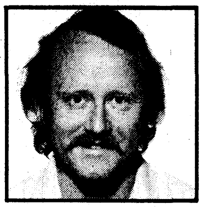
TOM RHEA

ELECTRONIC PERSPECTIVES

An Overview



Music is probably as old as the human voice. Biblical references suggest that musical *instruments* have existed for millenia. Electricity has been used to make music only during the past century. And the voltage-controlled synthesizer has been in use for a scant decade. History lends perspective. In this column we will explore how electricity has been used to make music, and try to place electronic keyboards in context with other musical instruments.

An instrument is a utensil, a means by which something is achieved or performed. Implicit in this definition is the idea that the development of instruments is a facet of technology. Musical instruments certainly have never been exempt from dependence on technology. Instruments of the orchestra became possible only as woodworking and metallurgy were developed. And the escapement mechanism in the piano is as much an outgrowth of technology as the loom or the spinning wheel. Electronic musical instruments are no more a product of technology than are earlier instruments: they merely reflect a *contemporary* technology—electronics.

The first encounter with a new technology is often uncomfortable. How alien the gaudy dynamics of the early pianoforte must have sounded to the clavichordists' pristine ears! When a musical intrument is in its infancy, its musical validity is invariably subject to question. Is this so surprising? Most intruments, electronic or otherwise, are not introduced at maturity, but undergo considerable evolution. To understand this evolution helps us understand the instrument and its music.

Not being aware of the history of electronic instruments, we tend to divorce them in our minds from ten centuries of legitimate musical roots. A look backward can be both instructive and entertaining, instructive because observation of the successes and failures of musical instrument design sharpens our appreciation of the musical values that remain valid throughout time, and entertaining because this particular historical landscape is filled with extravagant overstatement, outrageous nonsense, elegant idealism, and, occasionally, sublime prophecy. Here are a few samples:

Every time I see or hear a new wonder like this I have to postpone my death right off. I couldn't possibly leave this world until I have heard this again and again.
Mark Twain, on hearing the Cahill Telharmonium (1906).

Dr. Cahill's instrument gives us a hint of what the music of the future may be like. With its wires spreading in every direction, the best music may be delivered at towns, villages, and even farmhouses up to a hundred miles or more from the central station.
R.S. Baker, on the Cahill Telharmonium (1906).

All the fixtures and machinery belonging to the Cahill Telharmonium Company were placed on ten flat cars this morning and will be shipped to New York, where Mr. Cahill has already opened a large factory.
Holyoke Transcript (April 25, 1911).

In all my work with the audion, I have never found any phase of its unlimited possibilities quite so interesting as this of producing musical notes. In the next twelve months I hope to be able to produce an instrument....
Lee DeForest, on the use of the triode tube as an oscillator (1915).

Mager produced today an organ with many registrations on which four-voice playing is possible. So far there is only one difficulty; that is, that each voice must have its own keyboard, thus the four-voice movement must be played on three manuals and the pedal. For this reason the manuals must be close to each other and the keys short, so that one can easily play on several manuals with one hand.
Newspaper review of Joerg Mager's Klaviatur-Spaerophon (1930).

With the technical means of radio something much higher and more powerful could be achieved, namely to place at the disposal of music the totality of all additional [over]tones on which the timbre depends. With this totality a new world of sounds can be created which can overshadow all that has been achieved until now.
Joerg Mager, pioneer designer (c. 1935).

We do not like to think of a populace at the mercy of this fearfully magnified and potent tone that Professor Theremin has brought into the world. The radio machines are bad enough, but what will happen to the auditory nerves in a land where super-Theremin machines can hurl a jazz ditty through the atmosphere with such horribly magnificent sonorities that they could deaden the sound of an automobile exhaust from twenty miles away?
Newspaper review of a Theremin concert (1929).

While electro-acoustics has dealt in the last few years primarily with problems of reproduction, I wish to prepare for the creative artist new possibilities of expression. Mechanical music has not enriched art as such, but only enlarged it in respect to the former case. I, however, believe that I am serving creative art through my work before all and, therefore, contributing to the reconciliation of the two branches of the human mind which have erroneously been placed in opposition to each other: art and technology.
Friedrich Trautwein, on his development of the Trautonium (1930).

This new stringless piano may be the forerunner of a whole new class of electronic musical instruments of widely differing tonal performance. The lowly fixed-free reed, virtually the "sow's ear" among musical vibrators, has become the "silk purse" of electronic design and technique with the great advantages of low cost and weight, silence when desired with headsets, and the ability to stay in tune for many decades.
B.F. Miessner, on his struck-reed electric piano (1945).

This new Orgatron conforms to the standards and recommendations of the American Guild of Organists. The Orgatron looks, sounds, and plays like a pipe organ!
Brochure on the Everett Orgatron (c. 1935).

It is possible to make a photographic record of the most perfect tones of Kreisler or Caruso, and adapt them to the tone records of the Superpiano. The Superpiano will then not only sound with the tone colorings of Kreisler's violin or Caruso's voice, but will compel the former to play contrabass and the latter to sing bass.
E. Spielman, on his Superpiano photoelectric organ (1931).

At the present writing, plans are being discussed with a view to a symphony orchestra which is composed exclusively of electronic organs, of which there will be about 35.
Description of plans to use Ivan Eremeeff's Syntronic Organ in an electronic orchestra to be conducted by Leopold Stokowski (1934).

In building the Pianorad it was found that the simplest method is to fill the center holes of the windings with modeling clay, and then to stick the iron wires into the clay. In this way a very gradual change in pitch can be made and it can be held constant at the desired value.
Technical detail of the construction of Hugo Gernsback's Pianorad (1926).

The Coupleaux-Givelet Organ, like DeForest's plan, utilizes one audio-frequency oscillator tube for each note of the musical scale. For each different timbre they use a complete series of such oscillators followed by an amplifier and speaker. Thus, for 10 different timbres through a pitch range of 70 notes, they use 700 oscillator tubes and 10 amplifier and reproducer outfits.
Description of the French Coupleaux-Givelet Organ (1930s).

It is going to be about as easy to keep the Hammond Novachord out of every orchestra as it would be to bar a sax from a jazz band. Not only does it produce several instruments for the price of one, but it produces tones that no one ever imagined outside a Thorne Smith alcoholic extravaganza.
Nicolas DeVore (1939).

In the method and apparatus of this invention the composer, arranger, or conductor has at his command means for controlling the quality of each note, its intensity, intensity envelope, the degree of accent, duration, and tempo, without necessarily affecting any other note or tone of the composition.
John Hanert, on his encoded-performance synthesizer developed at the Hammond Organ Company (1945).

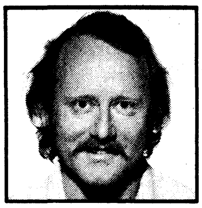
Engineers and composers now acknowledge that the consistent and systematic use of *voltage-controlled* instruments simplifies both the generation of complex, dynamically varying sounds and the arrangement of these sounds into a composition.
Dr. Robert A. Moog, on the Moog Synthesizer (1967).

Hindsight is equipped with 20/20 vision. From our vantage point we can appreciate the humor, pathos, or brilliance of prior developments. Hopefully, our glances into the past will lend some perspective on the use of contemporary electronic keyboards, and will foster the vision for future developments.

TOM RHEA

ELECTRONIC PERSPECTIVES

The Cahill Telharmonium, Part I

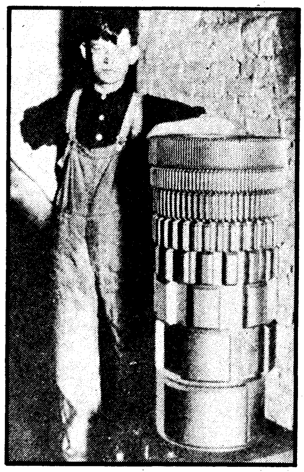


The earliest use of electricity to make music was in motor-driven acoustic instruments such as DeLaborde's Electric Harpsichord (1761). And some of the first discoveries in electrically *produced* sound happened accidentally, as when in 1837 Dr. C.G. Page inadvertently discovered the principle of the electronic tuning fork while experimenting with magnets and coils. In 1885, Ernst Lorenz patented an instrument in which an electromagnet alternately attracted and released small metallic bars.

Against the background of these and other early experiments, the electric music system designed and built by the American Thaddeus Cahill (1867-1934) is the *tour de force* of early electric musical instruments. Cahill's designs were predicated on three 19th Century technological developments: 1) the overtone theory, as demonstrated by Helmholtz some five years before Cahill's birth, which theory indicated that a complex tone may be produced by summing individual sine waves (simple tones with no harmonics); 2) the development of electric generators (alternators or dynamos) which were known to produce alternating current in a sine-wave pattern; 3) the newly invented telephone, which acted as a transducer that converted sound into corresponding fluctuations of electricity that could be transmitted by wire and reconverted into sound by a telephone receiver.

Cahill reasoned that if the output of an alternator were connected directly into a telephone receiver a simple tone would be produced. The pitch of this tone would correspond to the frequency of the current produced by the alternator. Cahill also knew that alternator frequency could be controlled in several ways, including regulating the speed at which the shaft of the alternator is turned. It was apparent that the outputs of many alternators could then be thrown onto the line using switches connected through mechanical linkages to a modified organ keyboard. With many such alternators and an elaborate switching system using several miles of wiring, one could create the complete harmonic series for each key on the keyboard and adapt the stops on the console for regulation of the volume of each harmonic. It would then be possible to combine all of the various alternator outputs used in a single line using transformers, thereby creating at the telephone receiver complex tones whose timbres were under complete control. The use of dynamos and the telephone receiver gave rise to the descriptive names "Dynamophone" and "Telharmonium."

If all of this is starting to sound a little like a Hammond Organ, it should. Laurens Hammond extended and used most of Cahill's ideas some 35 years later. So why didn't we have the Cahill tone-wheel organ in 1900? Primarily because Cahill's design preceded some important technological developments. Lee DeForest's "audion" (triode tube), which was the basis of the vacuum tube amplifier, appeared the same year (1906) that Cahill completed an advanced model of his Telharmonium. Within ten years, Dr. H.D. Arnold and others at Bell Telephone perfected the amplifier to the point where it could be used on transcontinental telephone circuits.



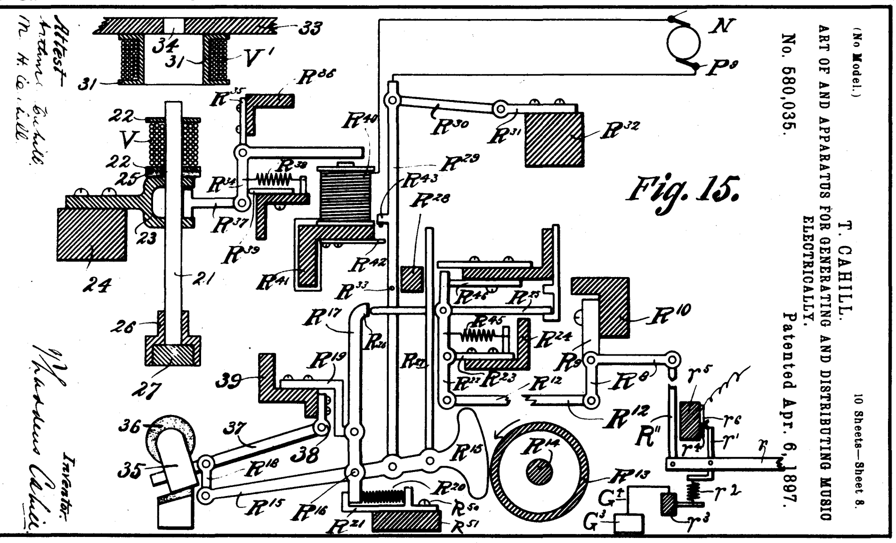
Rheotome cylinder tone wheel for Cahill's Telharmonium, c. 1902. This tone wheel produced a single tone having eight harmonics.

Because Cahill didn't have amplifier technology, the Telharmonium was a roadie's nightmare. Judging from photos and patent descriptions it weighed in at several hundred tons, and required a dozen railroad cars to be moved. These gargantuan dimensions were dictated because the instrument was designed to produce from twelve to fifteen *thousand* watts for each rotating element, without benefit of amplification.

Of course, Cahill had no idea of mass-producing the Telharmonium. He envisioned a network of telephone wires that would distribute "Telharmony" to thousands of distant subscribers. The Telharmonium was our first Muzak system!

Cahill's earliest models produced electrical signals not with alternators, but with simple rotating tone wheels or "rheotomes," that had alternate sections of conducting and insulating material. These tone wheels served to regularly interrupt an electrical circuit, creating alternating current. The complex waveform produced was smoothed to approximate a sine wave by filtering through successive inductances. Individual rheotomes were grouped with a fundamental frequency and up to seven overtones, comprising a "rheotome cylinder." Seven each of these rheotome cylinders were grouped on twelve long shafts, thereby producing the equal-tempered scale through seven octaves. A motor-driven system of pulleys which differed in diameter in the same ratios as the frequencies of the scale was used to rotate the twelve "pitch shafts." C# rotated slightly faster than C, and so forth.

Patent diagram of the touch-sensitive electromechanical-action keyboard mechanism of the Cahill Telharmonium.

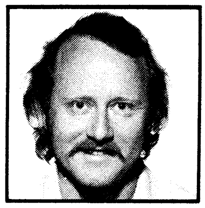


Of particular interest in Cahill's early Telharmonium model was the keyboard mechanism. Through a complicated electromechanical action which eventually brought two coils into relative degrees of proximity, the loudness was varied dynamically. An electrical instrument with a touch-sensitive keyboard, designed before 1900! It is interesting to note that the *interface* between man and machine has been the subject of concern for instrument designers throughout the history of electric musical instruments. Designs come and go, but the value of giving the musician *control* over sound in the performance situation has been recognized from the beginning. In our next column, we'll take a look at the public debut of the Telharmonium and examine some of its other expression devices.

TOM RHEA

ELECTRONIC PERSPECTIVES

The Cahill Telharmonium, Part II



Thaddeus Cahill (1867-1934) was a rare designer who combined a talent for invention with the legal expertise to patent his ideas and the business acumen to interest investors in his turn-of-the-Century Telharmonium. This massive instrument, also known as the Dynamophone, was virtually an electric power *generating plant*, with dynamos rotating at the frequencies of the musical scale.

A prototype with 35 rotating rheotome cylinders (tone generators) was developed in Washington, D.C., during 1900 and electric music was "distributed" by telephone wire in the area. These demonstrations attracted investors who made it possible for Cahill to complete a more sophisticated model in Holyoke, Massachusetts. Among the technical improvements in the latter model was the introduction of a gear-driven alternator (dynamo) system for tone generation, providing more accurate intonation. The speaker system was also improved so as to avoid the "shouting" of some notes encountered with earlier speakers.

From the performer's standpoint, an important feature of the new model was the multiple keyboard console, which could produce several tone colors simultaneously. The drawing below showing Cahill's voluminous patents indicates details. Several pitch manuals (45) and a pedal (45) could be programmed for different tone colors using switches (55) to govern various harmonics. Swell pedals (95) afforded variable and independent loudness control over these manuals. In addition, a small "dynamic" manual (67) was provided to allow instantaneous loudness changes. Cahill stated that two performers were necessary to master the console.

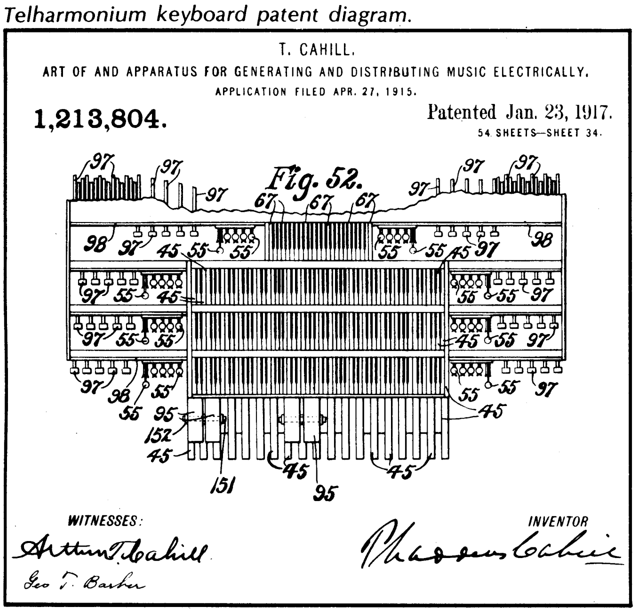
The summer of 1906 marked the commercial debut of the Telharmonium; demonstrations were made by wire at the Hamilton Hotel in Holyoke, about a mile from the plant. Media descriptions stressed the "fullness, roundness, and pureness" of the tones. Some reporters felt that Cahill had realized utopian predictions of music in the year 2000. Others hailed the Telharmonium as the harbinger of "democracy" in music, since fine music could now be delivered to "...towns, villages, and even farmhouses up to a hundred miles or more from the central station."

Spurred by these rave reviews, Cahill packed up his instrument—on several railroad cars—and moved to Telharmonic Hall in New York City. In September the doors were opened to some 900 members of the New York Electrical Society for the first public Telharmonium concert. Officers explained that the plant had power to supply fifteen or twenty *thousand* subscribers, and that plans were underway to supply four circuits with different kinds of music. The concert included several "classical" transcriptions, imitations of instruments, sound effects such as the passing of a drum and fife corps, and several vocals with Telharmonium accompaniment. (Times haven't changed much!) It was another round of success for Cahill's heavyweight.

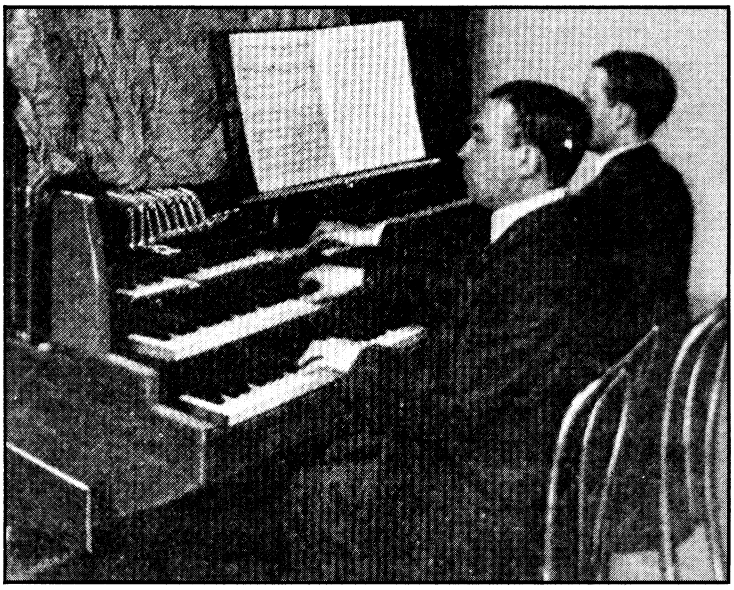
Although the outlook seemed bright and patronage was at first encouraging, the venture failed due to its own flaws before fledgling radio even had a chance to scuttle the music-by-wire concept. Evidently, Telharmonium wires wreaked havoc with normal telephone service due to the strength of the signal they carried. Cahill was beset with technical and legal difficulties, and many potential subscribers lost interest. Perhaps the Telharmonium would have failed in any case. As one of the performers noted, "In spite of the variety of tone color available, the instrument itself had its own special character which pervaded everything, and which in time grew highly irritating to the nerves."

Even though the Telharmonium was not a commercial success, Cahill should be recognized as the pioneer in early electric music. The general principles he developed were successful later in rotating-wheel electronic musical instruments such as the Rangertone and the Hammond Organ.

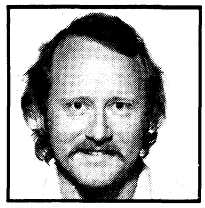
Telharmonium keyboard patent diagram.



Performers at the Telharmonium console.



TOM RHEA
ELECTRONIC PERSPECTIVES
The Cahill Legacy



Thaddeus Cahill's Telharmonium (1906) wasn't a commercial success, but the principles it embodied were used in later rotating-wheel electromagnetic instruments. The design based on Cahill's often consists of a number of iron disks with indented edges which are mounted on a shaft and arranged to rotate in front of an electromagnetic pickup. The pitch depends on the number of indentations and the speed of the rotation. The waveshape (timbre) produced approximates the pattern of the indentations. Many builders have used this design or variants of it; of particular interest are the instruments built by Ivan Eremeeff and R.H. Ranger.

Eremeeff constructed several electromagnetic instruments during the early Thirties, using several techniques discussed in a magazine article which appeared in 1932:

> The larger instrument is a synthetic type, operating on principles involving the synthesis of fundamental frequencies with harmonic, sub-harmonic, multiple, and fractional frequencies, for the production of musical tones of predetermined pitch, volume, and tone quality.

This is a description of additive synthesis, the creation of complex tones through the mixing of simple tones (sine waves). In contrast to this, the following passage describes an instrument utilizing subtractive synthesis, the modification of a complex tone using external circuitry, e.g. a filter.

> The smaller instrument, called a Gnome, works on the same basic principles employed in the larger instrument. The Gnome produces tone quality with the aid of a dial wave-alteration control, in which waveforms are modified by the selective connection of the output circuit to different taps of a transformer, or by a system of condensers which are adjusted by dial.

The Gnome had touch-sensitive immovable "keys" made of metal. The performer sat on a metal plate which made their body act as part of the circuitry! Expression devices included a volume pedal, a tremolo pedal, and a sustain pedal which controlled the final release of the tone. Particularly with Eremeeff's instruments, we are again struck by the early designers' interest in providing nuance with expression devices under the direct control of the performer.

Another early electromagnetic instrument was the Rangertone Organ (1931) developed by Richard H. Ranger. This instrument had some 50,000 separate circuits, and according to the inventor, a home model would have cost $5,000 (in 1931 dollars!). An unusual feature of the instrument was the amplifier-selection tone color system. The Rangertone had separate amplifiers that acted as individual channels when chords were played on the keyboard. The keyboard was split, and the highest three notes played by the right hand were routed to separate amplifiers; the lower keyboard had a similar arrangement. Thus it was possible to produce six notes with different tone colors by filtering the output of each amplifier independently. Separate tremolos were also possible.

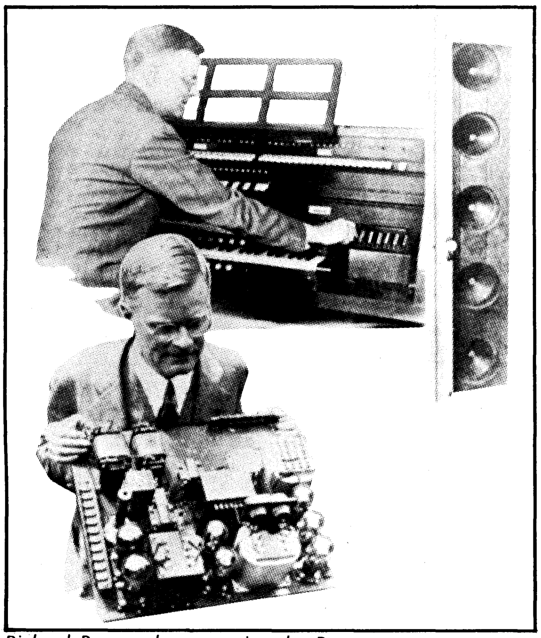
Public demonstrations and a radio debut of the Rangertone produced euphoric reviews. An example:

> No longer is the composer limited to the tones of traditional instruments. He can now specify timbres. What will become of the orchestra? Perhaps a quintet seated at keyboards and controlling electrical devices will take the place of an entire symphonic organization. Perhaps a new type of virtuoso will arise, a Paderewski and a Toscanini fused into one super-performer who deals with a thousand horsepower instead of a hundred musicians.

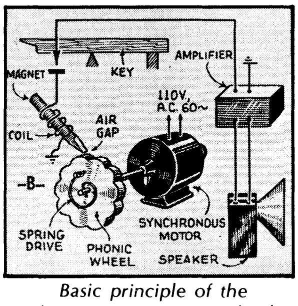
The prediction of the demise of the orchestra was premature. Doubtless, Richard Ranger had no such intentions or delusions. Nor did the reviewer think to ask as simple a question as, "What happens to the individual tone colors of the Rangertone *when the lines of the music cross?*" Musical imperatives must dictate the design of electronic musical instruments, just as they have the design of acoustic instruments.

Historically, there has been a perennial fascination with the 'keyboard-as-orchestra' concept. Given one brain and one pair of hands, a single performer just can't act like a hundred people. Perhaps it would be more constructive to explore electronic musical instruments for their value as limited but unique instruments.

Next month, the electromagnetic tone wheel makes good: the Hammond Organ story.

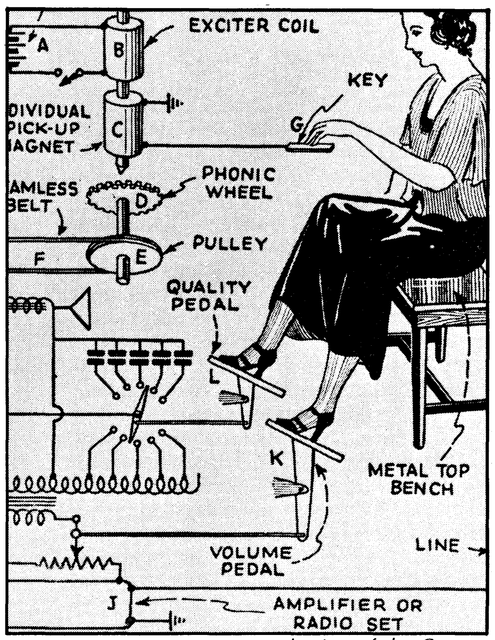


Richard Ranger demonstrating the Rangertone.



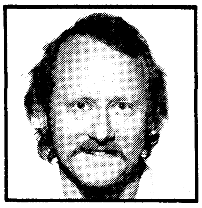
Basic principle of the electromagnetic tone wheel.

Eremeeff's Gnome.



Mechanism of the Gnome.

TOM RHEA
ELECTRONIC PERSPECTIVES
The Hammond Organ, Part I



The father of the Hammond Organ may have been a clock. At least, the tone-wheel Hammond Organ is driven by a synchronous motor similar in design to the motor of the electric clock that was the first product of the Hammond Company. The secret of this clock's accuracy was the motor which *synchronized* its speed to the closely-regulated frequency of electric current (60Hz in the U.S.). The same principle that made the Hammond Clock more accurate made the Hammond Organ more pitch-stable than its contemporaries that had vacuum tube oscillators.

When the Depression caused the market to be flooded with similar clocks, Hammond invented a device that shuffled a pack of playing cards into four piles. He built the device into some cabinetry to produce the Hammond Bridge Table! Far-fetched? Some fourteen *thousand* of these tables were sold in 1932, but the line was soon discontinued, again due to the Depression.

In 1933, Laurens Hammond began the search for a way to use his synchronous motor in a new product. After two years of research in collaboration with John Hanert, research engineer, Hammond constructed and patented his now-famous instrument.

The tone-wheel Hammond Organ is based on the modernization of Thaddeus Cahill's designs for the Telharmonium. (See my columns for Feb. and Mar. '77.) The Hammond Organ was made suitable for mass production by the mechanical simplicity of the design and the miniaturization made possible through use of vacuum tube amplifiers. This made it possible to have silver-dollar-sized tone wheels in place of Cahill's huge whirling dervishes. The early (A) model Hammond Organ had two manuals and pedal, a tone generating system with 91 iron disks driven in pairs on a common shaft by the synchronous motor, and a drawbar system that facilitated the production of many different timbres.

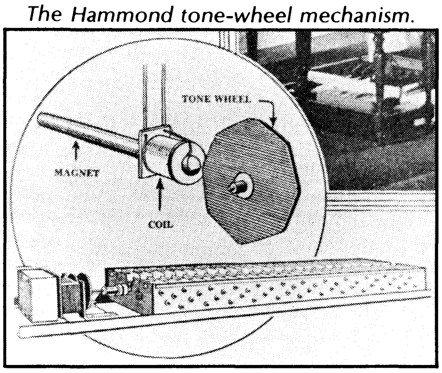
Laurens Hammond, c. 1937.

The Hammond Organ had its public debut in April, 1935, at the Industrial Arts Exposition in Radio City's RCA Building. On the way there, sales manager Emory Penny stopped in Detroit to give a demonstration for the company's first customer—Henry Ford. The New York demonstration was greeted enthusiastically by many who took their turn at the keyboard: Pietro A. Yon, organist at St. Patrick's Cathedral; Fritz Reiner, conductor of the Chicago Symphony; and George Gershwin, who immediately ordered one for his own use. As the story goes, when Gershwin got his Hammond home, he found the "lost chord" on it. But he got up to answer the phone and couldn't remember the registration when he returned!

The Hammond Organ had a significant impact on pop music almost immediately. In 1935, Milt Herth became the organist at radio station WIND in Gary, Indiana. He helped to establish a new style of playing. As a Hammond Company brochure put it,

> Herth's staccato style of playing the Hammond on WIND and other radio stations caught on quickly and became the distinguishing characteristic of his work. His "Stomping At The Savoy" recording in 1936 was the first of many discs that helped build his fame as a leading entertainer in theater, radio, and nightclubs.

The Hammond tone-wheel mechanism.



Another well-known performer on the Hammond Organ was Ethel Smith, a frequent performer on the "Hit Parade" and "Hit Parade Of Old Time Tunes" on radio. She specialized in Latin-American styles, of which, in a 1944 interview published in *Etude* magazine, she said:

> Latin-American music had long intrigued me, especially the rhythms, and believing the Hammond was particularly adapted to playing this music, I made a trip to South America to study it firsthand, adding Portuguese to my college Spanish. In eight months I had collected a number of examples of the samba, rhumba, tango, and conga, and found that the Hammond lent itself particularly to these sparkling rhythms. It was while playing at the Copacabana in Rio that I was offered a radio contract in the United States, and returned to accept it.

Since that time, the parade of professionals who have used the Hammond Organ is very lengthy. For many years, "electric organ" and "Hammond" were practically synonymous.

The Hammond Organ has long been secure in its niche in our musical society; but this was not always the case. In my next column we'll look at the furor that the Hammond stirred in its early years.

Ethel Smith at the Hammond, c. 1940.

TOM RHEA
ELECTRONIC PERSPECTIVES
Hammond Organ, Part II: Hammond And The FTC

Marshall McLuhan, media sage, says that the *content* of a new medium is likely to be an older *medium.* Some of the early movies contained vaudeville, and the content of television is often the older medium of film. When the videotape system becomes commonplace, its primary content will probably be television. Perhaps the content of a new musical instrument—its repertoire—is also derived from previous instruments. For instance, the content of Walter Carlos' *Switched-On Bach* is heard via the new medium of the multitrack tape recorder. Don't we actually hear an older *medium*—the orchestra?

Even those instruments destined for success go through a trial by comparison with earlier instruments, often suffering from derogatory comment. This fact escapes us because we don't make the connection between the story from the past and the spectacle of the present. Not many people are aware, for example, that as recently as the Sixties, the American Federation of Musicians tried to ban the synthesizer. Or that the introduction of the RCA Synthesizer in 1955 created a heated controversy between the A.F.M. and RCA. In the same way, the Hammond Organ Company was called before the Federal Trade Commission in 1936 for having the audacity to call their instrument an *organ!*

Hammond versus the FTC is a classic episode in the history of electricity and music; a story that continues to have implications today. When Laurens Hammond introduced his organ in 1935, he said that it shouldn't be compared with any other instrument; that it had a "voice of its own." But in 1938, the FTC ordered the Hammond Company to cease and desist from representing that its Hammond Organ "produces the entire tone coloring necessary for the rendition, without sacrifice, of the great works of classical organ literature"; that "it covers the entire range of musical tone colors"; that "any tone that is a sustained tone can be produced on this marvelous instrument"; and that "an infinite variety of tones, covering the flute, diapason, string, and reed families, are instantly available to the organist."

No one, including the Hammond Company, would make these claims today in behalf of the instrument. In fact, the Hammond Company had already dropped these advertising phrases by the time the FTC ruled. The ruling was actually a victory for Hammond, since it vindicated their use of the word *organ* to describe the instrument.

Today, an organ is an organ is an organ. But in 1936, pipe organ manufacturers insisted that the new Hammond gadget could never be called an organ; they suggested it might be called an "electrotone" to avoid confusing the public. During the court battles that ensued, there was a great deal of talk about the "faulty" harmonics of the Hammond, which were based on the equal-tempered scale. There were arguments concerning the construction of the human ear, and tests using tone analyzers that yielded complicated oscillographs. To shift to current perspective, you can imagine Jimmy Smith saying: "Hmmm. Neither a Rohr Flute nor a Koppel Flute. Must be a useless registration!"

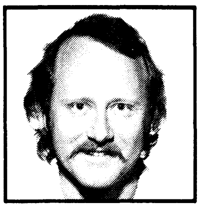
The furor reached its zenith when a Hammond organ was pitted against the $75,000 Skinner pipe organ in the chapel of the University of Chicago. Nine experts and fifteen University of Chicago students, the latter picked at random, were marched in for the test. Thirty selections were played, some on the Hammond and some on the Skinner; the panel was asked to tell which instrument was being played. The experts averaged about ten mistakes apiece, while the students came out about 50-50. The importance of the event lies in its *occurrence*, not in the interpretation of the results. However, the laws of probability do indicate that the students' judgements could have been duplicated by tossing a coin!

Beneath the smokescreen of talk about the debauchery of the word *organ*, there was some hard economic reality. The peak year for the pipe organ industry in this era had been 1927. By 1935, when the Hammond was introduced, there had already been a decline of some eighty percent in pipe organ sales. The electrical intruder was economical, portable, and reliable. Pipe organ makers were feeling the pinch. Some five thousand Hammonds were sold in the first three years, and about 35% of these went into churches. I believe, though, that the Hammond Company would soon have suffered if their organ had been perceived solely as a substitute for the pipe organ. As is often the case, the new instrument created a new market, and found its own position without displacing its predecessor.

There are certain parallels between this story and the present climate for the sale of synthesizers. How much nonsense have we heard about the "infinite" potential of the voltage-controlled synthesizer, which will supposedly make the sounds of "every instrument in the orchestra." (I've never heard an actual *designer* of a synthesizer make this claim.) How many arguments must we endure about esoteric notions such as the "purity" of the waveshape produced by an oscillator? (Musical instruments—and musicians!—have never been very pure. Virgin sinewaves we don't particularly need.) And now we must contend with the apparently magical word "polyphonic," which can transform an organ into something it isn't. Even the word synthesizer is of little use, since this can now mean anything from a legitimate musical instrument to a wah-wah pedal that promises the musical moon.

Claims as extravagant as the medieval argument about how many angels could dance on the head of a pin seem often to accompany new developments. A study of the history of electrical musical instruments suggests, however, that these survive *despite* rather than because of the hype that is written about them. This will undoubtedly be the case with the synthesizer.

Next time, we'll start the first of several columns on photoelectric musical instruments.



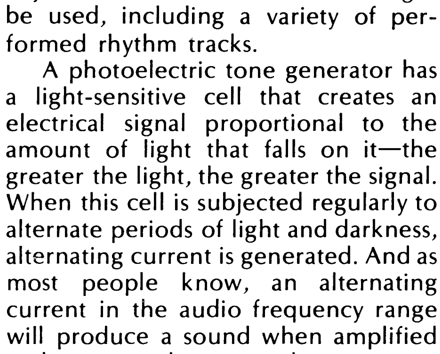
TOM RHEA
ELECTRONIC PERSPECTIVES
Photoelectric Instruments, Part I: The WCAU Photona

The photoelectric tone generator is one of the oldest and most popular designs for early electric musical instruments. The roots of this idea can be traced to 1890, when Ernest J.P. Mercadier used a rotating light interrupter with light-sensitive cells to create frequencies used for multiplex telegraphy. (This made it possible to send many messages simultaneously over a single wire.) Musical instruments using similar techniques began to appear during the early part of this Century. A modern photoelectric instrument is the VanKoevering (Vako) Orchestron, which reproduces sounds via endless-loop recordings that are inscribed in concentric circles on a single plastic tone disc. Theoretically, any sound that can be recorded might be used, including a variety of performed rhythm tracks.

A photoelectric tone generator has a light-sensitive cell that creates an electrical signal proportional to the amount of light that falls on it—the greater the light, the greater the signal. When this cell is subjected regularly to alternate periods of light and darkness, alternating current is generated. And as most people know, an alternating current in the audio frequency range will produce a sound when amplified and connected to a speaker.

Many types of photoelectric tone generators have been devised. One type has a rotating "tone wheel" that is placed between a light source and the photoelectric cell. Slits or other openings are cut radially on the wheel, and the wheel is rotated by a motor. The opaque sections that intervene between the slits interrupt, or modulate, the amount of light that passes from the lamp to the electric eye. The photoelectric cell "sees" alternate periods of light and dark. The pitch produced depends on the speed of rotation and the number of slits cut in the disc.

Photoelectric tone wheel mechanism.



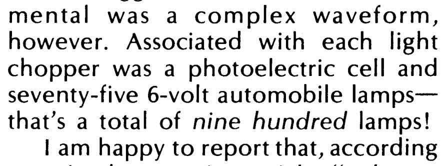
Ivan Eremeeff used such a design for an instrument constructed during the period 1933-35. The WCAU Photona was built in Philadelphia at the Electronic Music Studios of radio station WCAU. According to press reports, the Photona made its official debut in February, 1935, and was presented to the public over coast-to-coast and foreign broadcasts beginning in April, 1935.

The Photona was also known as the Eremeef Organ. (There is no truth to the rumor that it was ever known as a "polyphonic ensemble.") The Photona had twelve light choppers driven by a single endless belt connected to a synchronous electric motor. Slots were cut in such a way as to produce tones having various partials. Written accounts suggest that even the fundamental was a complex waveform, however. Associated with each light chopper was a photoelectric cell and seventy-five 6-volt automobile lamps—that's a total of *nine hundred* lamps!

I am happy to report that, according to a timely magazine article, "...due to the short time duration of usage of each lamp, the percentage of burned-out lamps is so small as to be negligible." And there is no truth to the rumor circulated by competitors that the instrument invariably caught fire when Henry Cowell's keyboard clusters were performed!

Seriously, the lamps were connected, through different circuits, to the keyboard of two 73-note manuals and to "stops" which governed tone control. When a key on a manual was depressed, corresponding lamps were lit and the appropriate tone was "chopped" by the tone wheel. For timbre control, the partials of any tone could be varied in strength with knobs which increased or decreased the amount of current feeding into the appropriate lamps. (Technical trivia: Alternating current was used for keying these lamps; the Photona was constructed using no rectifiers.)

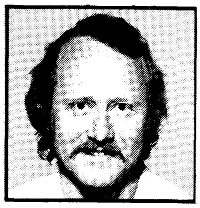
Photona tone wheels.



Eremeeff was a designer with an ear for musical nuance. In addition to the volume-control pedal that was standard fare for instruments of the era, he arranged for foot-operated control of *vibrato amount*. This was accomplished with a mechanical linkage that engaged a cam with a motor-driven gear; this in turn caused the displacement of the tone-generator drive belt on a cone-shaped pulley, creating true vibrato. This type of feature would be a welcome relief today from the constant-amount vibrato that still afflicts some electronic musical instruments.

The Photona also had a "percussion push" button that caused a sudden rush of current to the photoelectric cells, creating a cracking, percussive sound. Maybe Eremeeff was trying to provide a rudimentary dynamic keyboard for touch-responsive phrasing? Even though the Photona had an impossibly complex tone generator, there were sparks of genius in its musical engineering.

Of course, today we have electronic oscillators that can easily supplant electromechanical tone generators such as that of the Photona. So is there any real need for a photoelectric tone generator today? Yes and no. No, if we wish to produce only the classic rectangular, sawtooth, triangle, and sine waveforms—these can be generated easily and economically by an electronic oscillator. *Yes,* when exact replications of sounds such as the human voice and violins are desired; these are difficult to synthesize using electronic tone generators. Would the combination of the tone-shaping power of synthesizer modules with a photoelectric reader of acoustic sound be a felicitous marriage? In the next few columns we'll explore older photoelectric instruments to give some idea of what has been and what might be.



TOM RHEA
ELECTRONIC PERSPECTIVES
Photoelectric Instruments: The Superpiano

As explained in last month's column, a "light chopper," or rotating tone wheel, can be used to interrupt the light shining onto a photoelectric cell, generating alternating current that creates pitched sound. The Austrian Emerick Spielmann used the rudiments of this concept in his *Superpiano,* a photoelectric instrument developed during the early 1930s. But before we discuss this instrument, let's take a look at a principle concerning tone-wheel generators in general.

Ideally, any rotating tone generator should conform to a basic requirement: for each wheel, the number of indentations, teeth, holes, photographed waveshapes, or whatever is responsible for creating periodic electrical currents, should be a *whole number,* and the spacing between repetitions on the wheel should be exactly uniform. Otherwise, noise may be introduced or faulty intonation result. Unfortunately, frequencies of our commonly-used equal-tempered scale have irrational (not reducible to integers) ratios rather than whole-number relationships; only octaves of a given note have a whole number as their common denominator (a 2:1 ratio). Therefore, it is difficult to meet the integer relationship requirement of rotating disk technology and still build a single disk that will produce all the notes of the equal-tempered scale. Richard Dorf gives a concrete example of the problem in his book *Electronic Musical Instruments:*

> ...if the disc is rotated at 6.125 [rotations per second], the 16-hole outer band produces G-98 [Hz] and the 8-hole inner band yields the G an octave lower at 49 [Hz]. You will find that there is no other [integral] number of holes which could be used at this speed to produce any other musical note [in the equal-tempered scale]. In fact, you will have to have discs going at twelve different speeds to produce the twelve different tones.

In short, it would require *fractions* of holes to create the equal-tempered scale. But we know that this introduces noise and bad intonation. However, as Dorf suggests, we might put all the *octaves* of a note on a single disk without violating the whole-number requirement. Twelve such disks rotated at the proper speeds would produce the equal-tempered scale. For instance, a wheel with seven concentric bands of holes, the outer band numbering 512, the one next to it 256, and so forth, can be rotated at 6.125 rounds per second to produce high G (3136Hz), low G (49Hz), and all the intervening octaves. An unbroken span of six octaves of the equal-tempered scale could be produced with twelve such wheels. If you look back to my columns on the Telharmonium [see *CK*, Feb. & Mar. '77], you'll notice that Cahill solved the tone-wheel "problem" in a similar fashion.

Spielmann's Superpiano was based on the work of an early experimenter named Thiring. Little is known of Thiring's instrument except that it used twelve disks with holes that stood in octave relationships. A detail of the Superpiano tone generator shows twelve such disks of blackened film with light holes, and a mechanism which rotated each disk at the appropriate speed.

Spielmann's most unusual contribution was a keyboard which sensed the *depth* to which a key was depressed. As the diagram shows, when a key (Touche) was depressed, a flexible band of metal (Lame ressort) came into contact with a resistive element (Rheostat), gradually covering it. As the element was more fully covered, the strength of current and hence the volume of sound produced was increased. The Superpiano was therefore touch-sensitive—in a way that was musically useful only to the extent that the performer could master the difficulty of depressing the keys to various depths. Obviously, this keyboard would have presented some difficulties during rapid playing, but just imagine the sensitive attack for lyrical legato passages!

Spielmann understood the limitations of his design and foresaw expanded possibilities for the Superpiano:

> If, instead of mathematically calculated rows of holes on the tone plates of the Superpiano, photographic reproductions of single instrumental tones were fixed—a method known and accomplished since the sound film—the Superpiano would reproduce tones of this color in the loudspeaker. For example, it is possible to make a photographic record of the most perfect tones of Kreisler or Caruso, and adapt them to the tone records of the Superpiano. The Superpiano will then not only sound with the tone colorings of Kreisler's violin or Caruso's voice, but will compel the former to play contrabass and the latter to sing bass.

Spielmann also speculated about microtonal and theoretical scales with implications for composition:

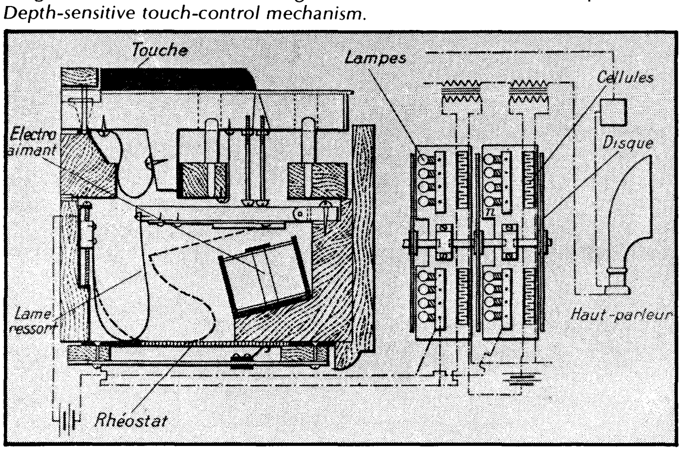
> There are future possibilities for music which the Superpiano can and will realize owing to its inherent powers. One can produce unlimited or theoretically-determined tone scales on it....Aside from the realization of the whole-tone scale, a mathematically exact quarter- or eighth-tone scale can easily be built. With reference to tone coloring, the Superpiano offers the possibility of entering upon untrodden ground. The Superpiano will need but a small time for the full realization of the vast possibilities dormant therein.

But as with so many electronic musical instruments throughout history, evidently no one really exploited the "unlimited" possibilities for tone scales. The Superpiano failed to attain its predicted success.

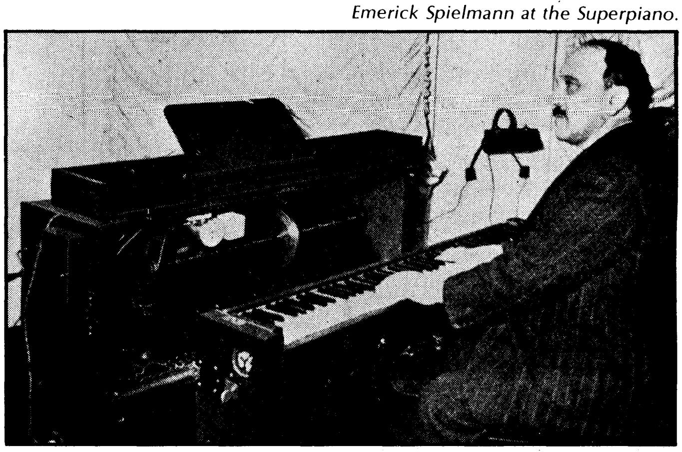
Perhaps our perennial fascination with the tone-coloring possibilities of electronic instruments has partially blinded us to the *necessity* for electronic instruments that afford increased control over the *nuance* of sound—performance control. I wonder what would happen if we declared a one-year moratorium on the "low-cutoff-frequency-high-resonance-on-the-filter" synthesizer syndrome. Oh, for that great day when the producer doesn't say, "Make it more electronic!" Or perhaps we might even settle for not knowing exactly which knob to turn when he makes that statement!

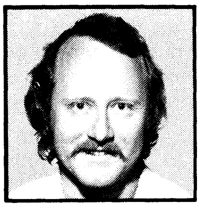
Upcoming columns will include more photoelectrics. Many designs have occurred, including some acceptable single-disk solutions to the tone-wheel integer requirement. I would also like some feedback from readers. What do you think of this column? Write to me c/o *CK* with your suggestions and comments.

Depth-sensitive touch-control mechanism.



Emerick Spielmann at the Superpiano.





TOM RHEA

ELECTRONIC PERSPECTIVES

Photoelectric Instruments, Part III: The Cellulophone

The "light chopper" tone wheel of the type found in the photoelectric instruments described in my last two columns acts to interrupt the path between a light source and a photoelectric cell. The basic concept is that the amount of light that falls on a photoelectric cell can be manipulated over time in such a way as to produce tones of various pitches when the signal from the cell is sent through a speaker. In the case of a simple design, waveform selection is somewhat limited; only certain tone colors can be produced. But using more sophisticated design concepts makes it possible to use the photoelectric principle to produce a wider variety of tone colors, including recordings of acoustic instruments.

Several photoelectric instruments have been built that allow the production of an explicitly defined waveform or the reproduction of recorded sounds. Before looking at these instruments, however, let's take a closer look at the photoelectric idea so we can better understand the design principles involved.

The output of a photoelectric cell is proportional to the amount of light falling on it—more light, more signal. Looked at another way, the more *area* of the cell we expose to light, the stronger the signal will be. That is, we can create a tone by controlling the amount of area exposed on the cell over time. Thinking in these terms, we can describe the light-chopper tone wheel in another way. When the opaque section of a typical light chopper is in front of the photoelectric cell, we can think of it as completely *masking* the cell. When the light slit on the wheel is directly over the cell, the entire area of the cell is exposed to light. Obviously, there are transition states, since the wheel moves smoothly from the masking position to the slit position, but it is apparent that this on/off system can produce only a limited array of waveforms. But if we had a way of masking the area of the cell that was exposed to light in a way that varied according to a specified pattern over time, we could produce any waveform that we could define, giving rise to a panoply of exotic tone colors.

There are two major ways of accomplishing this kind of photoelectric scanning, and they could be compared to bringing the mountain to Mohammed and vice-versa. The first employs an illuminated *stationary* scanning slit the light from which is modulated by a moving variable-area mask across it. Sound complicated? Just think of the soundtrack at the edge of a strip of movie film. The optical soundtrack is most often a variably darkened track that alters the amount of light allowed to fall on a photoelectric cell. Or, if you will, the amount of cell area that is exposed to light is constantly changing.

But for the time being, let's concentrate on the second type, which is the converse of the first. In this case, the tone-defining mask remains stationary while scanning slits one fundamental wavelength apart are moved over it. (Let's see, that's equivalent to having one frame of film and moving hundreds of projectors over it every second!) Actually, this scheme should sound somewhat familiar. Suppose we place a piece of opaque material such as cardboard over the photoelectric cell, first cutting out the exact waveform we want to create. Now let's take one of those rotating tone wheels with radially cut light slits—very narrow slits in this case—and place it between a light source and the masked cell.

As the slit passes over the hole in the mask, the mask will govern the length of the band of light falling on the cell, so that the cell will see a varying amount of light. We can control the amount of cell area that is exposed to light at any given instant by varying the shape of the mask. It should be apparent that this kind of tone generator will produce only *recurrent* signals—identical pulses will be produced as successive slits pass over the mask. Speech and other sophisticated, dramatically varying sounds wouldn't be possible, unless you could become an incredible quick-change artist with the masks! The stationary mask design, though, does yield explicit control over waveform, thus making available a wide variety of tone colors.

Instruments of the stationary mask type were produced as early as 1921, when the Frenchman E. Hugoniot patented an experimental layout with photoelectric cells fitted with shutters cut according to a definite waveform. In 1929, the German A. Schmalz improved on this arrangement with the addition of accurately etched waveforms that he called phonograms. At the same time, Earle Kent in the U.S. was suggesting a photoelectric instrument of a similar type.

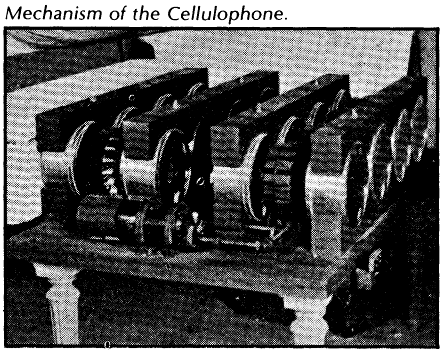
Only a small percentage of the designs for photoelectric instruments have led to complete instruments becoming commercially available. One that did was the Cellulophone, which was constructed by P. Toulon in France in the 1930s. The Cellulophone had the archetypal stationary mask design just described, but with some interesting features. Toulon used an optical arrangement that concentrated the modulated light beams from all the notes in a given octave into the same photocell. The keying of the beams of light associated with individual notes on the keyboard was achieved using small electromagnetically actuated shutters placed at the focal points of the respective beams. Four tungsten filament lamps were placed in a row, with a pair of disks placed symmetrically on either side of each lamp, giving the instrument an eight-octave range.

The Cellulophone used a *single* disk to create the twelve semitones in each octave, an arrangement that does not conform to the requirements of good tone-wheel technology (see my column for Aug. '77). The number of slits in each concentric row on a disk was undoubtedly a whole number (necessary to avoid sudden clicks or noise at the point of disjuncture in the row), and therefore the tone wheels had to have created tuning inaccuracies greater than the normally acceptable 0.1%. The Cellulophone was permanently out of tune.

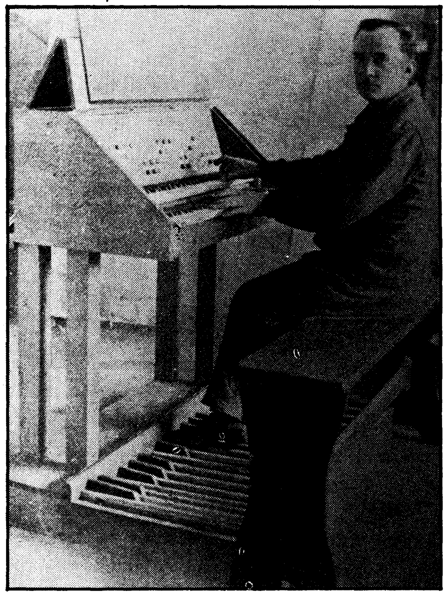
Even considering the tuning problems, this instrument offered some interesting musical possibilities. Because each octave of keys was routed to a separate disk, it would have been possible to place a different waveform mask in each octave, creating a total of eight different timbres simultaneously on one manual. But although Toulon had the backing of several business firms, the Cellulophone never achieved any lasting popularity.

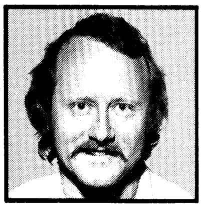
Next month, we'll talk about some photoelectric instruments that made film music—literally!

Mechanism of the Cellulophone.



The Cellulophone.





TOM RHEA

ELECTRONIC PERSPECTIVES

The Syntronic Organ

Ivan Eremeeff developed the Syntronic Organ around 1934 in collaboration with Leopold Stokowski, who was then the Director of the Philadelphia Symphony Orchestra. This instrument is yet another of the type that has a stationary, illuminated mask governing tone color. However, Eremeeff departed from the typical tone-wheel design [see *CK*, July, Aug., Sept. '77]. Instead he used a film with transparent "light slits" which passed rapidly over the photoelectric cell. Some models had a "pitch film" that would run for a limited time—just like a tape recorder. (Fake it! I have to rewind my organ!) Another version had an endless-loop pitch film.

The following is a synopsis of the operating principles of the Syntronic Organ (please refer to the diagram): The rapidly moving pitch film (a) rode on padded rollers, driven by a variable-speed motor that allowed tuning. The quality mask (b) was divided into sections and could be advanced manually (c) or by motor (d) to provide a selection of tone colors. Light from sources (e) was projected through the selected quality mask, then through variable "translucency disks" (f, g) which provided pedal control of volume and speed of tremolo. Finally the light passed through the running pitch film (a) onto a photoelectric cell. When a given key was depressed, an associated light shutter (h) was raised. This allowed the light to pass through the quality mask and fall on a single pitch track of the film. (The instrument was completely polyphonic, having 88 such shutters.) The light shutters rode in the spacers of the "diminishing rollers" (i), which revolved at a controllable speed in the direction which would cause the light shutters to return to their original position (creating silence).

The Syntronic Organ's envelope (loudness) control was remarkable. Each light shutter had a spring that held it against the diminishing rollers. A pedal could be used to simultaneously alter the speed of these rollers, *and* control the volume using the translucency disk (f), permitting the tones to fade away. That is, the Syntronic Organ could hold the sound and create a gradual release after the fingers left the keyboard—like a synthesizer. When spring tension was released, the shutters were freed; then when a key was depressed, its associated shutter would drop by its own weight back to its resting place. This created short tones comparable to staccato tones on a piano—or "zero sustain" on a synthesizer envelope generator that controls the voltage-controlled amplifier. Also, the 88-note keyboard was *scaled* so that "...each frequency of the musical scale has its own predetermined intensity."

Eremeeff designed not only this fascinating instrument, but the entire technology necessary for its support. He constructed a "universal" recorder capable of creating pitch and quality films by exposing running film to light patterns generated by a "flicker box" (see diagram). The pitch films were composed of numerous repeating uniform slits or apertures produced by rotating cams of the appropriate shape; light was permitted to pass through their openings and expose the film, creating tracks of definite frequency. To prepare quality films (masks), the recorder used cams with predetermined wave patterns cut into their peripheries (as shown); these too, revolved in the path of the light beams projected onto the running raw film. Naturally, the quality tracks were produced in a size that would correctly correspond to the associated pitch track.

Eremeeff and Stokowski had ambitious plans for this instrument. We read in 1934:

> At the present writing, plans are being discussed with a view to a symphony orchestra which is composed exclusively of electronic organs, of which there will be about 35. In such an orchestra, the individual instruments will, at specified intervals, play with definite qualities. When it is required that the quality be changed, the individual instruments themselves will take on, selectively, an entirely new and different tone.

Evidently these plans failed to materialize. But it is apparent from the preceding that Maestro Stokowski would have exploited the timbral capacities of the instrument to the fullest. Of more importance was the awareness of the features of musical *nuance* that constitute good performance:

> The tonal effects, such as the tremolo, which produces a rapid or slow fluttering reiteration of the tones, the diminishing or "fading away" of the tones after the performer's fingers have left the keys, the volume control, and the effects produced by the manner of key attack, are all controlled and varied by the individual touch of the artist. That is to say, the player must be an artist, since, in any symphonic music, the many intricacies of music modulation must be completely understood by each participant.

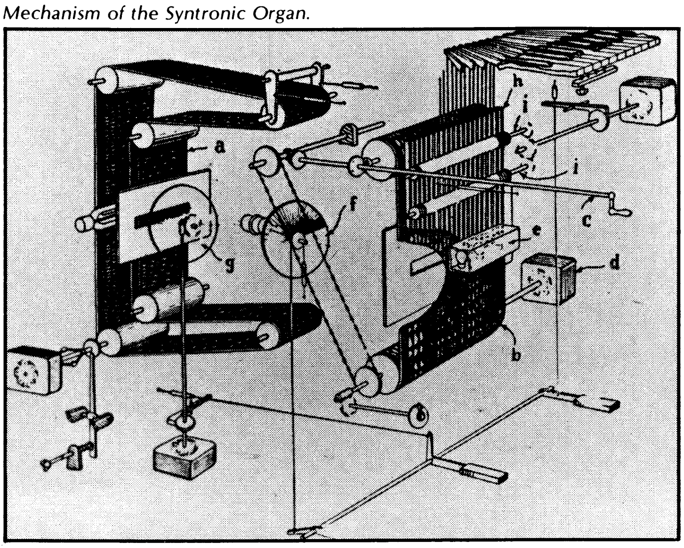
I believe Maestro Stokowski envisioned an orchestra of sound, not a "keyboard ensemble." So often we have fallen into the "timbre trap." Truly, one of the exciting things about electronic instruments is the control they allow over tone color. We can construct timbre electronically in ways that are difficult or impossible with instruments of a physical construction. But must we forget basics? The final quote on the Syntronic Organ hits this nail squarely on the head:

> The electronic organs permit of the finest musical control and expression, *due to those devices which change the musical effects* as well as to the many qualities which can be had from the quality masks [*italics added*].

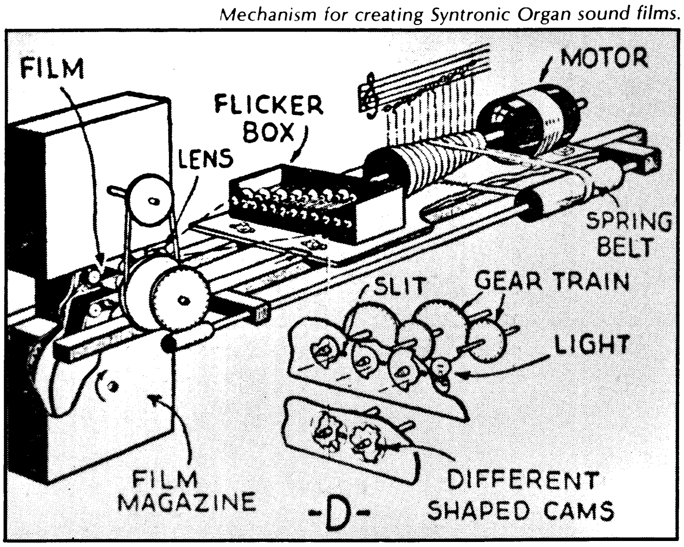
Stokowski and Eremeeff knew this in 1934. I wish that all existing manufacturers of electronic musical instruments knew it *now*.

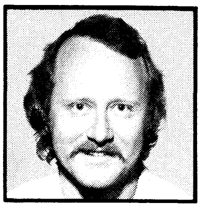
Next month, a final column on photoelectrics.

Mechanism of the Syntronic Organ.



Mechanism for creating Syntronic Organ sound films.





TOM RHEA

ELECTRONIC PERSPECTIVES

Photoelectric Acoustic-Sound Instruments

In this final column in our series on photoelectric instruments, we'll look at several keyboard instruments of yesteryear that could reproduce recorded acoustic-instrument sounds. (Yes, Virginia, the Mellotron and Orchestron have ancestors!)

As explained in my September '77 column, these instruments used the same principle as the film soundtrack. That is, a varying "mask" is moved past an illuminated slit and translated by a photoelectric cell, becoming electricity and thence sound.

One of the earliest examples of this type of instrument was the Hardy-Goldwaithe Organ, built around 1930 by Arthur C. Hardy and Sherwood F. Brown using ideas provided by Du Val R. Goldwaithe, a patron of the arts in New York City. The instrument was polyphonic, and had a pitch span of 71 notes. Tones sounded at the frequencies of the equal-tempered scale were recorded and transcribed photographically onto a single disk. Separate disks could be used for different tone qualities or instrument voices. In this design, the concentric tone rings on the disk were not in an integer relationship, so the inventors had to overcome the abrupt click that many of the wave tracks created due to the sudden phase shift at the end/beginning of the track. (For a fuller explanation of this phenomenon, see my column for Aug. '77.) Hardy devised an ingenious method for minimizing the discontinuities which occurred at the reentry point. Instead of allowing all of the phase shift to occur at a single point, it was divided among several points spaced equally around the wave track. In this way only a fraction of the total phase shift occurred at any given time, and the annoying click was avoided. (Incidentally, later versions of the tone disks for the present-day Orchestron use the same principle with computer-assisted transcription onto film.) The keyboard of the Hardy-Goldwaithe keyed shutters used to articulate the beams of light involved in the production of sound. According to B. F. Miessner, an authority on such instruments, the Hardy-Goldwaithe Organ used wave tracks "...translated from recorded waves of original [acoustic] instrumental sound." It was possible to "play" string and voice choirs from the keyboard as early as 1930!

In 1936, another photoelectric organ using similar designs was introduced by Edwin Welte in Germany. The Welte Organ was produced commercially before World War II; it had glass disks etched with photographically transcribed tone patterns. Like the Hardy-Goldwaithe Organ, the scanning slits of the Welte remained stationary and the glass disks were rotated. Also similarly, the glass disks could be removed and changed at will, making various registrations possible. But the Welte had twelve rotating disks, and conformed to requirements for good tone wheel technology—it could produce an accurate equal-tempered scale. Not only did each tone wheel provide the same pitch in successive octaves—typical of this type of design—but it provided a selection of waveforms within each octave as well. This meant that the keyboard of the Welte could be scaled to produce different tone colors in each octave—subtle or radical differences.

In fact, Edwin Welte had hoped to bring the tones of world-famous pipe organs to music lovers everywhere by recording sound tracks from actual stops of famous European organs. (Not a bad idea; I'd buy one today if someone could provide it!) But the instrument was destroyed during the war, and the project was abandoned.

One of the most curious instruments from this era was the Singing Keyboard built by Frederick M. Sammis in 1936. His comments are typical of the euphoria of the time regarding the photoelectric principle:

> Since it is possible to record any sound by the method used in talking pictures, suppose we consider just what a 'singing keyboard' can accomplish.... The talking and singing keyboard, together with electronic music, will place instrumental keyboard music on an entirely new plane, with new voice qualities and choral effects.

Sammis had come to Hollywood in 1929 to head up the "talking picture business" for RCA. He was familiar with the Moviola, or editing sound head. He reasoned that individual words could be uttered if appropriate strips of film soundtrack were pulled over the Moviola head. If this action could be placed under keyboard control—*voila!* (or *Movoila!?*)—the Singing Keyboard. But he encountered some problems:

> How were we to release these words when any key was touched; how were we to start the word from the beginning only? How were we to prevent the words from repeating themselves? No form of rotating or continuously-moving sound track seemed to fulfill these requirements. Reciprocating sound tracks were resorted to and immediately produced the desired results. There was still a fly in the ointment, though. True, the depression of any key caused a sound track recording of the word to be drawn over a light slit and between the usual exciter lamp and light-sensitive photocell, and the word then would be spoken by the loudspeaker; but when the key was released, the film track would travel back over the same light path and not only mess up the word itself by saying it backward, but interfere with the music and other succeeding words as well!

Sammis solved these problems with a mechanism that caused a drum to be rotated ninety degrees when a key was struck. The attached sound track was drawn over the light slit and photoelectric cell as described. A shutter was used to obtain the required one-way action, so the word would not be heard backwards.

Sammis had some very practical intentions for his Singing Keyboard:

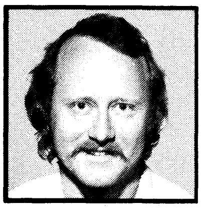
> Let us suppose that we are to use this machine as a special-purpose instrument for making 'talkie' cartoons. At once it will be evident that we have a machine with which the composer may try out various combinations of words and music and learn at once just how they will sound in the finished work. The instrument will probably have 10 or more sound tracks recorded side by side upon the strip of film, and featuring such words as 'quack' for a duck; 'meow' for a cat; 'moo' for a cow.... It could as well be the bark of a dog, the hum of a human voice at the proper pitch, or the universally understood 'la la' known to all, and to my mind, superior to much of the twaddle indulged in by some of our tin pan alley song writers.

If all of this sounds a little far out, just substitute *magnetic tape* for *film soundtrack* and *playback head* for *photoelectric cell,* and you would have an instrument something like a Mellotron!

Are these old instruments of any real interest today? Perhaps not in their original form, but just maybe.... Stop and consider that the most popular electric keyboards used by the working musician date back an average of at least 25 years in their design. Could we have missed something? Perhaps a further updating of music from light—fiber optics and laser technology—will yield a futuristic instrument that realizes some of the musical dreams of the early designers.

The fascination of accurately reproducing and controlling acoustic sounds from a keyboard is as strong today as it was when photoelectric instruments first made it a reality. What do you think?

See you next month with a new topic.



TOM RHEA
ELECTRONIC PERSPECTIVES
Prelude To The Electric Piano

Where did the electric piano come from? Efforts to "electrify" the acoustic piano in the '30s grew out of even earlier attempts to modify the instrument by *non-electric* means.

The mood for experimentation was brought about when sales of pianos slumped by fifty percent during the years 1913–1921. Some blamed the decline of the piano industry on the growing popularity of the phonograph and the radio:

> It seems that the pianoforte is passing away. A few years ago the music shops were full of songs and piano and violin music; now they devote their space to gramophone disks and jazz records. Piano teachers complain that they have fewer pupils.

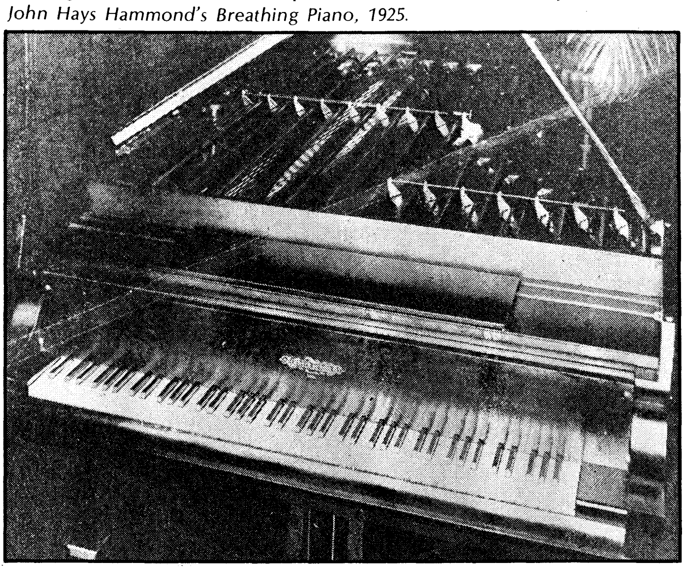
Several inventors offered modifications of the piano that were intended to create new expressive effects. In 1921, Emmanuel Moor introduced his two-manual octave-coupled piano in England. With Moor's piano it was possible to attain 4′ and 16′ tones (like an organ) similar to the tone of the single keyboard piano. The Moor piano generated some enthusiasm at first, but eventually faded into obscurity.

In 1925, a more successful piano was introduced in the U.S. by John Hays Hammond Jr. Hammond's Breathing Piano used a series of pivoting slats mounted above and below the piano's soundboard. The object was to control the release of acoustical energy from the soundboard. The following was a description of Hammond's scheme:

> Mr. Hammond conceived the idea of reflectors which should cover the entire top of a soundproof case. The reflectors are parallel revolving slats which can be opened and closed at the will of the player by the extra pedal in very much the way the old-fashioned slatted window shutter was manipulated. Since the case is soundproof, as are the metal-faced reflectors, the tone can be built up within the pianoforte and then permitted to escape at will. Furthermore, the reflectors can return to the sounding board a large degree of the energy imparted to the strings by the musician, the amount depending on the angle at which the reflectors are set by the pedal operator with respect to the sounding board. The return of energy to the soundboard was suggested to Mr. Hammond by the so-called regenerative action familiar to radio fans. The action achieved in the Hammond device is a sort of acoustic regeneration, maintaining vibrations of the soundboard for unusual durations of time.

There is some doubt that the idea of using shutters over piano strings originated with Hammond. But he did a great deal to popularize the concept. His Breathing Piano was presented in several demonstrations by Lester Donahue. Later, in 1929, Donahue made an extended concert tour outside the U.S., during which both concert pianist and inventor won praise. Even so, the instrument disappeared after a few years.

John Hays Hammond's Breathing Piano, 1925.



These experiments with the acoustic piano had little lasting effect. Several writers forecast a gloomy future unless something could be done to rejuvenate public interest in the instrument. Margaret Anderton wrote in *The Musician:*

> The time has come, and has now ripened, for some further improvements in our well-beloved instrument. The whole scheme of the pianoforte is on the brink of great changes. Both manufacturers of this popular instrument and artists and players upon it have for some time been realizing the need for certain improvements.

Beryl Rubinstein, concert pianist, implied that the compositional possibilities for the piano might have been exhausted. He wrote:

> I am not an inventor and cannot presume to say just what directions new ideas of piano playing or manufacturing will take. We seem to have traveled the full length of the road so far opened. We have scanned the scenery thoroughly. We must have a new horizon, otherwise we shall look no more, and not looking we will cease to think. There remains then stagnation.

The stage was set for the application of electricity to the piano—attempts to create an instrument with new tonal and expressive capabilities.

In 1930, Simon Cooper, a Brooklyn scientist and engineer, introduced his Crea-Tone, which was designed to prolong the tones of an acoustic piano. The Crea-Tone represents a halfway point in the evolution of the piano from the acoustic to the electric design. It used electrical circuits to maintain the vibration of acoustic piano strings. Conversely, today's electro-mechanical pianos (Wurlitzer, Rhodes, and others) use vibrating elements to generate electrical oscillations. These pianos require a loudspeaker; the Crea-Tone did not.

The Crea-Tone was essentially a piano fitted with electrical feedback circuits designed to maintain any string in vibration as long as its key was depressed. Joseph Schillinger reported that the "...musical characteristic of the tone, which is produced by the help of electro-magnetic induction of the strings, is the absence of vibrato." This instrument made it possible to achieve a continuous sound on some keys while others could be played as usual. A lyrical melody with staccato accompaniment was possible. A reviewer described a concert given at the Wanamaker Auditorium in New York City:

> The effects of the sustained tones, with varied dynamic gradations and nuances being obtained by use of a pedal, was striking, especially in Chopin's "Etude In *E* Major." The increased prominence of overtones which the device apparently brought out, as well as the extra sympathetic vibration, resulted in many unusual effects. To the auditor the notes lost their characteristic pianistic quality and took on poetic and mixed timbre, suggestive of the same note being held simultaneously by an English horn, a saxophone, and an old-fashioned small reed organ.

Unfortunately, the Crea-Tone was short-lived. Today we see a reflection of Cooper's basic idea in the E-Bow, a device that can be held close to guitar strings to give them infinite sustain.

Imagine an electric piano with pickups that transduce the movement of strings; the strings are kept in motion a la the Crea-Tone. But now we have an electrical signal that can be modified with synthesizer modules. Might this produce an instrument with the *liveness* of an electro-mechanical tone generator and the flexibility of articulation offered by voltage-controlled envelope and filter control? Maybe such a development could alleviate the idea that electronic musical instruments don't sound "live."

Personally, I am not ready to bring down the curtain on electro-mechanical tone generators; many of the instruments we play today have them. Perhaps some instruments from the past have potentially useful elements that are ignored because they are no longer "state-of-the-art." State-of-the-art electronics doesn't necessarily guarantee that an instrument will be musical.