

Chapter 11. Meeting 11, Interfaces: Electronic and Electromagnetic Instruments

11.1. Announcements

- Next class is a Discussion and Workshop meeting
- Focus on Bimber reading
- Experiment with electro-magnetic pickups (bring anything with vibrating metal)
- Building oscillators with Collins CMOS Hex Schmitt Trigger IC design

11.2. Quiz Review

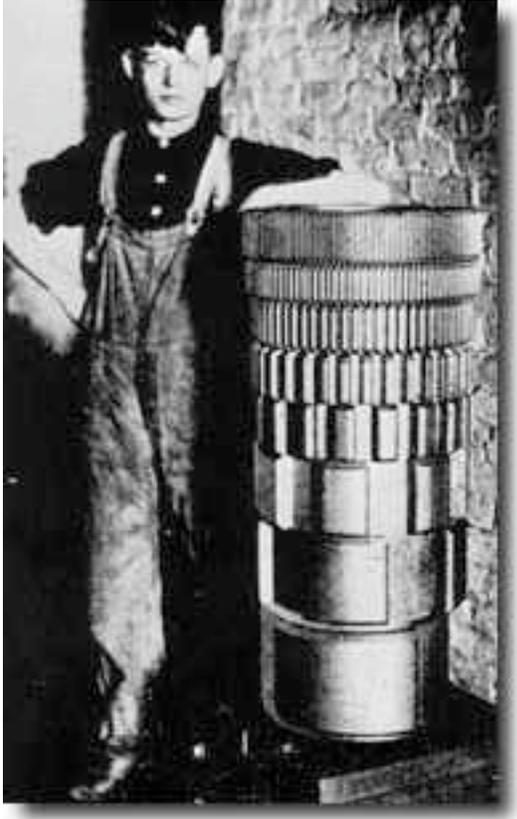
- ?

11.3. Reading: McSwain

- McSwain, R. 2002. “The Social Construction of a Reverse Salient in Electric Guitar Technology: Noise, the Solid Body, and Jimi Hendrix.” In *Music and Technology in the Twentieth Century*. H. Braun, ed. Baltimore: The Johns Hopkins University Press. 186-198.
- What are the three stages of suggested for electric guitar development?
- What is a technological reverse salient
- What does it mean to re-conceptualize a reverse salient? What are the possible outcomes?

11.4. The Telharmonium (Dynamophone): Idea

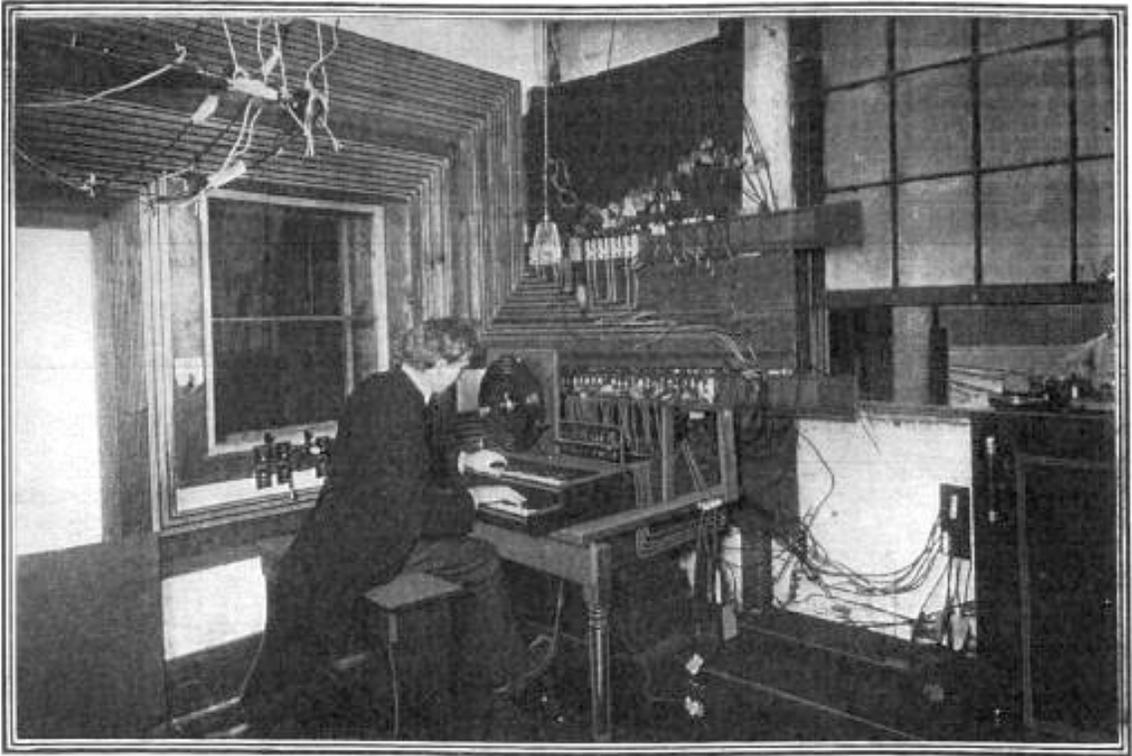
- Thaddeus Cahill (1872-1917)
- Considered the first electronic polyphonic instrument
- One or two performers sit at a keyboard with multiple manuals
- Keyboards trigger dynamo oscillators
- Dynamos contain large cylinders on pitch shafts (Holmes 2008, p. 8) with raised bumps called rheotome

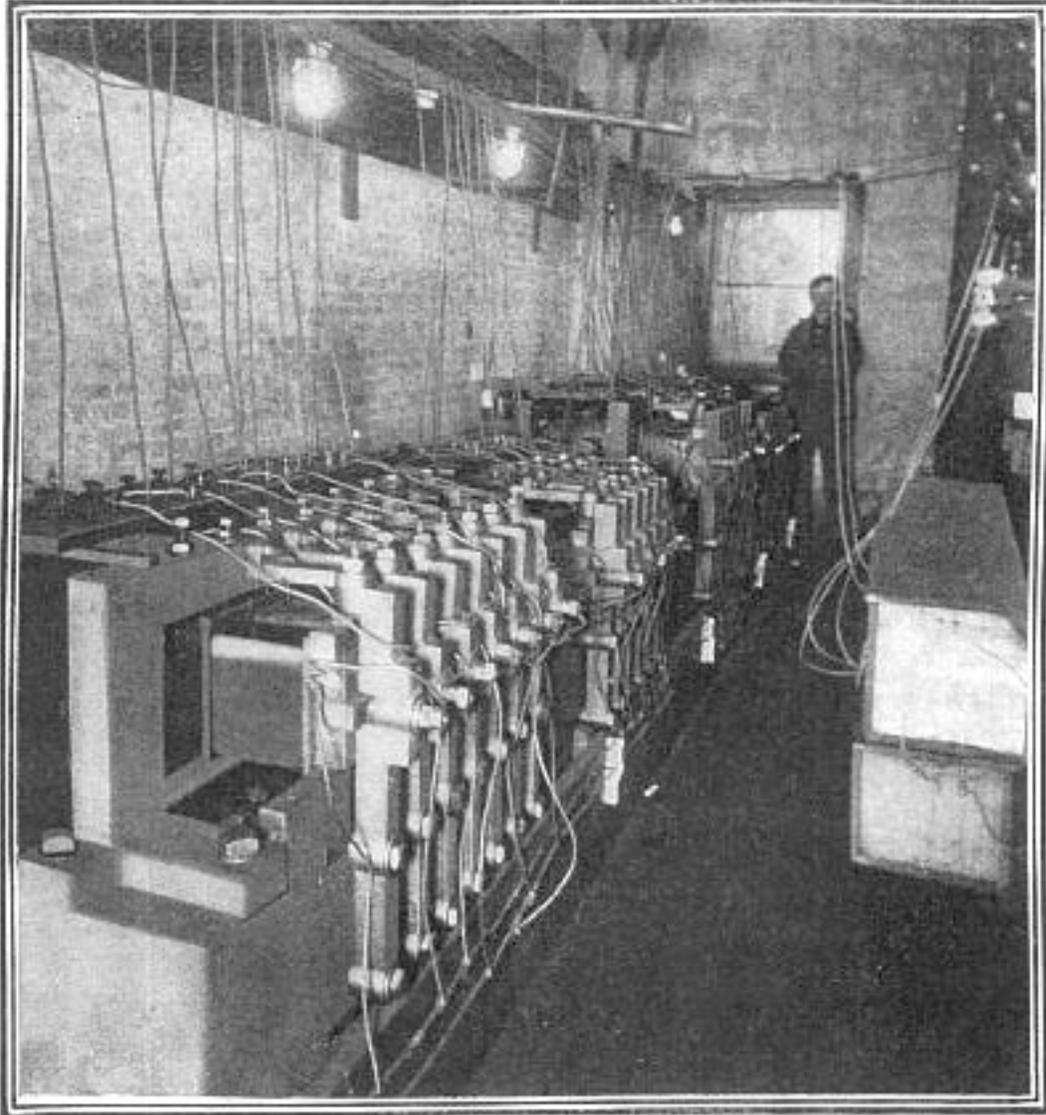


- Size and number of teeth in each rotor determines frequency (similar to a tone wheel)
- Up to five (Holmes 2008, p. 9) Sine-like tones mixed and processed to produce more complex tones
- Output distributed over conventional telephone lines
- Goal of distributing music (Telharmony) everywhere via phone lines as a commercial service to restaurants, hotels, and individuals

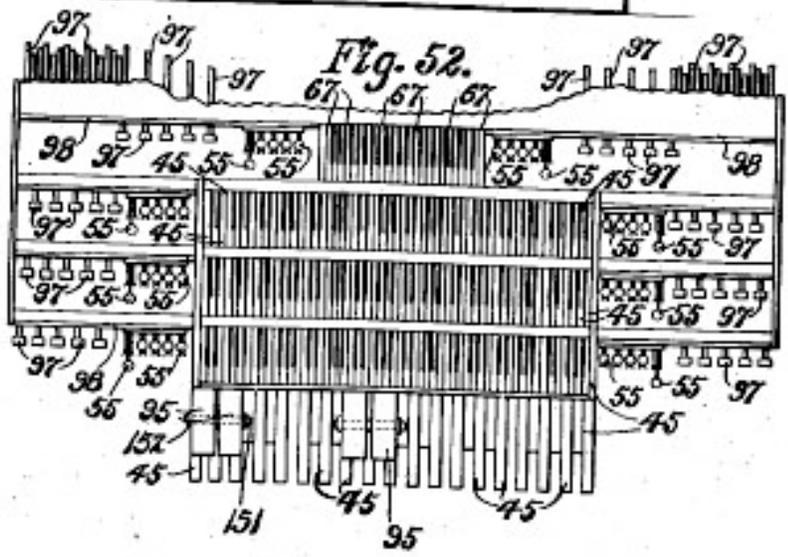
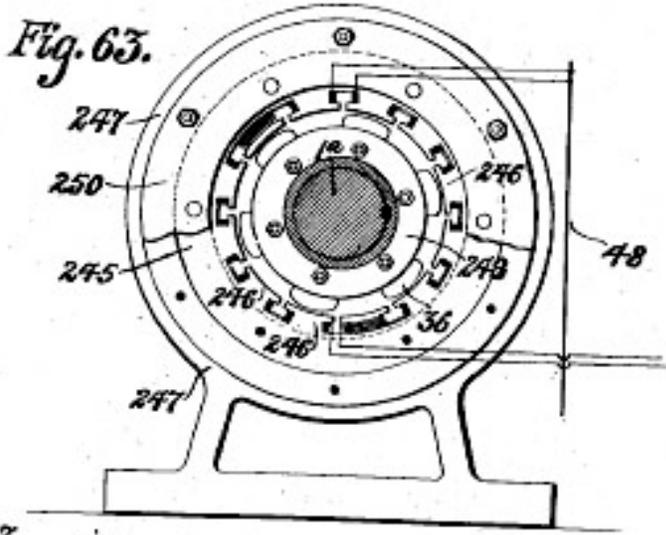
11.5. The Telharmonium (Dynamophone): Images

- Photos





- Patent drawings



WITNESSES:
Arthur Cahill
Geo. T. Barber

INVENTOR
Thomas Cahill

T. CAHILL.

ART OF AND APPARATUS FOR GENERATING AND DISTRIBUTING MUSIC ELECTRICALLY.

No. 580,035.

Patented Apr. 6, 1897.

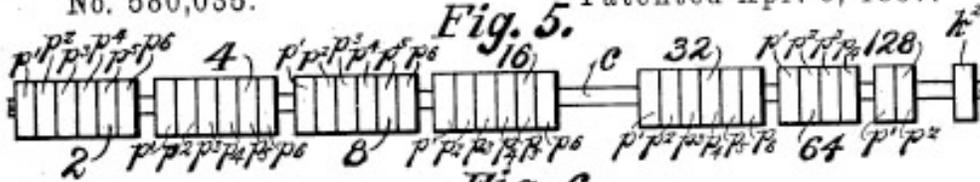


Fig. 5.



Fig. 6.

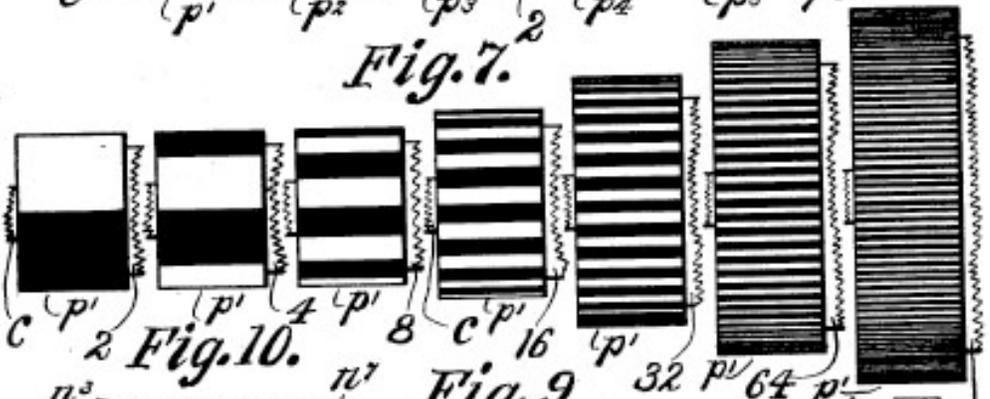


Fig. 7.

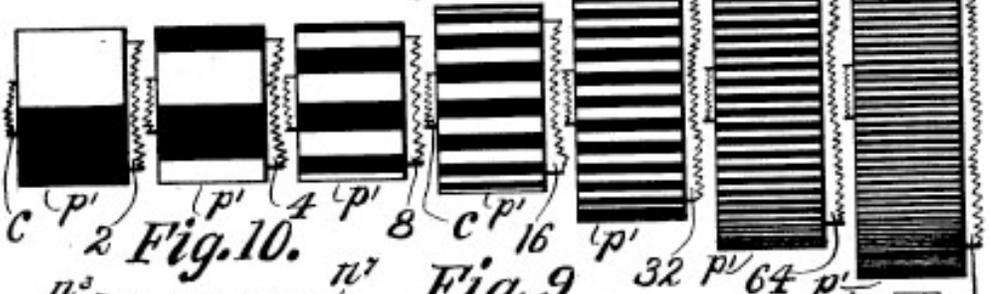


Fig. 8.

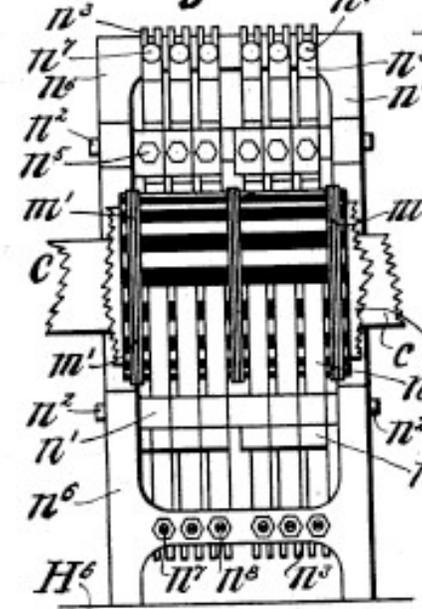


Fig. 9.

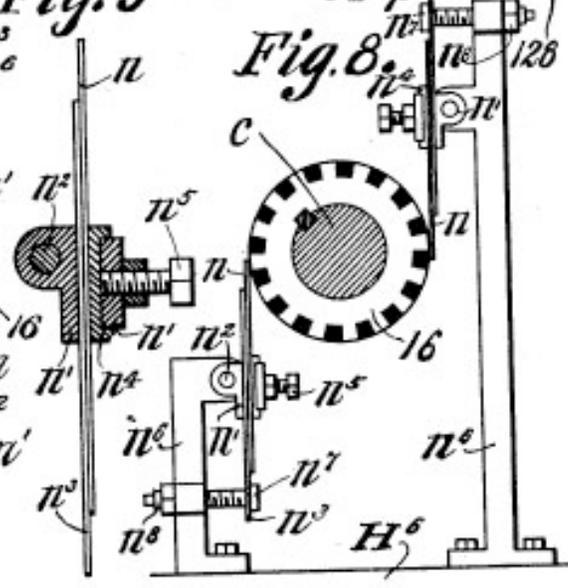


Fig. 10.

Attest.
 Arthur T. Cahill.
 M. H. Cahill.

Inventor.
 Thomas Cahill

11.6. The Telharmonium (Dynamophone): History

- 1884: Cahill was a student at Oberlin Conservatory in Ohio (Holmes 2008, p. 8), learned of Helmholtz
- Began experiments with telephones in 1893
- First patents in 1895, 1896, and 1897

UNITED STATES PATENT OFFICE.

THADDEUS CAHILL, OF NEW YORK, N. Y.

ART OF AND APPARATUS FOR GENERATING AND DISTRIBUTING MUSIC ELECTRICALLY.

SPECIFICATION forming part of Letters Patent No. 580,035, dated April 6, 1897.

Application filed February 4, 1896. Serial No. 572,046. (No model.)

To all whom it may concern:

Be it known that I, THADDEUS CAHILL, a citizen of the United States, and a resident of the city, county, and State of New York, 5 (residing temporarily at Washington, in the District of Columbia,) have invented a new and useful Art of and Apparatus for Generating and Distributing Music Electrically, of which the following is a specification.

10 In a former application of mine, filed August 10, 1895, Serial No. 558,939, an art of and apparatus for generating and distributing music electrically is described. The art described in this application is the same art

the subject-matter of the original application, filed August 10, 1895, as is disclosed in the present case, and I have removed the claims 55 for such subject-matter from the former case in order to prosecute them in this, and to prosecute in the original application, Serial No. 558,939, only that subject-matter which belongs peculiarly to it and which is not illustrated or described in this. In other words, 60 the line of division which I draw between this case and the original application, Serial No. 558,939, filed August 10, 1895, is to cover in this case everything illustrated and de- 65 scribed in it asserting herein all claims for

- First prototype built from 1898-1901
- 1901: Demonstrated in Baltimore at the Maryland Club, with sounds generated in Washington D.C. on one-octave instrument (Holmes 2008, p. 9)
- Moved to Holyoke Massachusetts to build improved model, started Cahill Telharmonium Company
- Moved Telharmonium to New York City on 30 railroad flat cars
 - 1905: New York Electric Music Company established
 - Telharmonic Hall: 39th St and Broadway, NYC
 - Weighed over 200 tons, measured over 60 feet long, required 2000 switches (Holmes 2008, p. 10), and included 145 dynamos

- NYC premier: 26 September 1906, later up to four public performances a day
- 1908: New York Electric Music Company collapsed
- Problems with maintaining volume, power consumption, and crosstalk
- 1909: Third Telharmonium completed
- 1910: The New York Cahill Telharmonic Company
- 1911: installed new Telharmonium at 535 West 56th Street, NYC
- 1912: demonstrated at Carnegie hall
- 1914: Company bankrupt
- Operation ceased in 1916

11.7. The Theremin: Idea

- Lev Sergeyevich Termen (1896-1993)
- The first successful monophonic electronic instrument, first gesture controlled instrument
- Performer's hands act as the grounded plate of a variable capacitor
- Vertical antenna: distance from performer's hand determines frequency via capacitance
- Horizontal loop: distance from performer's hand determines amplitude via capacitance
- Beat frequency oscillator: employs two supersonic radio frequency oscillators that are heterodyned to produce the audible frequencies
- Early models included an integrated Loudspeaker
- Some models offer different timbres available with switches

11.8. The Theremin: History

- 1920: first demonstrated in Russia
- 1922: demonstrated to Lenin
- 1927 to 1938: Theremin, in U.S., spies for the Soviet Union (Holmes 2008, p. 22)
- late 1920s (1925 or 1929): RCA manufactures 500 theremins
- 1920s: composers such as Pashchenko, Shillinger, and Varèse compose works with the Theremin

- 1954: Bob Moog begins to build theremins

11.9. The Theremin: Images

- Historic Models (RCA)



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Courtesy of Sonny the Radiolaguy (<http://www.radiolaguy.com>). Used with permission.



Courtesy of Sonny the Radiolaguy (<http://www.radiolaguy.com>). Used with permission.

- Contemporary Models: Moog Theremin (\$419)



- Contemporary Models: Moog Etherwave Pro (\$1395)

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11.10. The Theremin: Video

- Theremin virtuoso Clara Rockmore

11.11. The Ondes Martenot: Idea

- Maurice Martenot (1898-1980), influenced by Leon Termin
- Monophonic instrument with a vacuum tube oscillator, designed to be a symphonic instrument
- First models used a “pull wire” to control pitch; a conventional keyboard was added in fourth version (1930)
- Originally used a touch sensor; the fifth version added a ribbon controller (1933)
- Keys can be moved laterally to create small pitch changes
- Amplitude was controlled by a pressure sensitive key for the left hand, switches could be used to alter timbre
- Same synthesis technique as the Theremin: (beat-frequency oscillator)
- Used in works by Boulez, Varèse, Milhaud, Honegger, and others

11.12. The Ondes Martenot: History

- 1923: Martenot meets Termin
- 1928: Patents instrument as “Perfectionnements aux instruments de musique électriques”
- 1929, 1930, 1933: improved versions
- 1930-1931: tours with instrument
- 1947: Martenot establishes classes at Paris Conservatory

11.13. The Ondes Martenot: Images

- Photos



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- Jean Laurendeau and the Ondes Martenot

YouTube (<http://youtube.com/watch?v=Yy9UBjrUjwo>)

11.14. Listening: Oraison

- Oliver Messiaen (1908-1992), French composer, interested in new harmonic and rhythmic structures
- 1937: Oliver Messiaen: Oraison for Ondes Martenot Quartet

11.15. The Ondes Martenot: Abstraction of a Musical Interface

- Modern Controller: Analogue Systems French Connection with Wire Traveller



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- Examples

YouTube (<http://youtube.com/watch?v=5XsLwkc67lw>)

YouTube (<http://youtube.com/watch?v=MnxE7Mu115o>)

11.16. The Electric Guitar: History

- Oud: possibly the earliest lute, from Mesopotamia 3 BCE



© Viken Najarian (<http://en.wikipedia.org/wiki/File:Oud.jpg>). All rights reserved. This content is excluded from our Creative Commons license. For more information, see <http://ocw.mit.edu/fairuse>.

YouTube (<http://youtube.com/watch?v=c5Ra5NHacxE>)

- 1920s: Los Angeles, George Beauchamp tries to build louder guitars with horns
- 1920s: with John Dopyera, builds guitar with metal resonators (the Tri-Cone)



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YouTube (<http://youtube.com/watch?v=HAf6HPPv-sE>)

- 1920s: with John Dopyera, Beauchamp leaves and forms Dobro Corporation
- 1930s: George Beauchamp develops a pickup with magnets

Aug. 10, 1937.

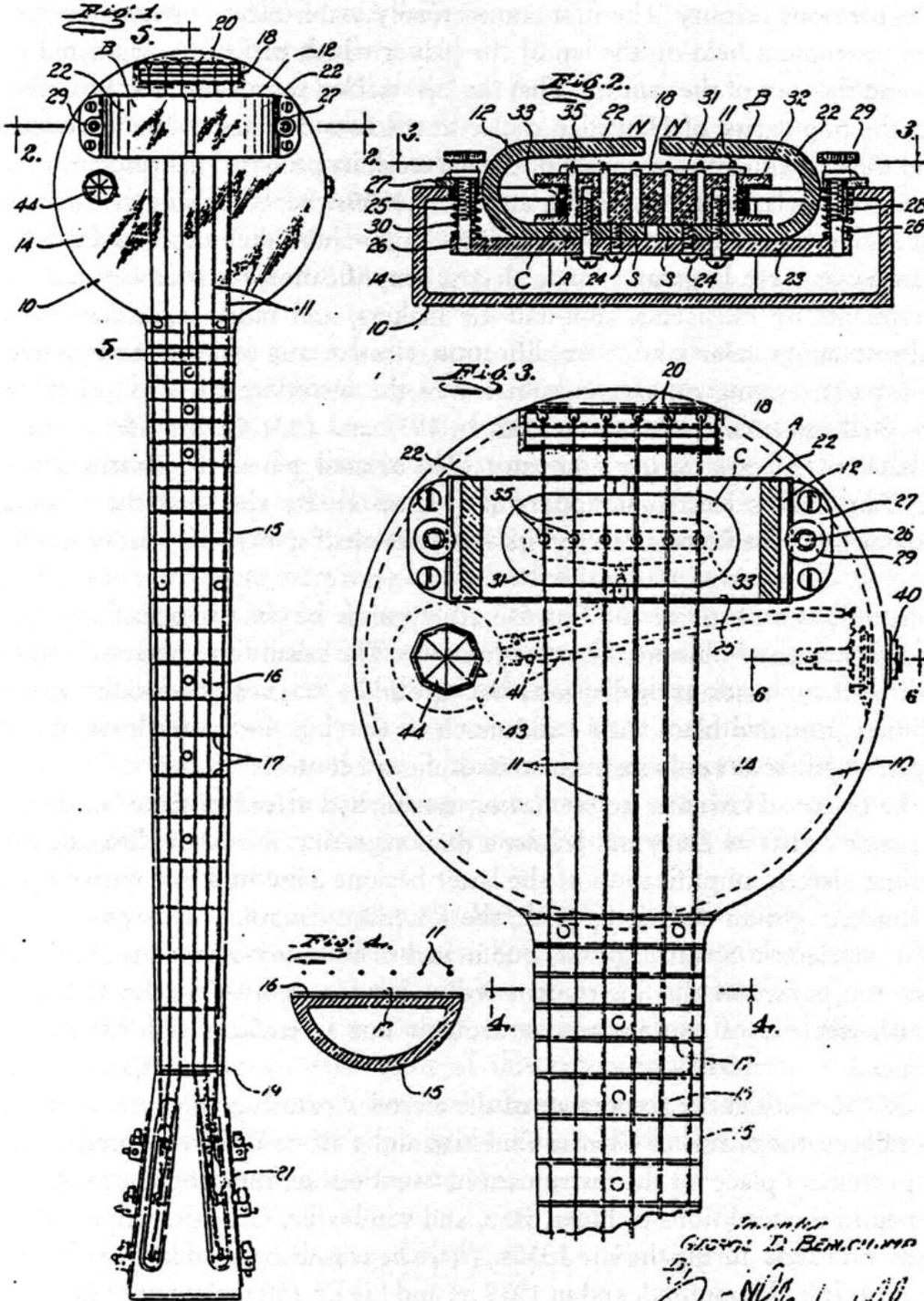
G. D. BEAUCHAMP

2,089,171

ELECTRICAL STRINGED MUSICAL INSTRUMENT

Filed June 2, 1934

3 Sheets-Sheet 1



Inventor
GEO. D. BEAUCHAMP
By *[Signature]*
Att.orney

- 1935: Rickenbacker (then Electro String) releases The Frying Pan, or the Electro Spanish guitar (Bakelite A22)
- 1935: Rickenbacker Bakelite Model B Spanish guitar (thick plastic semi-solid)
- 1940s: Les Paul begins developing guitars
- 1950: Leo Fender begins work
- 1950s: Seth Lover at Gibson develops humbucker (PAF)

July 28, 1959

S. E. LOVER

2,896,491

MAGNETIC PICKUP FOR STRINGED MUSICAL INSTRUMENT

Filed June 22, 1955

2 Sheets-Sheet 1

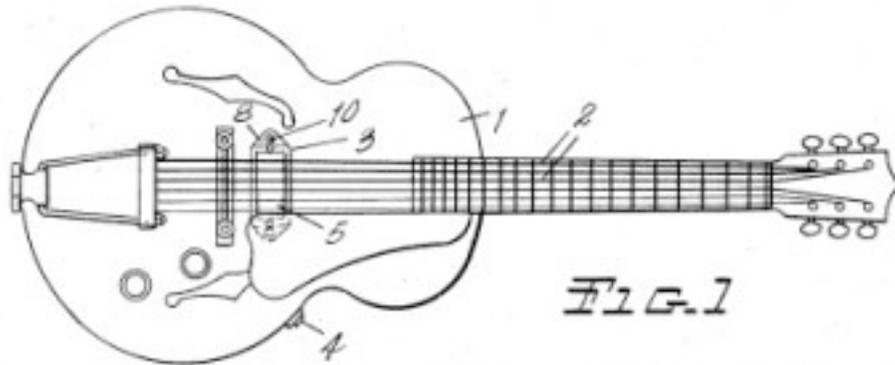


FIG. 1

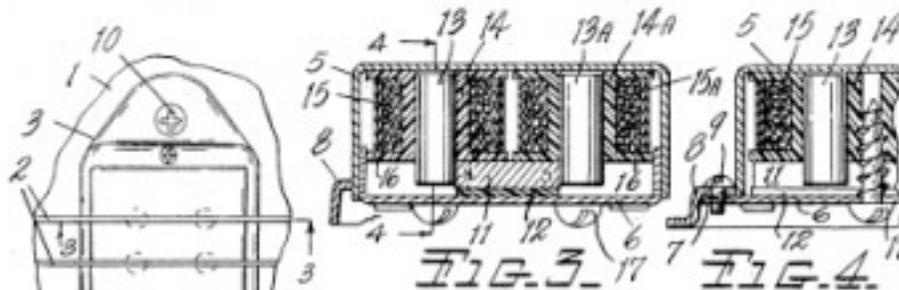


FIG. 3

FIG. 4

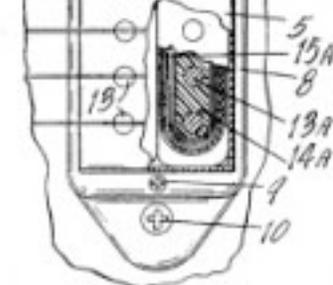


FIG. 2

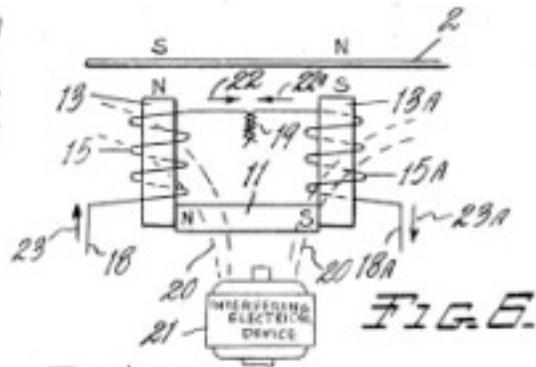


FIG. 6

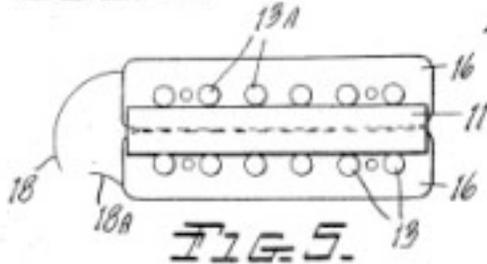


FIG. 5

INVENTOR
Seth E. Lover
BY
O. Carl
Attorney

- 1952: Gibson Les Paul released
- 1954: Fender Stratocaster

11.17. The Electric Guitar: Concepts

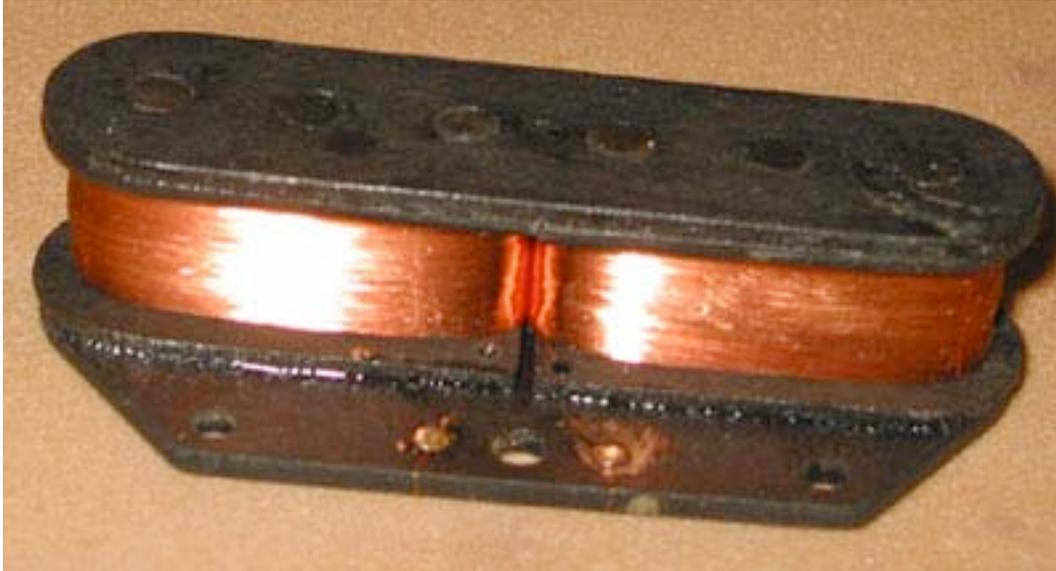
- The problem of loudness
- Moving metal in a magnetic field
 - Telharmonium dynamos
 - Hammond tone wheels
 - Pickups: a metal string in magnetic field
- Instrument does not have to be a full resonator: solid body
- Excessive resonance can lead to feedback
- Electrical output signal can be further processed and modified

11.18. The Electric Guitar: Single Coil Pickups

- Copper wire coiled around a bar or 6 rods
- Earliest models from 1930s
- Rods focus magnetic field around each string



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- Bright and clear sound
- May induce electrical noise (hum) due to polarity of magnetic field

11.19. The Electric Guitar: Dual-Coil Pickups

- Humbucker: buck the hum
- Two coils in reversed polarity: cancels noise when summed



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- Higher output, better signal to noise ratio
- Warm and fat
- Can be packed into a single coil form



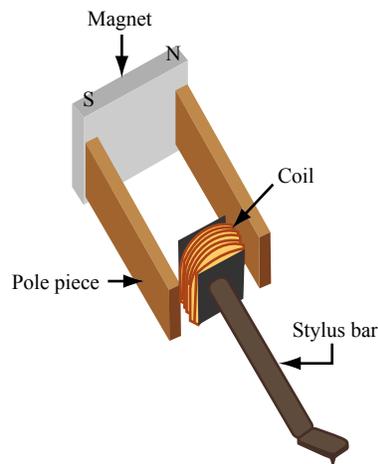
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11.20. Listening: Hendrix

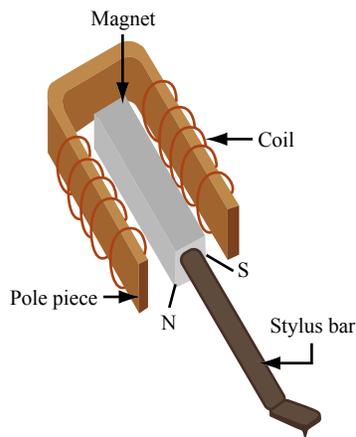
- Jimi Hendrix (1942-1970)
- Clear overdrive tone, extreme sustain
- Jimi Hendrix: “Machine Gun,” Band of Gypsys, 1970

11.21. Analog Turntable Pickups

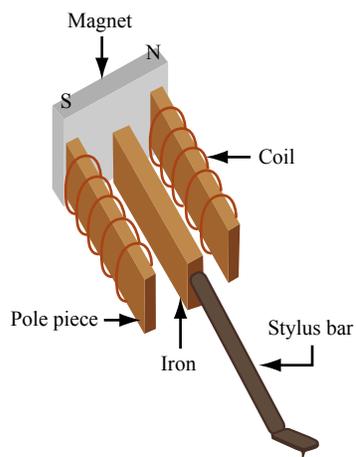
- Phonograph pickups (styli): piezoelectric crystal (contact microphone) or electromagnetic induction (dynamic microphone)



Moving coil



Moving magnet



Variable reluctance

Basic structures of three types of magnetic phonograph pickups.

Figure by MIT OpenCourseWare.

11.22. Listening: Cage

- Cage uses turntables playing test-tones in a composition
- Imaginary Landscape No. 1: four performers playing piano, cymbal, and two variable speed phonographs
- John Cage, Imaginary Landscape No. 1, 1939

11.23. Listening: Cage

- Creative applications of phonograph cartridges
- "In "Cartridge Music" one inserts all kinds of small objects into the cartridges, such as pipe-cleaners, matches, feathers, wires etc. Furniture is used as well, with contact microphones connected to them. All sounds are to be amplified and controlled by the performer(s). The number of performers should be at least that of the cartridges and not greater than twice the number of cartridges. Each performer makes his part from the materials provided: 20 numbered sheets with irregular shapes (the number of shapes corresponding to the number of the sheet) and 4 transparencies, one with points, one with circles, another with a circle marked like a stopwatch and the last with a dotted curving line, with a circle at one end. These transparencies should be superimposed on one of the 20 sheets, in order to create a constellation from where one can create one's part." (www.johncage.info)

Courtesy of André Chaudron (<http://www.johncage.info>). Used with permission.

- John Cage, Cartridge Music, 1960

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21M.380 Music and Technology (Contemporary History and Aesthetics)
Fall 2009

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