

[54] **SIGNAL CONVERSION APPARATUS**
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Related U.S. Application Data

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[51] Int. Cl. **G101 1/00**
[58] Field of Search **179/1 SA, 1 SB, 15.55 R, 179/15.55 T**

[56] **References Cited**
UNITED STATES PATENTS

3,322,891 5/1967 Kalfaian 179/1 SA
3,622,706 11/1971 Kalfaian 179/1 SA

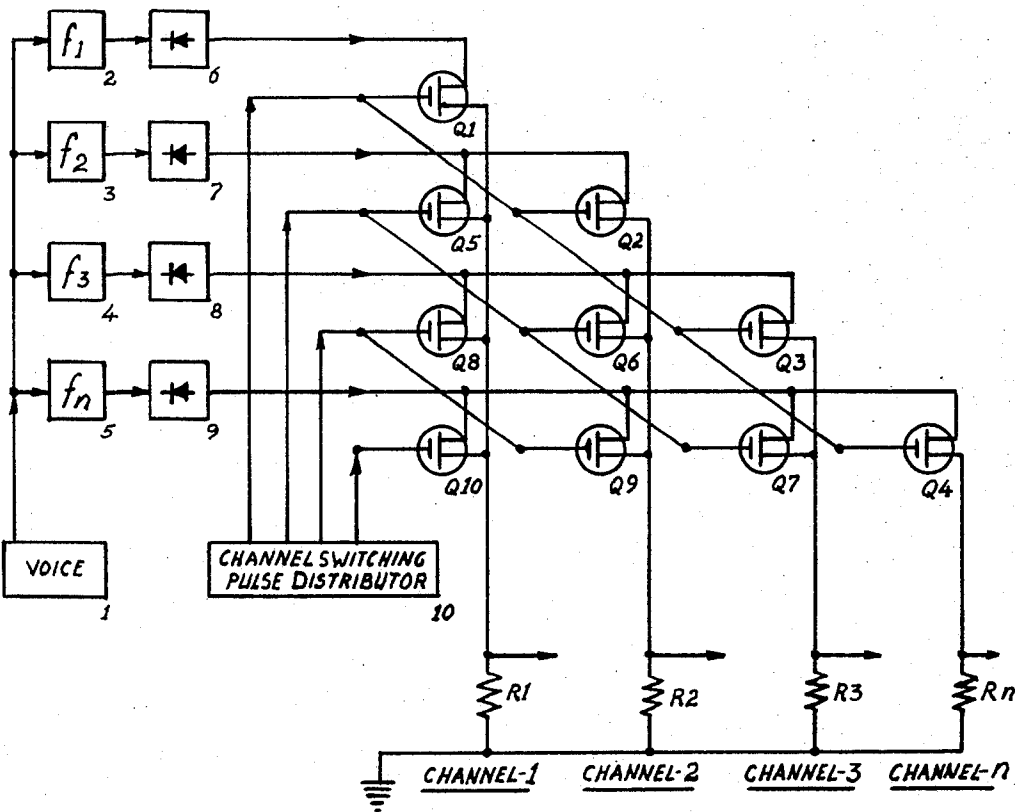
3,659,051 4/1972 Kalfaian 179/1 SA
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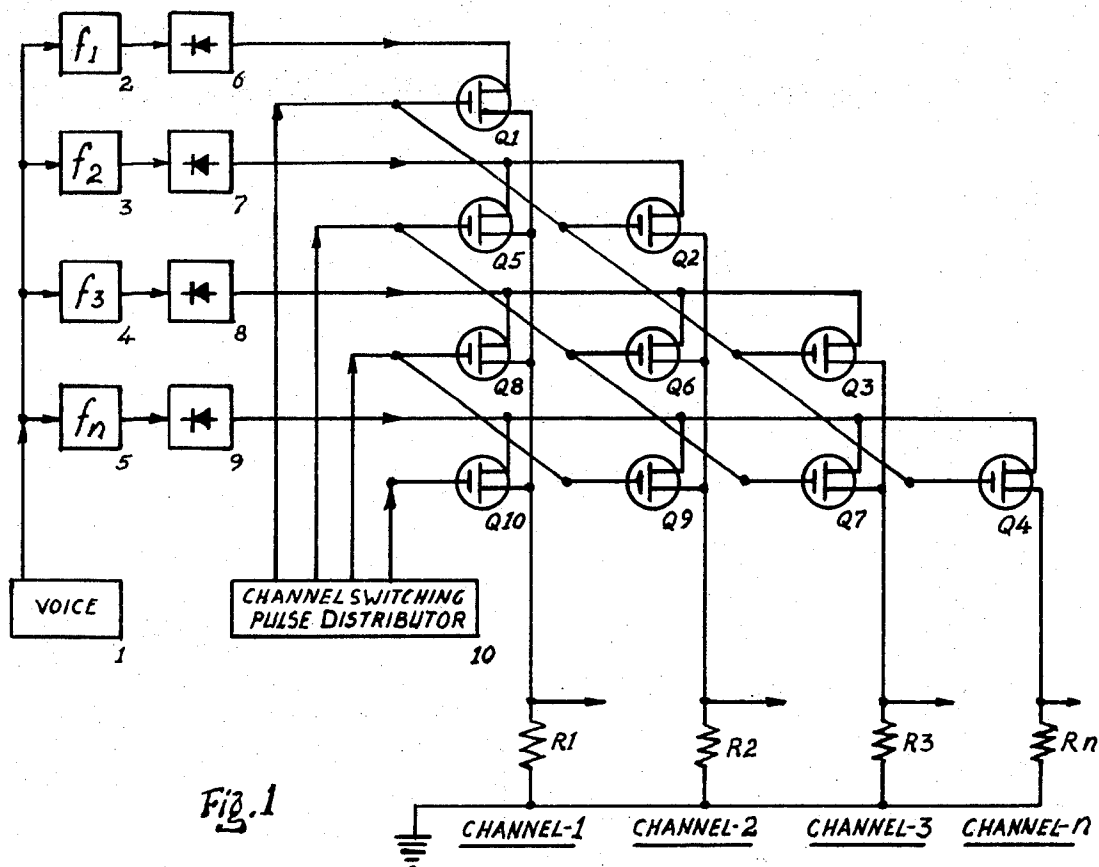
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[57] **ABSTRACT**

Identification of complex signals such as a specific phoneme spoken by different speakers is accomplished by analyzing and normalizing the spoken phoneme's group of frequencies (formants) to a standard group, while maintaining the original harmonic-ratio information as channel number differences. A set of filters followed by rectifiers, to an electronic switching matrix, shifts the original filter output set through sequential sets of channels until the fundamental frequency at some input channel activates the lowest numbered output channel.

2 Claims, 4 Drawing Figures





1 f_1	39 Hz	39 f_{39}	349 Hz	77 f_{77}	3,136 Hz
2 f_2	41 Hz	40 f_{40}	370 Hz	78 f_{78}	3,322 Hz
3 f_3	44 Hz	41 f_{41}	392 Hz	79 f_{79}	3,520 Hz
4 f_4	46 Hz	42 f_{42}	415 Hz	80 f_{80}	3,730 Hz
5 f_5	49 Hz	43 f_{43}	440 Hz	81 f_{81}	3,951 Hz
6 f_6	52 Hz	44 f_{44}	466 Hz	82 f_{82}	4,186 Hz
7 f_7	55 Hz	45 f_{45}	494 Hz	83 f_{83}	4,434 Hz
8 f_8	58 Hz	46 f_{46}	523 Hz	84 f_{84}	4,698 Hz
9 f_9	62 Hz	47 f_{47}	554 Hz	85 f_{85}	4,978 Hz
10 f_{10}	65 Hz	48 f_{48}	587 Hz	86 f_{86}	5,274 Hz
11 f_{11}	69 Hz	49 f_{49}	622 Hz	87 f_{87}	5,588 Hz
12 f_{12}	73 Hz	50 f_{50}	659 Hz	88 f_{88}	5,920 Hz
13 f_{13}	78 Hz	51 f_{51}	698 Hz	89 f_{89}	6,272 Hz
14 f_{14}	82 Hz	52 f_{52}	740 Hz	90 f_{90}	6,644 Hz
15 f_{15}	87 Hz	53 f_{53}	784 Hz	91 f_{91}	7,040 Hz
16 f_{16}	92 Hz	54 f_{54}	831 Hz	92 f_{92}	7,460 Hz
17 f_{17}	98 Hz	55 f_{55}	880 Hz	93 f_{93}	7,902 Hz
18 f_{18}	104 Hz	56 f_{56}	932 Hz	94 f_{94}	8,372 Hz
19 f_{19}	110 Hz	57 f_{57}	988 Hz	95 f_{95}	8,868 Hz
20 f_{20}	116 Hz	58 f_{58}	1,046 Hz	96 f_{96}	9,396 Hz
21 f_{21}	123 Hz	59 f_{59}	1,109 Hz	97 f_{97}	9,956 Hz
22 f_{22}	131 Hz	60 f_{60}	1,175 Hz	98 f_{98}	10,548 Hz
23 f_{23}	139 Hz	61 f_{61}	1,244 Hz	99 f_{99}	11,176 Hz
24 f_{24}	147 Hz	62 f_{62}	1,318 Hz	100 f_{100}	11,840 Hz
25 f_{25}	156 Hz	63 f_{63}	1,397 Hz		
26 f_{26}	165 Hz	64 f_{64}	1,479 Hz		
27 f_{27}	175 Hz	65 f_{65}	1,567 Hz		
28 f_{28}	185 Hz	66 f_{66}	1,661 Hz		
29 f_{29}	196 Hz	67 f_{67}	1,760 Hz		
30 f_{30}	208 Hz	68 f_{68}	1,865 Hz		
31 f_{31}	220 Hz	69 f_{69}	1,975 Hz		
32 f_{32}	233 Hz	70 f_{70}	2,093 Hz		
33 f_{33}	247 Hz	71 f_{71}	2,217 Hz		
34 f_{34}	262 Hz	72 f_{72}	2,349 Hz		
35 f_{35}	277 Hz	73 f_{73}	2,489 Hz		
36 f_{36}	294 Hz	74 f_{74}	2,637 Hz		
37 f_{37}	311 Hz	75 f_{75}	2,794 Hz		
38 f_{38}	330 Hz	76 f_{76}	2,960 Hz		

Fig. 2

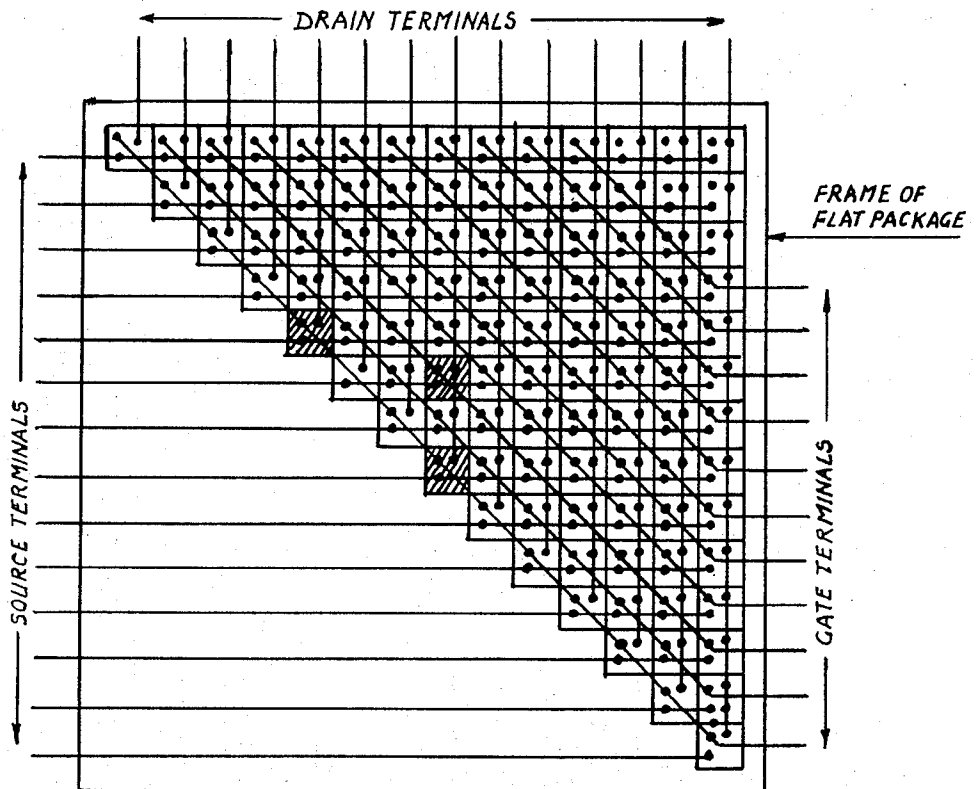


Fig. 4

SIGNAL CONVERSION APPARATUS

This is a continuation of application Ser. No. 235,943, filed Mar. 20, 1972.

This invention involves the identification of complex signals such as a specific phoneme spoken by different speakers. The basic problem, for example, may be that of recognizing a phoneme spoken in a low-pitched voice, and the same phoneme in a higher-pitched voice. It is well-known that a specific phoneme is a complex wave consisting of harmonically related frequency peaks, or resonances. Thus, it is well known that normalizing any arbitrarily pitched phoneme to a standard pitch set of harmonic frequencies representing the phoneme may simplify the recognition process. Such normalizing to a standard configuration may be accomplished by various forms of signal conversion systems.

This invention relates to signal conversion systems, and more particularly to a novel filter plus switching arrangement for regrouping (shifting) randomly originated complex signals to a reference grouping for simpler processing in a recognition device, for example, speech sound waves, voice print waves, sonar target waves, and so on.

Thus the particular arrangement disclosed herein is contemplated as being sufficiently versatile for a wide scope of uses, as will be apparent from the following specification in conjunction with the accompanying drawings, wherein:

FIG. 1 is a partly block and partly schematic diagram of the invention;

FIG. 2 shows the special center frequency sub-divisions of the pass-band filters, as used in the present invention;

FIG. 3 is a numerical chart showing how the detected signal outputs of the pass-band filters are switched linearly to the outputs of the numerically arranged channels in accordance with the present invention; and

FIG. 4 shows how a plurality of and-gates (analog switches) can be physically oriented on a planar surface for simple interconnections of terminals for the required switching arrangement.

In order to obtain high accuracy of signal regrouping without causing any cross switching of the input signal to the channel outputs, the center frequencies of the sub-dividing pass-band filters are arranged as in FIG. 2, wherein the sub-divisions are similar to the standard musical scale. In this arrangement, it will be noted that the sub-divisions are arranged in a series of digitals at like intervals in harmonic successions corresponding to the digitals in preceding intervals. Thus, the numerical ratios of the numerals from the second through the thirteenth numerals with respect to the first numeral is the same as the numerical ratios of the fourteenth through the twentieth numeral with respect to the thirteenth numeral, as exemplary demonstration. Such a numerical arrangement simplifies the actual channel switching arrangement, because it requires linearly sequenced numerical transfer without cross coupling of any of the pass-band outputs, such as would be by the arrangement of pass-band center frequencies of the filters shown in FIG. 11, and the chart of switching combinations in FIG. 12 of my related U.S. Pat. No. 3,622,706 issued Nov. 23, 1971. This is shown in greater clarity by the numerical chart in FIG. 3, wherein the top row of the numerals represent the channels, and the rows of numerals below represent the sequence of the numerals left hand of the sub-band frequencies in FIG. 2. For ex-

ample, in the first row (FIG. 3), all of the detected outputs of pass-band filters (starting from filter number-1) are applied to the inputs of the channels starting from channel number-1. In the second row, the detected filter outputs starting from the number-2 filter are applied to all of the channels starting from the channel number-1, and so on. As stated in the foregoing, such simplicity of switching sequence becomes inherently accurate, as long as the harmonic sequence at like intervals is considered in sub-dividing the sound spectrum, because the number of sub-band divisions and center frequencies of the pass-band filters may be arranged other than the frequencies shown in FIG. 2 without affecting the required accuracy.

Switching apparatus of FIG. 4

In reference to the chart shown in FIG. 3, it is apparent that the use of a large number of switching transistors is required for the switching performance. While multiple element channel switches in small packages of integrated circuits are available, it still will require large surface of printed circuit board with a large number of terminals to be soldered. Due to the simplicity of interconnecting design, however, a large number of these transistors, or any type of controllable semiconductors, may be integrated on a single wafer, such as shown in FIG. 4, wherein, each square represents the semiconductor as mentioned, three squares of which are shown in shaded lines in order to render them distinguishable in the maze of electrical connections. The connecting electrodes in each square are represented by the black dots to which are terminated the required parallel connections, as illustrated by the horizontal, vertical, and 45° parallel lines; the first representing the source electrode terminals, the second representing the drain terminals, and the third representing the gate electrode terminals of MOS FET transistors, although other types may also be used. Similarly, if enormously large number of transistors are to be deposited on a single wafer, it may be preferable to divide the arrangement of FIG. 4 into segments, in flat packages with connecting terminals attached thereto, so that the terminals of these segments may be connected externally for the complete assembly, as required.

Having described the details of parts for signal conversion of complex groups of signals, an exemplary system for signal conversion is shown in FIG. 1.

Signal conversion system of FIG. 1

I have described novel signal conversion systems in my related patents, for example, U.S. Pat. No. 3,622,706, U.S. Pat. No. 3,659,051, and copending applications Ser. Nos. 97,893 and 209,661, and reference may be made to these disclosures. However a simpler arrangement, in an exemplary form, may be described by way of the arrangement in FIG. 1, wherein the voice signals in block 1 are applied to the pass-band filters in blocks 2 through 5, for sub-dividing the sound spectrum band in the sequence of resonances, as shown in FIG. 2. The outputs of these pass-band filters are first detected in the blocks 6 through 9, respectively, and applied to the drain electrodes of switching transistors Q1 through Q4 (these switching transistors may also be termed as and-gates for the purpose contemplated herein, and therefore, the same terminology will also be used in the appended claims), respectively. The source electrodes of these transistors are connected to ground

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in series with the output resistors R1, R2, R3, and Rn, which represent the channel outputs for signal conversion of the arriving signals from the detected signals in blocks 6 through 9. In accordance with the numerical chart of FIG. 3, any one of the detected signals in blocks 6 through 9 may be coupled to the resistor R1 of channel-1. This is done by the additional transistors Q5, Q8, Q10, the source electrodes of which are all connected in parallel with the source electrode of Q1. Thus, when the first distributor pulse from the pulse distributor in block 10 is applied to the gate electrode of Q1 the detected signal of block 6 is admitted to the output resistor R1. When the second distributor pulse is applied to the gate electrode of Q5 the detected signal from block 7 is admitted to the output resistor R1. By such sequential pulse distribution to the gate electrodes of Q1, Q5, Q8, Q10, it is seen that any one of the detected outputs of the pass-band filters may be admitted to the resistor R1 of the channel-1. By such example, similar signal transfers are made to the channel outputs across resistors R2, R3, and Rn, in the linear numerical order of the chart in FIG. 3, by the parallel connections of the gate electrodes of transistors Q1 through Q4; Q5 through Q7; and Q8-Q9, etc., as shown in the drawing. Thus, as the distributor in block 10 applies sequential pulses to the parallel connected gate electrodes, as shown, the detected signals in blocks 6 to 9 are sequentially transferred to the channel outputs in the signal regrouping combinations of the chart in FIG. 3. During this sequence, one of the signal regrouping combinations at the channel outputs may represent the desired information, which may be decoded, or used, for any particular purpose that may be desired.

While the arrangement of FIG. 1 is given in an exemplary form, showing how signal conversion may be accomplished by the novel transistor arrangements of FIGS. 1 and 4, reference may be made to my disclosures in my reference patents for greater details of these signal conversion systems, because the gating functions of these transistors in the arrangement of FIG. 1 and FIG. 4 is contemplated for a wide scope of uses, and accordingly, both the arrangements and specific parts that I have mentioned in exemplary form may vary without departing from the true spirit and scope of the invention.

What I claim, is:

1. The system normalizing spectral variations of a group of information-bearing harmonically related frequency peak resonances in a complex sound wave by converting and standardizing the channel-location identities of said resonances, the system comprising a plurality of band-pass filters for separating the resonances of said complex wave in divisions such that the center frequency of said filters are arranged in a monotonically increasing series of frequencies; said series comprising a plurality of sub-series, all sub-series having the same number of channels such that each frequency in a sub-series is harmonically related to the

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same-placed frequency in the other sub-series; said filters being numbered sequentially for identity from the reference numeral one; a plurality of detectors for deriving detected signals from said band-pass filters, said detectors having numerical identities the same as the associated filters; a signal conversion switching arrangement comprising a plurality of input and output channels numbered sequentially, said switching comprising a plurality of AND-gates numerically identified from a reference numeral; first parallel connections of the first inputs of the corresponding AND-gates to corresponding input channels, second inputs of corresponding AND-gates to corresponding channel-switching control-gate inputs, third parallel connections of the outputs of corresponding AND-gates to corresponding output channels; coupling means from said detectors to corresponding first inputs of AND-gates; means for energizing said parallel-connected second inputs sequentially for said signal-switching conversion, all input channels being switched simultaneously to sequentially lower-number channels, until said group of detected signals are admitted to the output channels in an order such that the detected signal having the lowest numerical identity within the input group of signals is switched to the output channel having said reference numeral one, while the other detected signals of the input group are switched to corresponding output channels, such that the information concerning input frequency harmonic ratios is maintained relative to the input fundamental frequency, and thereby having input channels to a normalized group of output channels.

2. Apparatus in the system as set forth in claim 1, wherein said plurality of AND-gates in each of said channels consist of semiconductor devices, each device having first and second electrodes for forming electrical conductive path therebetween, and a third electrode for controlling the resistance of said conductive path, and said devices are assembled in numerically identified plurality of rows in linear numerical successions from a reference numeral, in each of said rows said devices being identified numerically in linear numerical successions from said reference numeral, and said devices being numerically aligned in the assembly; first parallel connections of the first electrodes of the numerically corresponding devices in said parallel rows, respectively, for forming said first inputs of said channels; second parallel connections of the third electrodes of the numerically identified devices in the numerically succeeding rows with that of the third electrodes of the numerically succeeding devices from the numerically corresponding devices in the numerically preceding rows, respectively, for forming said second inputs of said channels; and third parallel connections of the second electrodes of the numerically identified devices in said rows, respectively, for forming said channel outputs.

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