# Strange Brew - Musical Instrument Patents through the ages

Mark Kahrs
Currently visiting Musical Acoustics Group
University of Edinburgh

Talk outline

1. Introduction

2. What are patents?

3. How to read a patent

4. Musical Instrument Patents

   (a) Electric guitars

   (b) Physical modeling

5. Patent Research

6. Conclusion

Introduction to patents - Why should you care?

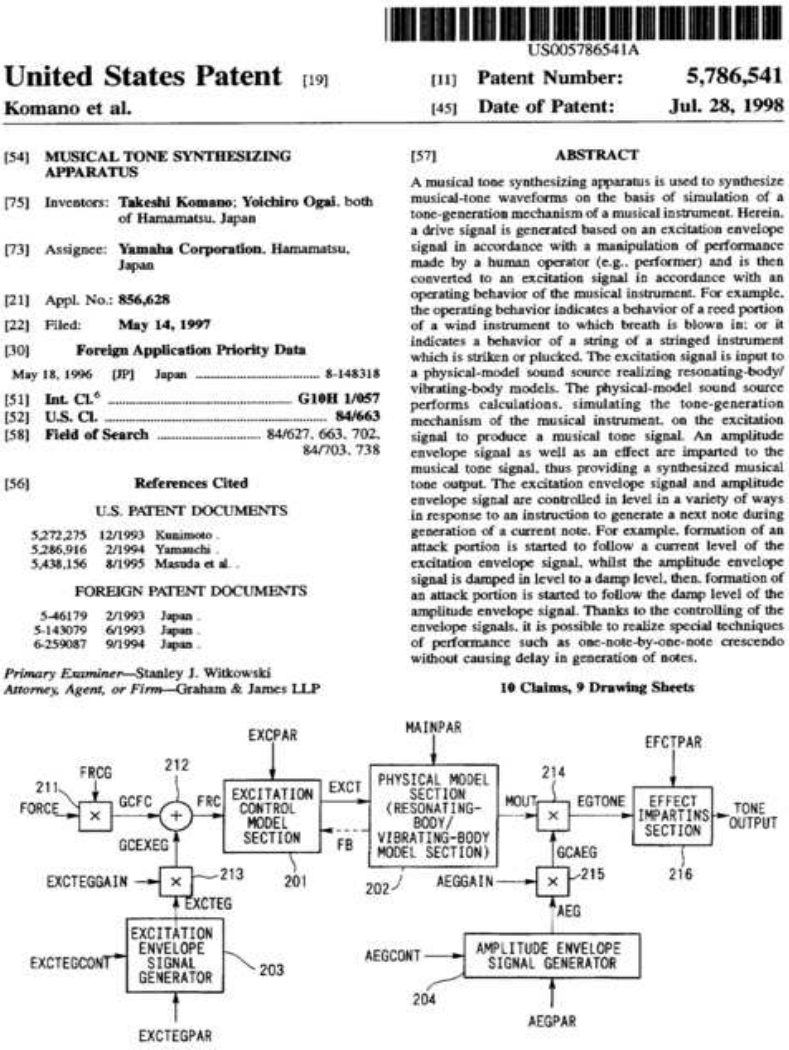
- Unheralded method of publication
  - Some companies don't publish (Yamaha)
  - Very popular in audio
- Patents can be money (ask CCRMA)
- Patent rights can be traded
- Can be entertaining
- Illustrate technological history

What are patents?

- Legally grant exclusive rights to the *assignee* for a limited period of time
- Utility: Protect a practical concept/idea
- Design: Protect a specific implementation

How to read a US patent (new style)

1. Read the first page:
   (a) Title, inventor, assignee
   (b) Dates filed and granted
   (c) References to past patents
   (d) Abstract
   (e) Enticing figure
2. Skim the figures
3. Read the body: Explanation (refer back to figures)
4. Legally concerned? Read the claims



US005786541A

**United States Patent** [19]
**Komano et al.**

[11] **Patent Number: 5,786,541**
[45] **Date of Patent: Jul. 28, 1998**

[54] **MUSICAL TONE SYNTHESIZING APPARATUS**


[75] Inventors: **Takeshi Komano**; **Yoichiro Ogai**, both of Hamamatsu, Japan

[73] Assignee: **Yamaha Corporation**, Hamamatsu, Japan



[21] Appl. No.: **856,628**

[22] Filed: **May 14, 1997**

[30] **Foreign Application Priority Data**

May 18, 1996 [JP] Japan ..... 8-148318

[51] **Int. Cl.**[6] ..... **G10H 1/057**

[52] **U.S. Cl.** ..... **84/663**

[58] **Field of Search** ..... 84/627, 663, 702, 84/703, 738



[56] **References Cited**

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5,272,275 12/1993 Kunimoto .
5,286,916 2/1994 Yamauchi .
5,438,156 8/1995 Masuda et al. .

FOREIGN PATENT DOCUMENTS

5-46179 2/1993 Japan .
5-143079 6/1993 Japan .
6-259087 9/1994 Japan .



*Primary Examiner*—Stanley J. Witkowski
*Attorney, Agent, or Firm*—Graham & James LLP



[57] **ABSTRACT**

A musical tone synthesizing apparatus is used to synthesize musical-tone waveforms on the basis of simulation of a tone-generation mechanism of a musical instrument. Herein, a drive signal is generated based on an excitation envelope signal in accordance with a manipulation of performance made by a human operator (e.g., performer) and is then converted to an excitation signal in accordance with an operating behavior of the musical instrument. For example, the operating behavior indicates a behavior of a reed portion of a wind instrument to which breath is blown in; or it indicates a behavior of a string of a stringed instrument which is striken or plucked. The excitation signal is input to a physical-model sound source realizing resonating-body/vibrating-body models. The physical-model sound source performs calculations, simulating the tone-generation mechanism of the musical instrument, on the excitation signal to produce a musical tone signal. An amplitude envelope signal as well as an effect are imparted to the musical tone signal, thus providing a synthesized musical tone output. The excitation envelope signal and amplitude envelope signal are controlled in level in a variety of ways in response to an instruction to generate a next note during generation of a current note. For example, formation of an attack portion is started to follow a current level of the excitation envelope signal, whilst the amplitude envelope signal is damped in level to a damp level, then, formation of an attack portion is started to follow the damp level of the amplitude envelope signal. Thanks to the controlling of the envelope signals, it is possible to realize special techniques of performance such as one-note-by-one-note crescendo without causing delay in generation of notes.


**10 Claims, 9 Drawing Sheets**



Utility patent: Yamaha physical modelling piano

- Inventors: Komano, Takeshi (Hamamatsu, JP), Ogai, Yoichiro (Hamamatsu, JP)

- Filing Date: 05/14/1997

- Publication Date: 07/28/1998

- Assignee: Yamaha Corporation (Hamamatsu, JP)

- Primary Class: 84/663

- US Patent References: 5272275 Dec, 1993 Kunimoto. ; 5286916 Feb, 1994 Yamauchi. ; 5438156 Aug, 1995 Masuda et al.

- Foreign References: 5-46179 Feb, 1993 JP. ; 5-143079 Jun, 1993 JP. ; 6-259087 Sep, 1994 JP.

# Abstract

A musical tone synthesizing apparatus is used to synthesize musical-tone waveforms on the basis of simulation of a tone-generation mechanism of a musical instrument. Herein, a drive signal is generated based on an excitation envelope signal in accordance with a manipulation of performance made by a human operator (e.g., performer) and is then converted to an excitation signal in accordance with an operating behavior of the musical instrument. For example, the operating behavior indicates a behavior of a reed portion of a wind instrument to which breath is blown in; or it indicates a behavior of a string of a stringed instrument which is striken or plucked. The excitation signal is input to a physical-model sound source realizing resonating-body/vibrating-body models. The physical-model sound source performs calculations, simulating the tone-generation mechanism of the musical instrument, on the excitation signal to produce a musical tone signal. An amplitude envelope signal as well as an effect are imparted to the musical tone signal, thus providing a synthesized musical tone output. The excitation envelope signal and amplitude envelope signal are controlled in level in a variety of ways in response to an instruction to generate a next note during generation of a current note...

## Patent class 84/663

```
1   DF   INSTRUMENTS {9}
600   DF   .~ Electrical musical tone generation {5}
647   DF   .~.~ Digital combinational circuit {7}
662   DF   .~.~.~ Expression or special effects {3}
663 .~.~.~.~ Envelope shaping (i.e., attack, decay, sustain, c
```


US00D484490S

(12) **United States Design Patent** (10) **Patent No.:** **US D484,490 S**
**Lewis** (45) **Date of Patent:** ** **Dec. 30, 2003**

(54) **LOUDSPEAKER**

(75) Inventor: **David Lewis**, Copenhagen (DK)

(73) Assignee: **Bang & Olufsen, S.A.**, Stuer (DK)

(**) Term: **14 Years**

(21) Appl. No.: **29/166,965**

(22) Filed: **Sep. 5, 2002**

(30) **Foreign Application Priority Data**

Jun. 26, 2002 (DK) ..... 2002 00524

(51) **LOC (7) Cl.** ..... **14-01**
(52) **U.S. Cl.** ..... **D14/216**
(58) **Field of Search** ..... D14/204, 207, D14/209–216, 356; 181/143–145, 147–148, 150, 153, 157, 198–199; 381/300–302, 306, 340–342, 345, 361–364, 386–388

(56) **References Cited**

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D230,997 S * 3/1974 Shannon ..... D14/211
D314,575 S * 2/1991 Wegner ..... D14/210
D334,750 S * 4/1993 Negishi et al. ..... D14/213
D376,364 S * 12/1996 Boothroyd et al. ..... D14/216
D409,617 S * 5/1999 Freadman ..... D14/215
D460,064 S * 7/2002 Solland ..... D14/207

* cited by examiner

*Primary Examiner*—Nanda Bondade

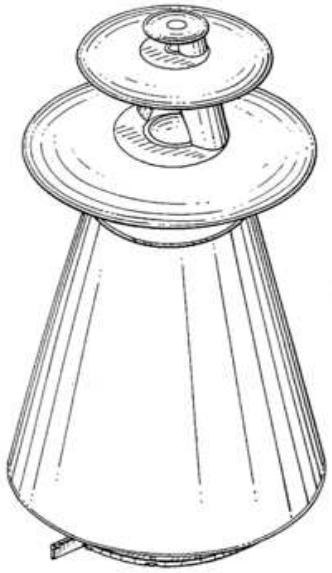
(57) **CLAIM**

I claim the ornamental design for the loudspeaker, as shown and described.

**DESCRIPTION**

FIG. **1** is a top right perspective view of the front of a loudspeaker of the present invention;
FIG. **2** is a top left perspective view of the rear thereof;
FIG. **3** is a front view thereof;
FIG. **4** is a rear view thereof;
FIG. **5** is a left side view thereof;
FIG. **6** is a right side view thereof;
FIG. **7** is a top view thereof; and,
FIG. **8** is a bottom view thereof.

**1 Claim, 7 Drawing Sheets**



Design patent example

## Electric Guitars

- Invented by Beauchamp & Rickenbacker in 1931 (filed in 1934, granted in 1937)

  Body resonance a problem

- Les Paul creates "The Log" (*not patented*)

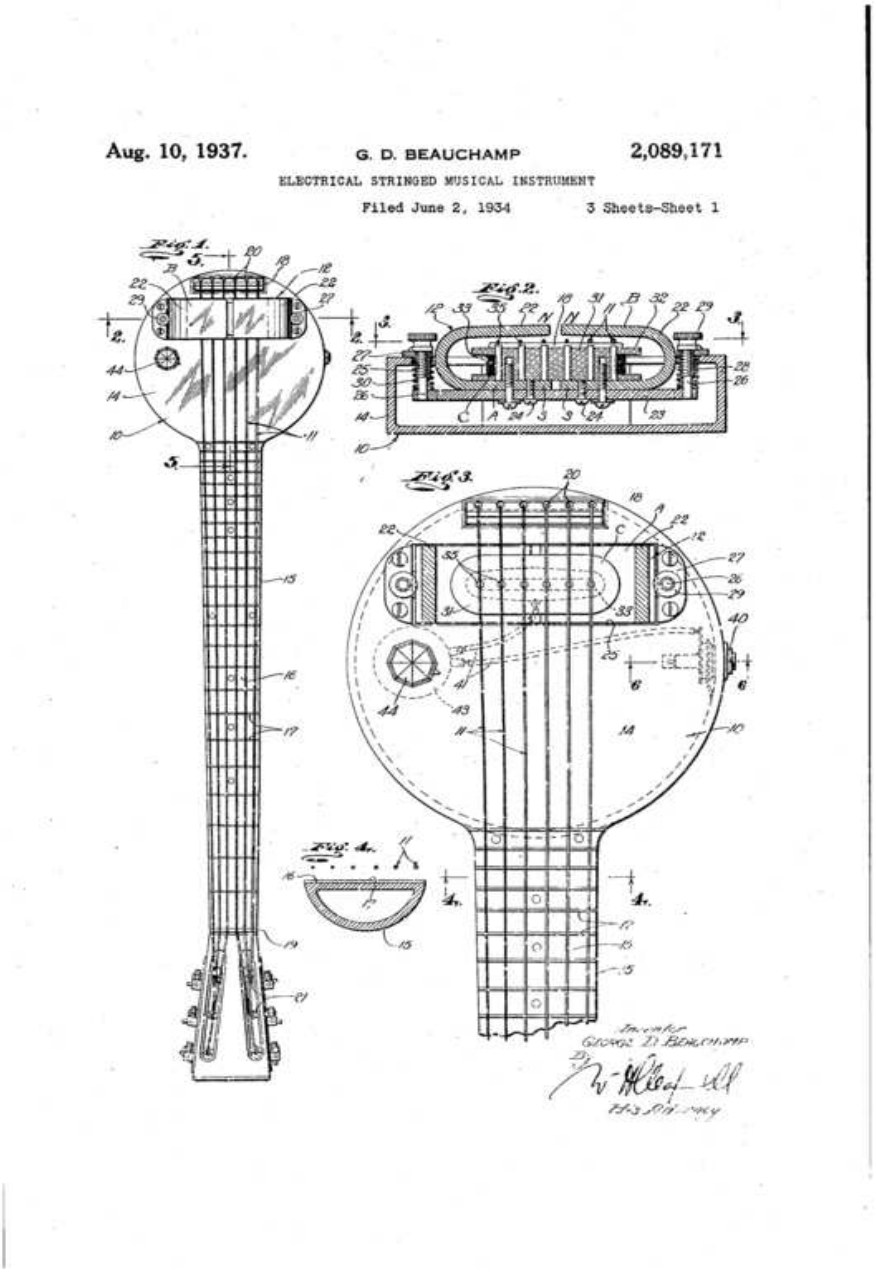
  A 4x4 post with two halves

- Leo Fender invents the solid body - 1943 (filed in 1944, granted in 1948)

- Theodore M. McCarty [Gibson] (with assistance from Les Paul) invents the electric acoustic - 1953 (filed in 1953, granted in 1955)

Electric Guitars: cont'd

- Fender invents the Stratocaster - 1954 (patent applied for 1958, granted in 1960)
- Fender invents the electric bass - 1954 (patent applied for 1958, granted in 1960)
- Seth Lover invents the humbucker - 1955


Aug. 10, 1937. G. D. BEAUCHAMP 2,089,171

ELECTRICAL STRINGED MUSICAL INSTRUMENT

Filed June 2, 1934 3 Sheets-Sheet 1

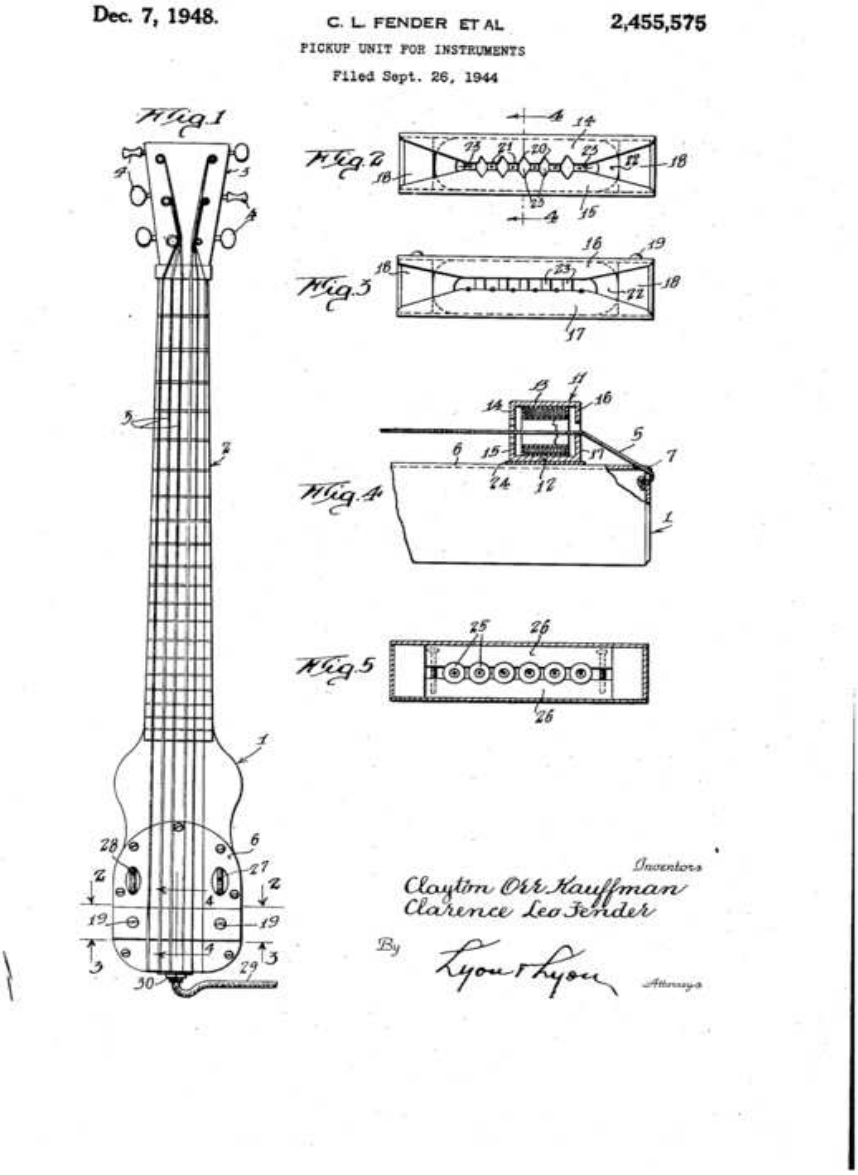
Beauchamp and Rickenbacker's "frying pan"

“Frying pan” claim

“A pick up unit for use with the vibratory strings of a musical instrument, including a permanent magnet, a coil supported by the magnet between its poles, means mounting the magnet to have the strings, and core members within the coil each having an end facing a string”

Les Paul creates a guitar

(but *doesn't* patent it!)


Dec. 7, 1948. C. L. FENDER ET AL 2,455,575

PICKUP UNIT FOR INSTRUMENTS

Filed Sept. 26, 1944

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Inventors
Claytim Orr Kauffman
Clarence Leo Fender

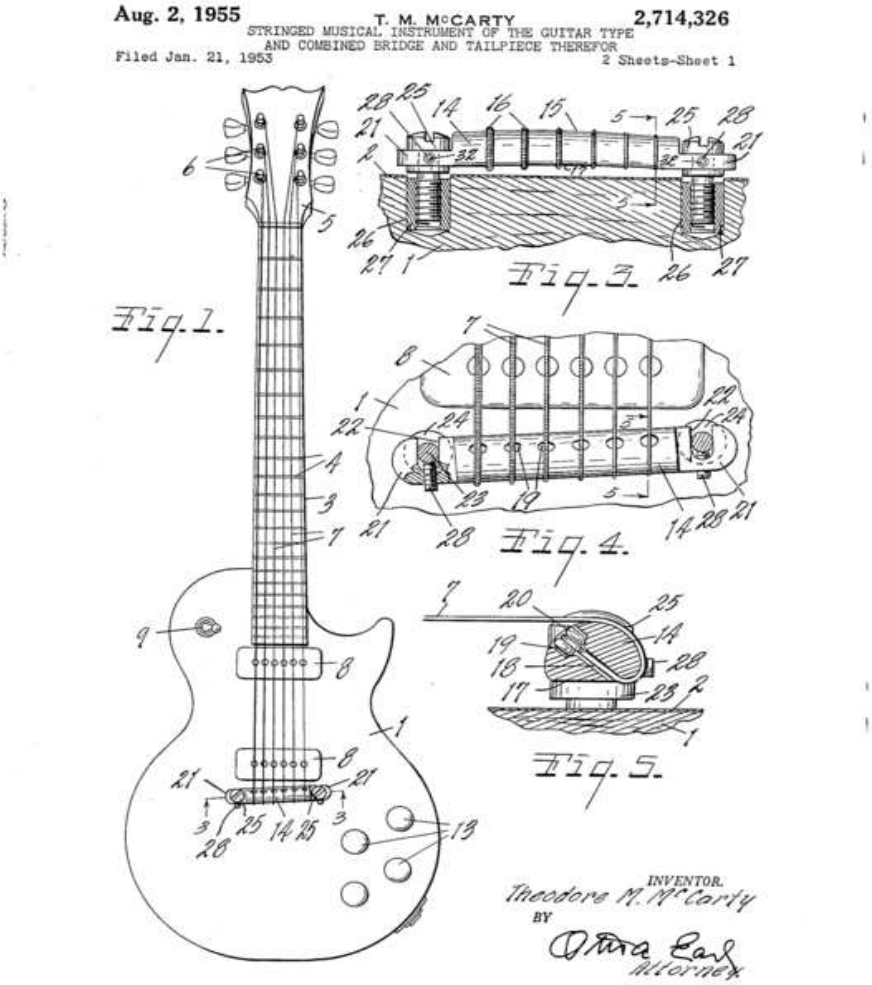
By Lyon & Lyon Attorneys

Leo Fender solid body

Fender claim:

“...to provide an electrical pickup which may be associated with any type of stringed instrument such a guitar, violin, piano and many others”

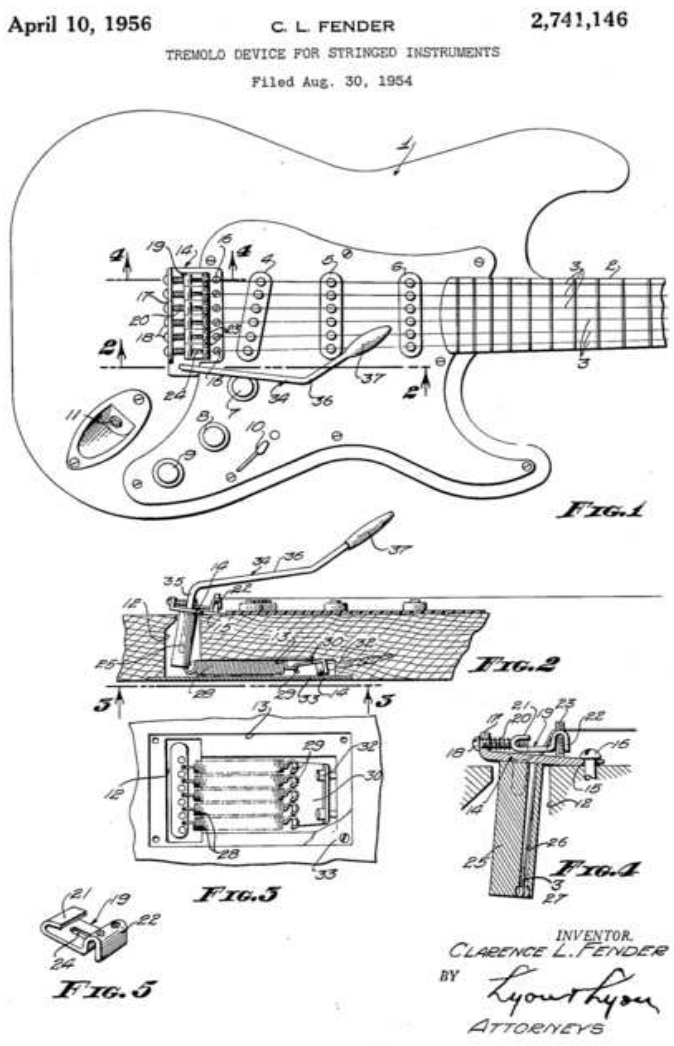
“A pick-up device for stringed musical instruments, comprising a pair of U shaped pole pieces disposed with their leg portions confronting but spaced from each other forming pole tips...”



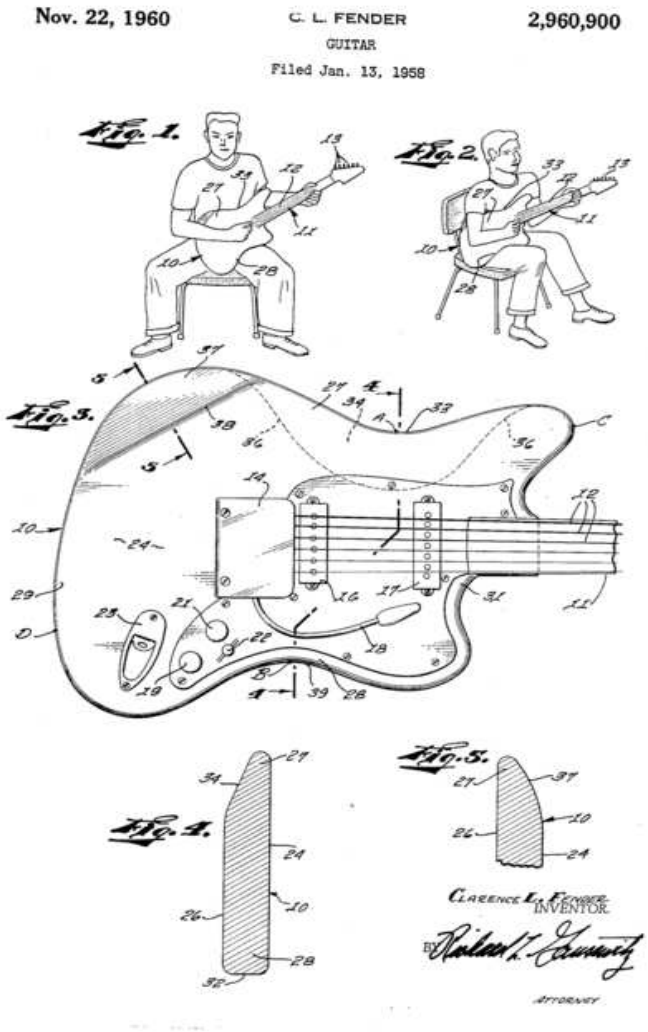

Gibson's Les Paul Acoustic

McCarty's claim: 1/12

"A stringed musical instrument of the class described including a body and a neck, a bar-like bridge member having a longitudinally and transversely curved string supporting face and having inwardly and rearwardly inclined string bores provided with enlargements..."




Fender Wang Bar


Nov. 22, 1960 C. L. FENDER 2,960,900

GUITAR

Filed Jan. 13, 1958

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

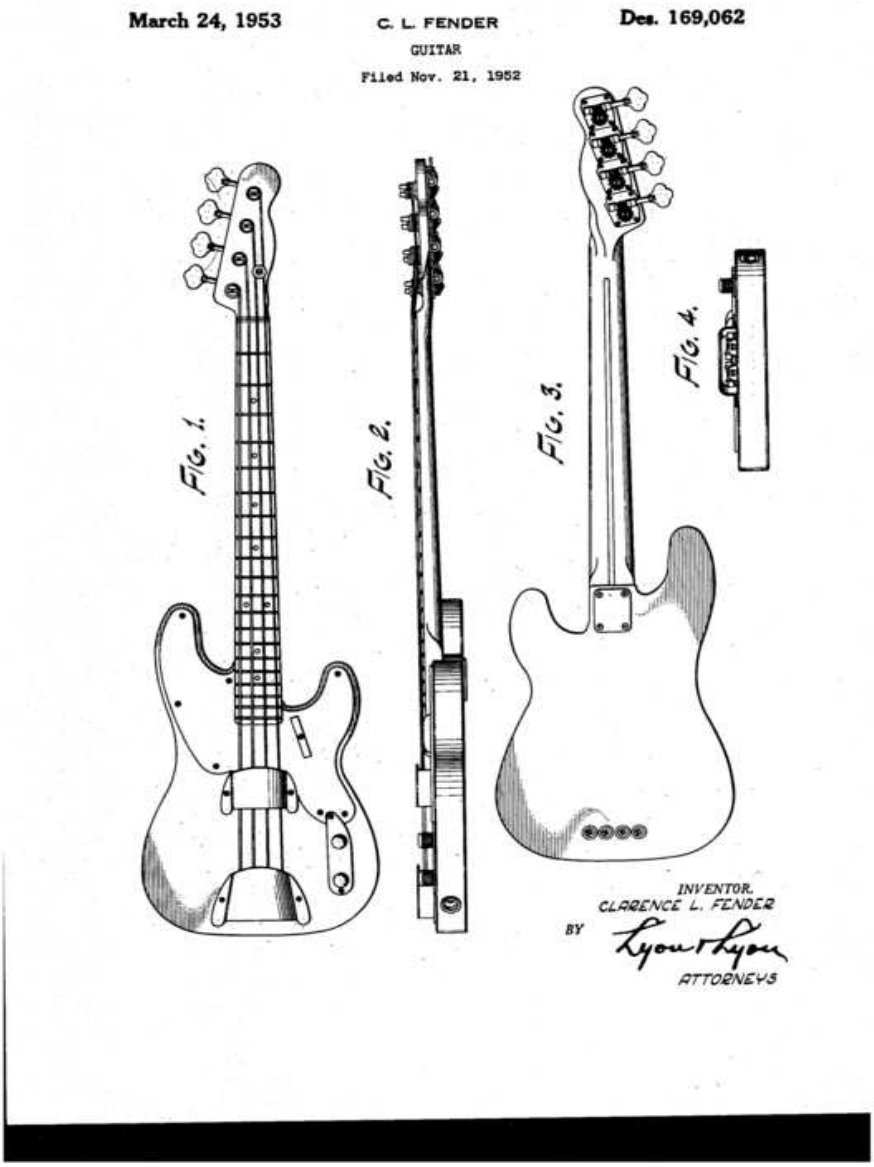
Fig. 5.

CLARENCE L. FENDER INVENTOR.

BY Robert T. Edwards

ATTORNEY

(also Design Patent D186826)
Fender Stratocaster


March 24, 1953 C. L. FENDER Des. 169,062

GUITAR

Filed Nov. 21, 1952

FIG. 1.

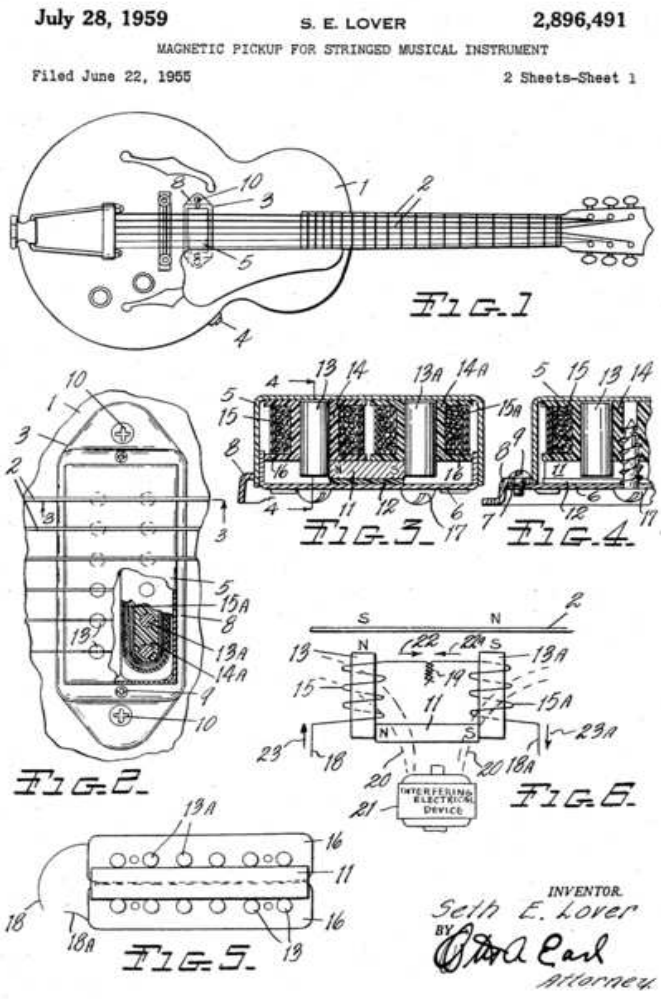
FIG. 2.

FIG. 3.

FIG. 4.

INVENTOR.
CLARENCE L. FENDER
BY Lyon & Lyon
ATTORNEYS

Fender "Precision Bass"




Lover's humbucker

Lover's claim: "A magnetic pickup for a stringed instrument comprising an elongated permanent bar magnet magnetized from side to side, a plurality of pairs of cylindrical pole pieces of magnetizable soft iron material arranged at spaced intervals along said magment...a first coil wound around all the pieces on one side of said magnet, a second coil wound around all the pieces on the other side of the magnet, one end of each coil being electrically connected to the end of the other..."

Summary of electric guitars:

- First: metal strings + electrical pickup
- Then: improvements to pickup
- Next: solid body
- Now: composite materials

# Physical Modeling: physical model + waveguide + string(s)

- Multidimensional digital waveguide signal synthesis system and method US Pat. 5471007 - Filed May 4, 1993 - The Board of Trustees of the Leland Stanford Junior University

- Music synthesizer system and method for simulating response of resonant ... US Pat. 5466884 - Filed May 10, 1994 - The Board of Trustees of the Leland Stanford Junior University

- Digital waveguide speech synthesis system and method US Pat. 5528726 - Filed May 8, 1995 - The Board of Trustees of the Leland Stanford Junior University

- Multidimensional digital waveguide signal synthesis system and method US Pat. 5614686 - Filed Nov 27, 1995 - The Board of Trustees of the Leland Stanford Junior University

- Method for inharmonic tone generation using a coupled mode digital filter US Pat. 5748513 - Filed Aug 16, 1996 - Stanford University

## Physical Modeling: physical model + waveguide + string(s)

- Method and device for setting or selecting a tonal characteristic using ... US Pat. 5739454 - Filed Oct 24, 1996 - Yamaha Corporation

- Efficient synthesis of musical tones having nonlinear excitations US Pat. 5777255 - Filed May 2, 1997 - Stanford University

- Synthesis of sounds played on plucked string instruments, using computers ... US Pat. 6011213 - Filed Sep 24, 1997 - Sony Corporation

- Method for evaluating quality of service of a digital network connection US Pat. 6801939 - Filed Oct 10, 2000 - Board of Trustees of the Leland Stanford Junior University S

US005471007A

**United States Patent** [19]

**Van Duyne et al.**

[11] **Patent Number: 5,471,007**

[45] **Date of Patent: Nov. 28, 1995**

[54] **MULTIDIMENSIONAL DIGITAL WAVEGUIDE SIGNAL SYNTHESIS SYSTEM AND METHOD**

[75] Inventors: **Scott A. Van Duyne**, Stanford; **Julius O. Smith, III**, Palo Alto, both of Calif.

[73] Assignee: **The Board of Trustees of the Leland Stanford Junior University**, Stanford, Calif.

[21] Appl. No.: **57,253**

[22] Filed: **May 4, 1993**

[51] **Int. Cl.**[6] ..... **G10H 1/02**; G10H 1/12; G10H 1/46

[52] **U.S. Cl.** ..... **84/622**; 84/659

[58] **Field of Search** ..... 84/622, 659; 333/28 R, 333/28 T, 157, 629, 633, DIG. 9, DIG. 10

[56] **References Cited**

U.S. PATENT DOCUMENTS

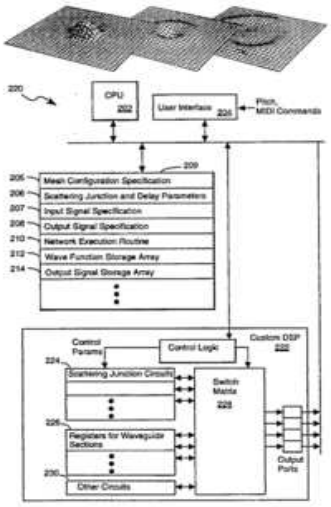
4,984,276 1/1991 Smith .

*Primary Examiner*—William M. Shoop, Jr.
*Assistant Examiner*—Jeffrey W. Donels
*Attorney, Agent, or Firm*—Flehr, Hohbach, Test, Albritton & Herbert

[57] **ABSTRACT**

A signal synthesizer uses a digital waveguide network having at least a two dimensional matrix of waveguide sections interconnected by junctions to filter one or more excitation signals so as to generate an array of synthesized output signals. The digital waveguide network has sets of waveguide sections interconnected by junctions. Each waveguide section includes two digital delay lines running parallel to each other for propagating signals in opposite directions and each junction has reflection and propagation coefficients assigned to it for controlling reflection and propagation of signals in the waveguide sections connected to that junction. Except for junctions along boundaries of the digital waveguide matrix, each junction is at least a four-way junction that interconnect at least four waveguide sections so as to scatter and intermix signals in flowing through those waveguide sections. At least one signal source, coupled to specified junctions of the digital waveguide network, provides excitation signals to the digital waveguide network. In addition, a parameter memory stores sets of control parameters, including waveguide control parameters for controlling how the digital waveguide network filters signals propagating therethrough and signal source parameters which govern the excitation signals produced by the signal source or sources. Finally, a digital signal processor or controller operates the signal sources and digital waveguide network using a selected set of the control parameters so as to synthesize an array of output signals.

**10 Claims, 24 Drawing Sheets**




First 2-D waveguide patent

Things to notice

- Cited by 83 patents... and ...
- Only one backward patent (4,984,276 [Smith])
- 4,984,276 is cited by 120 patents!

**United States Patent** [19]
**Smith**

[11] **Patent Number: 4,984,276**
[45] **Date of Patent: Jan. 8, 1991**

[54] **DIGITAL SIGNAL PROCESSING USING WAVEGUIDE NETWORKS**

[75] Inventor: **Julius O. Smith,** Menlo Park, Calif.

[73] Assignee: **The Board of Trustees of the Leland Stanford Junior University,** Stanford, Calif.

[21] Appl. No.: **414,646**

[22] Filed: **Sep. 27, 1989**

**Related U.S. Application Data**

[63] Continuation of Ser. No. 275,620, Nov. 14, 1988, abandoned, which is a continuation of Ser. No. 920,701, Oct. 17, 1986, abandoned, which is a continuation-in-part of Ser. No. 859,868, May 2, 1986, abandoned.

[51] **Int. Cl.**[5] ..... **H03G 3/00**
[52] **U.S. Cl.** ..... **381/63;** 84/630; 84/707
[58] **Field of Search** ..... 84/630, 707; 364/724.11, 724.15, 724.16; 381/63

[56] **References Cited**

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|---|---|---|---|
| 4,344,148 | 8/1982 | Brantingham et al. | 364/724 |
| 4,389,540 | 6/1983 | Nakamura et al. | 364/724 X |
| 4,548,119 | 10/1985 | Wachi et al. | 84/1.19 |
| 4,554,858 | 11/1985 | Wachi et al. | 84/1.19 |
| 4,633,500 | 12/1986 | Yamada et al. | 381/51 |

OTHER PUBLICATIONS

H. Kimura, "Generalized Schwarz Form and Lattice-Ladder Realizations of Digital Filters," *IEEE Transactions on Circuits and Systems*, vol. CAS-32, No. 11, Nov. 1985.

H. Kimura et al., "Canonical Pipelining of Lattice Filters," *IEEE Transactions on Acoustics, Speech, and Signal Processing*, vol. ASSP-35, No. 6, Jun. 1987.

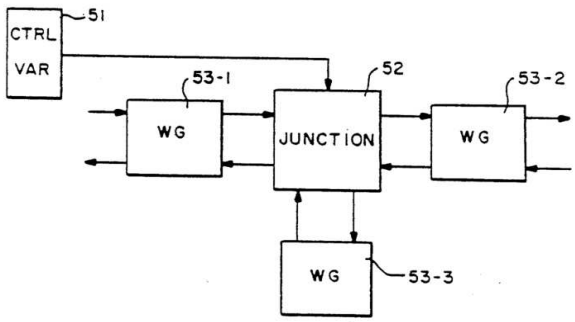
Maurice Bellanger, *Digital Processing of Signals Theory and Practice*, John Wiley & Sons, copyright © 1984, Library of Congress Catalog Card No.: 83-17035, pp. 229-239 & 362-368.

*Primary Examiner*—Forester W. Isen
*Attorney, Agent, or Firm*—Spensley Horn Jubas & Lubitz

[57] **ABSTRACT**

Disclosed is a signal processor formed using digital waveguide networks. The digital waveguide networks have signal scattering junctions. A junction connects two waveguide sections together or terminates a waveguide. The junctions are constructed from conventional digital components such as multipliers, adders, and delay elements. The signal processor of the present invention is typically used for digital reverberation and for synthesis of reed, string or other instruments.

**16 Claims, 8 Drawing Sheets**




*The* waveguide patent

Things to notice

- Cites 5 patents backward
- Has two corrections at the end
- 4,984,276 is cited by 120 patents!
- Restrict by "string": 26 patents

US005157218A

**United States Patent** [19]

**Kunimoto et al.**

[11] **Patent Number: 5,157,218**

[45] **Date of Patent: Oct. 20, 1992**

[54] **MUSICAL TONE SIGNAL FORMING APPARATUS**

[75] Inventors: **Toshifumi Kunimoto; Akira Yamauchi**, both of Hamamatsu, Japan

[73] Assignee: **Yamaha Corporation**, Hamamatsu, Japan

[21] Appl. No.: **557,963**

[22] Filed: **Jul. 26, 1990**

[30] **Foreign Application Priority Data**

Jul. 27, 1989 [JP] Japan ..... 1-192708
Jul. 27, 1989 [JP] Japan ..... 1-194544

[51] **Int. Cl.**[5] ..... **G10H 1/14**; G10H 5/02
[52] **U.S. Cl.** ..... **84/659**; 84/661
[58] **Field of Search** ..... 84/659-661, 84/670

[56] **References Cited**

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4,736,663 4/1988 Wawrzynek et al. ..... 84/DIG. 9
4,882,965 11/1989 McClish ..... 84/453
4,984,276 1/1991 Smith ..... 84/630 X

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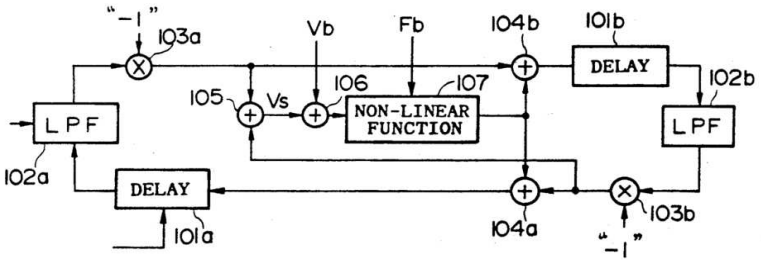
0248527 4/1987 European Pat. Off. .
63-40199 2/1988 Japan .

*Primary Examiner*—William M. Shoop, Jr.
*Assistant Examiner*—Brian Sircus
*Attorney, Agent, or Firm*—Graham & James

[57] **ABSTRACT**

An electronic musical instrument provides a musical tone signal forming apparatus in order to sound a desirable musical tone. This apparatus includes a closed-loop wherein a signal is repeatedly circulating while being delayed by a delay circuit. In addition, the signal circulating the closed-loop is subject to the non-linear conversion. Thus, the signal picked up from the closed-loop can be controlled in response to the desirable non-linear characteristic. Preferably, the signal circulating the closed-loop is a musical tone waveform signal. For example, the musical tone waveform signal is varied in response to the feature of string, string bowing pressure and the like. Further, hysteresis characteristic simulating the statical and dynamic frictions to be occurred between the string and bow of the string bowing instrument can be imported to the non-linear characteristic.

**9 Claims, 4 Drawing Sheets**




Typical Yamaha patent

US005212334A

**United States Patent** [19]
**Smith, III**

[11] **Patent Number: 5,212,334**
[45] **Date of Patent: May 18, 1993**

[54] **DIGITAL SIGNAL PROCESSING USING CLOSED WAVEGUIDE NETWORKS**

[75] Inventor: **Julius O. Smith, III**, Palo Alto, Calif.

[73] Assignee: **Yamaha Corporation**, Hamamatsu, Japan

[21] Appl. No.: **568,609**

[22] Filed: **Aug. 16, 1990**

**Related U.S. Application Data**

[60] Division of Ser. No. 414,646, Sep. 27, 1989, Pat. No. 4,984,276, which is a continuation of Ser. No. 275,620, Nov. 14, 1988, abandoned, which is a continuation of Ser. No. 920,701, Oct. 17, 1986, abandoned, which is a continuation-in-part of Ser. No. 859,868, May 2, 1986, abandoned.

[51] **Int. Cl.**[5] ..... **G10H 1/02**; G10H 1/12; G10H 1/46

[52] **U.S. Cl.** ..... **84/622**; 84/629; 84/633; 84/DIG. 9; 84/DIG. 10

[58] **Field of Search** ..... 84/622–625, 84/629, 630, 633, 648, 661–665, 675–677, 699, 700, 707, 736–741, DIG. 9, DIG. 10, DIG. 11, DIG. 26

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| 4,633,500 | 12/1986 | Yamada et al. | 381/51 |
| 4,649,783 | 3/1987 | Strong et al. . | |

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"Waveguide Digital Filters", by Julius O. Smith, CCRMA, Dept. of Music, Stanford University.
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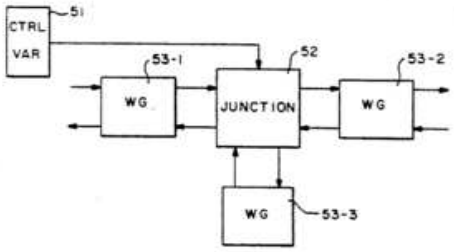
(List continued on next page.)

*Primary Examiner*—Stanley J. Witkowski
*Attorney, Agent, or Firm*—Graham & James

[57] **ABSTRACT**

A tone generation system includes one or more digital waveguide networks coupled to one or more junctions, one of which receives a control signal for controlling tone generation. The control signal initiates and interacts with a wave signal propagating through the waveguide networks to form a tone signal. A non-linear junction may be employed which receives a signal from a waveguide, converts it in accordance with a non-linear function based upon the value of the control signal and provides it back to the waveguide. A tone signal whose pitch is determined by the wave transmission characteristics of the waveguide network is thereby produced.

**61 Claims, 7 Drawing Sheets**




Smith again, different assignee

Things to notice

- Different abstract, same figure
- Appendix with SAIL code
- Similar but different contents (reeds, compressed table)

US005241127A

**United States Patent** [19]

**Kobayashi**

[11] **Patent Number: 5,241,127**

[45] **Date of Patent: Aug. 31, 1993**

[54] **MUSICAL TONE SYNTHESIZING APPARATUS**

[75] Inventor: **Kaoru Kobayashi**, Owariasahi, Japan

[73] Assignee: **Yamaha Corporation**, Hamamatsu, Japan

[21] Appl. No.: **633,051**

[22] Filed: **Dec. 20, 1990**

[30] **Foreign Application Priority Data**

Dec. 22, 1989 [JP] Japan ..... 1-334218
Jun. 1, 1990 [JP] Japan ..... 2-143736

[51] **Int. Cl.**[5] ..... **G10H 1/02**; G10H 5/02

[52] **U.S. Cl.** ..... **84/616**; 84/624; 84/625; 84/659; 84/660; 84/661; 84/DIG. 9; 84/DIG. 10

[58] **Field of Search** ..... 84/604, 616, 615, 622, 84/624, 625, 659–661, DIG. 9, DIG. 10

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*Primary Examiner*—William M. Shoop, Jr.

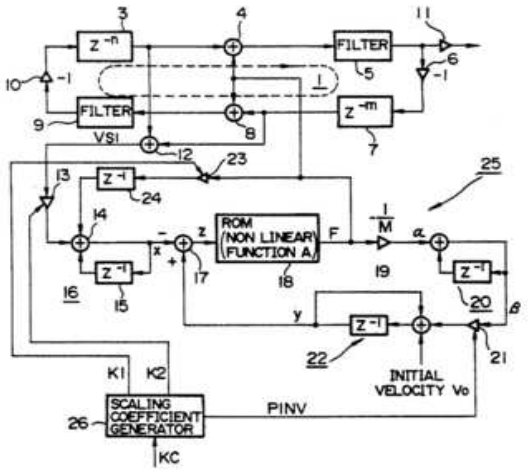
*Assistant Examiner*—Brian Sircus

*Attorney, Agent, or Firm*—Graham & James

[57] **ABSTRACT**

The musical tone synthesizing apparatus simulating the musical tones of a natural musical instrument such as a piano. The apparatus contains a closed-loop circuit for simulating the vibration mechanism of the strings and a excitation circuit for generating excitation signals to the closed-loop circuit, so that the excitation circuit simulates the hammer striking the string. The apparatus also contains a scaling coefficient generating circuit for generating and supplying scaling coefficients to the excitation circuit, where the scaling coefficients represent the influence rate corresponding to the influence to be applied to the hammer by the string. In the excitation circuit, the excitation signals are multiplied by the scaling coefficients so that a slight difference of tone color is applied to the excitation signals with respect to tone pitch (or each key). For example, the scaling coefficient for comparatively lower tone pitch is set at a comparatively small value, because the hammer for lower tone pitch has relatively rounder shape and larger mass, and the felt thereof is formed relatively thicker, while the scaling coefficients for comparatively higher tone pitch is set at a comparatively large value. For this reason, the musical tone synthesizing apparatus generates a musical tone of which tone color is slightly different with respect to each tone pitch.

**18 Claims, 4 Drawing Sheets**




Yamaha continues to elaborate

Summary of physical modeling of strings:

- Yamaha doesn't publish

- Julius Smith's '276 patent is the "root"

Summary:

Musical instruments = art + craft +
engineering + physics

(a *strange* brew)

## DIY patent research

- http://www.google.com/patents
- http://www.uspto.gov/patft/index.html
- http://gb.espacenet.com/
- http://www.wikipatents.com/

The End.