-like variation.

By arranging the sound units side by side instead of
arranging them one after the other, this wave-like varia-
tion does no longer appear, whilst this arrangement is
particularly suitable for operation on the interference
principle at high notes, which is not possible with an
arrangement of the units one after the other.

A microphone combination according to the invention
comprises two sound units \( M_1 \) and \( M_2, M_3 \) being arranged
centrally and \( M_4 \) symmetrically around \( M_1 \).

It is characterized in that below the separation fre-
cquency \( f_0 \) the output signals of \( M_1 \) and \( M_2 \) are joined
with such amplitudes and opposite polarities so that in
the direction of the height of the region of \( M_1 \) the sensi-
tivity of the microphone combination is zero, while the
output signals of \( M_1 \) and \( M_3 \) have furthermore joined to
them the output signal of \( M_4 \) in a given ratio and below
the frequency \( f_0 \) the output signals of \( M_1 \) and \( M_2 \) are
combined independently of frequency.

This means, in fact, that two directional characteris-
tics are subtracted, for example an eight-shaped charac-
teristic and an omnidirectional characteristic, so that one
or more extinctions are produced laterally, which has
the advantage that the microphone combination is in-
sensitive for ambient sound in a wide range.

In a further embodiment of the invention the micro-
phones of each sound unit are connected with equal
polarities and this permits of changing over the sound units so
that they form together a single column.

In an advantageous embodiment of the invention the
output signals of the sound units \( M_1 \) and \( M_2 \) are con-
ected by a filter prior to the said addition, the frequency
characteristic of said filter being inversely proportional
to the square of the frequency lying between a given low
frequency \( f_1 \) and the separation frequency \( f_0 \).

The frequency characteristics of \( M_1 \) and \( M_2 \) combined
in the preferential direction, are thus equalised to that of
\( M_1 \) alone.

By varying the amplitude of the added signal of the
sound unit \( M_2 \) the direction in which the sensitivity of
the microphone combination is zero, can be varied.

When use is made of unilaterally sensitive microphones,
which are directionally so that their preferential directions
coincide, the directional characteristic of the combination
is again multiplied by that of the individual microphone.

The invention will be described more fully with refer-
tence to the drawings.

FIGS. 1—11 illustrate various arrangements of micro-
phone units which may be used in the system of the inven-
tion; and

FIG. 12 is a circuit diagram showing the interconne-
tion of microphone units to a common output circuit according to the invention. Referring now to FIGS. 1 and 2, therein is illustrated a microphone arrangement in which cardiodi microphone units are aligned in side-by-side relationship. Each microphone is indicated by a circle. The plus or minus sign in each circle indicates the polarity of the microphone, i.e., the polarity with which it is connected in a circuit. An arrow pointing away from a circle indicates the direction of maximum sensitivity of the microphone. When a circle is shown without an arrow, it is considered that the direction of maximum sensitivity of the corresponding microphone is normal to the plane of the drawing.

FIGS. 1 and 2 thus show two views of a microphone arrangement having three cardiodi microphones. As shown in FIG. 2, which may be considered to be a top view of the arrangement, the direction of maximum sensitivity of all microphones is the same (i.e., toward the left) and the microphones are aligned in one plane. The view at FIG. 1, which may be considered to be a side view, shows that the microphones are also aligned in a second plane. The microphone in the center, with the positive polarity, is considered to be one microphone group or unit M1, and the two outside microphones with negative polarity are considered to be another group or unit M2.

As shown in FIGS. 3 and 4, which also illustrate two views of a microphone arrangement, the arrangement of FIG. 1 may be modified to include additional microphones, so that the central group M1 includes two microphones and the outside group M2 includes four microphones on each side of the M1 group, for a total of eight microphones.

The arrangement of FIGS. 3 and 4 may be modified, as shown in FIGS. 5 and 6 (which also shows two views of a microphone arrangement) so that the microphones are aligned in the side view, but along a curved line as shown in the top view.

In a further microphone arrangement as shown in the side view of FIG. 7, a single microphone comprising group M1 may be surrounded by four microphones of the M2 group. This arrangement may be modified, as shown in FIG. 8, wherein the central group M1 comprises eight microphones equally spaced about a central microphone, for a total of 9, while the M2 group comprises three microphones extending radially outwardly from each of the eight equally-spaced microphones of the M2 group, for a total of 24 microphones.

FIGS. 9-11 also show several arrangements of microphones for an omnidirectional system. In FIGS. 9 and 10 three nondirectional microphones are shown aligned in two directions, with the microphone in the center comprising the M1 group and the two outside microphones comprising the M2 group. In FIG. 11, five directional microphones are provided in a line, with the central microphone comprising the M1 group and the four outside microphones, having different directions of maximum sensitivity, comprising the M2 group.

In each of the arrangements of FIGS. 1-11, the microphones of each group are connected together.

Referring now to FIG. 12, therein is illustrated a circuit for combining the output signals of the microphone groups according to the invention. The output signals of the two groups of microphones M1 and M2 are combined so that for frequencies below a separation frequency of, for example, 1500 cycles per second, the signals are combined so that the system operates on the difference principle. For frequencies above the separation frequency, the signals are combined so that the system operates on the interference principle.

In the system of FIG. 12, the outputs of the two groups M1 and M2 of microphones are combined in amplifiers 1 and 2 respectively, and applied to opposite ends of a potentiometer 6 by way of resistors 3 and 4 respectively, and the combined signal appearing at the arm of the potentiometer 6 is applied by way of RC filter 6, 7 to an amplifier 8. The output of the amplifier 8 is connected to a RC filter 9, 10. As indicated by the polarity signs, the microphones M1 and M2 and at the outputs of the amplifiers, the signal at the arm of the potentiometer 6, and hence at the output of filter 9, 10, is a difference signal from the microphones of the two groups.

The signal from amplifier 2 is also applied by way of an adjustable series variable resistor 12 and shunt resistor 13, to an inverting amplifier 14. The outputs of the RC filter 9, 10, and the output of the amplifier 14, and applied in combination to the input of a low-pass filter 23, 24, by way of separation resistors 11 and 26 respectively. The output of the low pass filter 23, 24 is applied by way of resistor 25 to the output terminals 30, 31.

The output of the inverter 14 is also applied to input of an amplifier 19 by way of an adjustable potentiometer circuit consisting of series adjustable resistor 15 and shunt resistor 16, and the output of amplifier 19 is also applied by way of a series resistor 17 and shunt resistor 18. The output of amplifier 19, is applied by way of high pass filter 20, 21 to the output terminals 30, 31. The signal appearing at the output terminals due to this part of the circuit is thus the sum of the outputs of the microphones M1 and M2 in a frequency range above the cut-off frequency of high pass filter 20, 21.

What is claimed is:

1. A microphone combination of the type comprising a plurality of sound units of one or more microphones arranged at a small distance from each other and connected through filter elements to a common output, comprising first means for combining the outputs of first and second of said sound units with opposite polarity, low-pass filter means for applying the output of said first means to said common output, second means for combining the outputs of said first sound units with the same polarity, and high-pass filter means for applying the output of said second means to said common output, whereby the microphone combination operates on the interference principle in excess of a separation frequency between high and low notes, whereas below said frequency it operates on the difference principle.

2. A microphone combination as claimed in claim 1, characterized in that the sound units are arranged side by side in a uniformly curved line or in a plane.

3. A microphone combination as claimed in claim 1, characterized in that the microphone of each sound unit is connected with the same polarity.

4. A microphone combination as claimed in claim 1, characterized in that the individual microphones are unilaterally sensitive microphones, which are positioned so that their preferential directions coincide.

5. A microphone system comprising a plurality of closely spaced-apart microphones and means for connecting said microphone by way of first and second channels to a common output circuit, said first channel comprising first filter means for passing signals only less than a predetermined frequency and means for combining said microphones with opposite polarity to provide a difference signal output, said second channel comprising second filter means for passing signals only above said predetermined frequency, and means for combining the signal outputs of said microphones with the same polarity to provide an interference signal output.

6. A microphone system comprising a plurality of closely spaced-apart microphones arranged to form first and second microphone groups, an output circuit, first channel means for connecting the outputs of said first and second groups with opposite polarity and applying the combined signal output thereof to said output circuit, second channel means for combining the outputs of said first and second groups with the same polarity and applying the combined signal output thereof to said output circuit, said first and second channel comprising filter means for passing signals only below a predetermined frequency and said second chan-
anel comprising means for passing signals only above said predetermined frequency, whereby said microphone system operates on a difference principle below said predetermined frequency and on an interference principle above said predetermined frequency.

7. The system of claim 6, in which microphones of said first and second groups are in the same plane, and said microphones of said second group surround those of said first group.

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R. P. TAYLOR, Assistant Examiner.