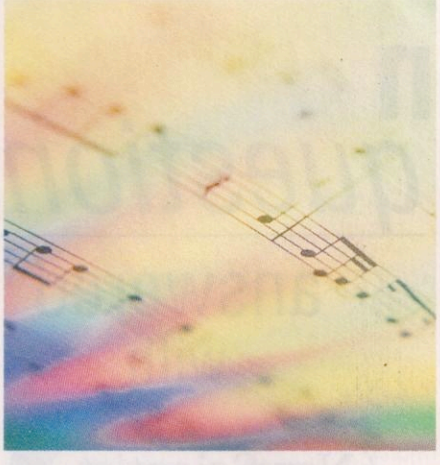
Rave from the grave

What are Rachmaninoff, Fats Waller and Oscar Peterson all doing in the living room, playing your piano?



Images

THIS October, fresh recordings by the great Russian pianist and composer Sergei Rachmaninoff shot into *Billboard* magazine's top ten. It was a curious turn of events. The recordings were made in a hall just outside Los Angeles earlier this year, yet Rachmaninoff has been dead for more than 50 years.

The key to Rachmaninoff's ghostly comeback is a computer-controlled piano and a series of binary recordings that the pianist made between 1919 and 1929. His performances were recorded as holes punched in piano rolls, which resembled rolls of fax paper and served as the floppy discs of the time. The new recording is the work of Wayne Stahnke, a Los Angeles inventor who is central to the development of computer-controlled pianos. He took the piano rolls, scanned the pattern of holes into his computer, and converted the resulting image into data that can be read by the Bosendorfer SE, the computer-controlled piano he designed. It was this machine that brought Rachmaninoff back to life this year.

Rachmaninoff is now available for repeat performances. But don't expect to hear him play a Bosendorfer SE—only 33 were ever made and Stahnke owns two of them. But Stahnke has also converted the performances into files that can be played on Yamaha's more widely available Disklavier. He's even posted a sample of the conversions on the Web. So if you want to hear Rachmaninoff play an extract from Rimsky-Korsakov's *Flight of the Bumble Bee*, all you have to do is to download it onto a floppy disc and put it in the nearest Disklavier.

In an age when pop CDs positively throb with digital sounds—everything from electronic drums to oral excitation and sampled passages stolen from past hits—player pianos may seem horribly old-fashioned. Yet the advent of a thing called the musical instrument digital interface, better known as Midi, has opened the way to a new generation of advanced player pianos, such as Disklavier and Bosendorfer SE, that are half computer, half acoustic instrument.

Midi is a standard for digital music, which emerged in 1981 after an agreement between the major manufacturers of electronic instruments, including Roland and Yamaha. Today, virtually all electronic keyboards, along with many other instruments and the soundcard in your computer, can produce a Midi file and play it back. A Midi file is essentially an electronic version of what is recorded on a piano roll, and includes such basic information as when a note should be sounded and how long it should last.

Many of the world's leading pianists have recorded for the new player pianos, including Chick Corea and Dick Hyman, who directed the music for several Woody Allen films. But why not listen to these musicians on CD? Part of the reason is that, even with the best recording techniques, no CD can match the perfect high fidelity of a piano. "My interest has always been in real piano music," says Stahnke.

Player pianos are also great teachers. A piano's keys are just levers that seesaw about a fulcrum. While a human pushes them down at the front, computer-controlled pianos have a row of solenoids at the rear that push the keys up. So when a midi file plays, phantom fingers appear to fly over the keys. For an aspiring pianist it's like a master class with the hero of your choice. You can even slow the music down to follow the fingers through a difficult passage until you have perfected it. In the 1920s and 1930s, Fats Waller and a host of other pianists learnt to play in just this way—though, of course, they had to rely on piano rolls rather than floppy discs.

The idea of recording a pianist and then playing back the performance on a piano goes back to about 1903, when a German

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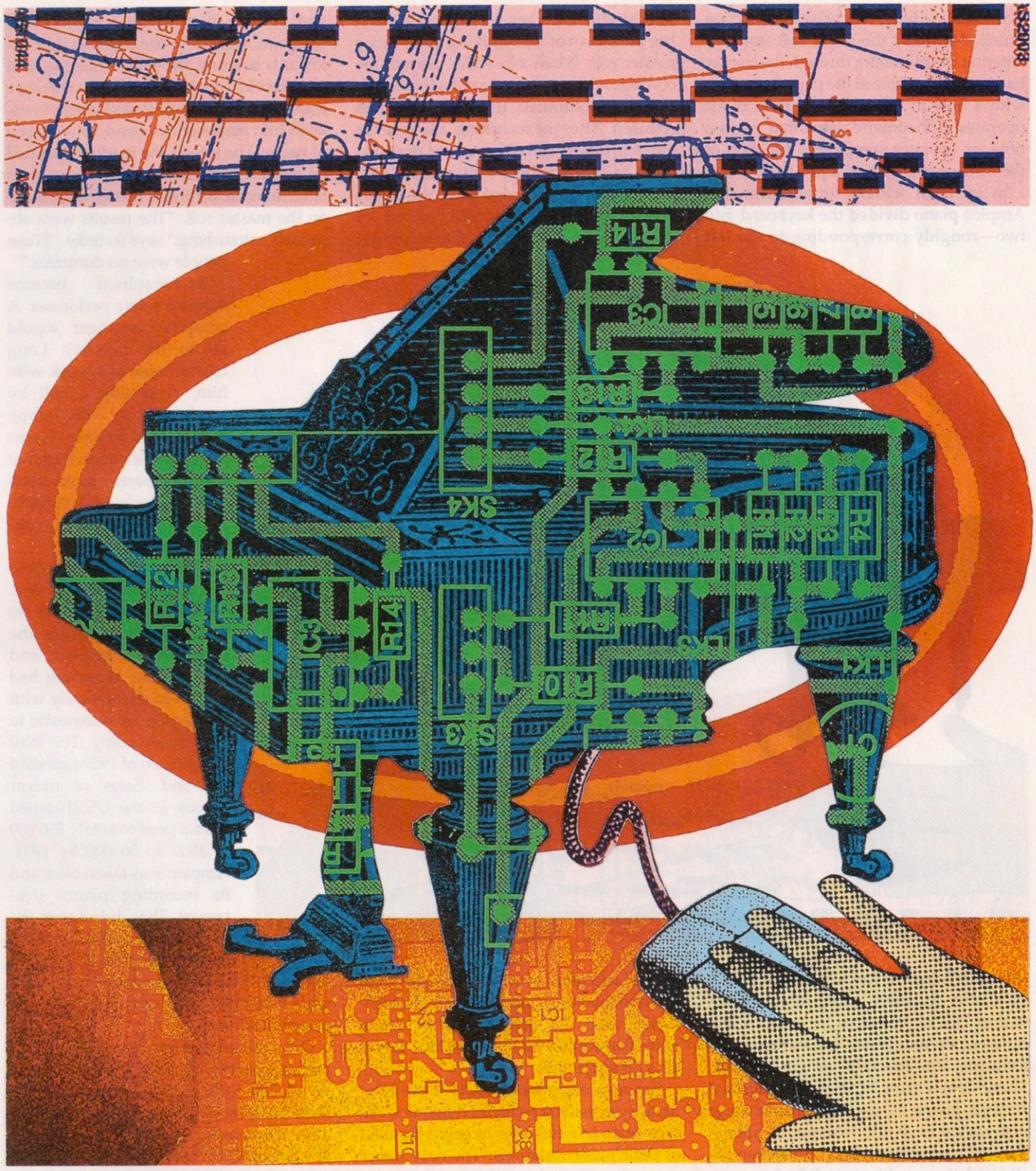


piano maker, Edwin Welte, invented a system for recording rolls. Many of Europe's leading soloists of the time recorded for Welte, including the French composer Maurice Ravel. Within a few years Welte's idea had spread to the US.

Left to their own devices, most player pianos play back just the notes on a piano roll at a constant volume. But there were a variety of very sophisticated machines at the top end of the market. Rachmaninoff made all his recordings for the American Piano Company, which marketed the "reproducing piano"—an instrument that the company claimed could reproduce every nuance of a performance, including the dynamic range. Ampico had an active research laboratory, which devoted considerable effort to perfecting its pianos and improving recording techniques.

These early machines worked by suction. As a piano roll unwinds, it passes over a brass "tracker bar", which has a row of holes cut into it. Each hole is connected via

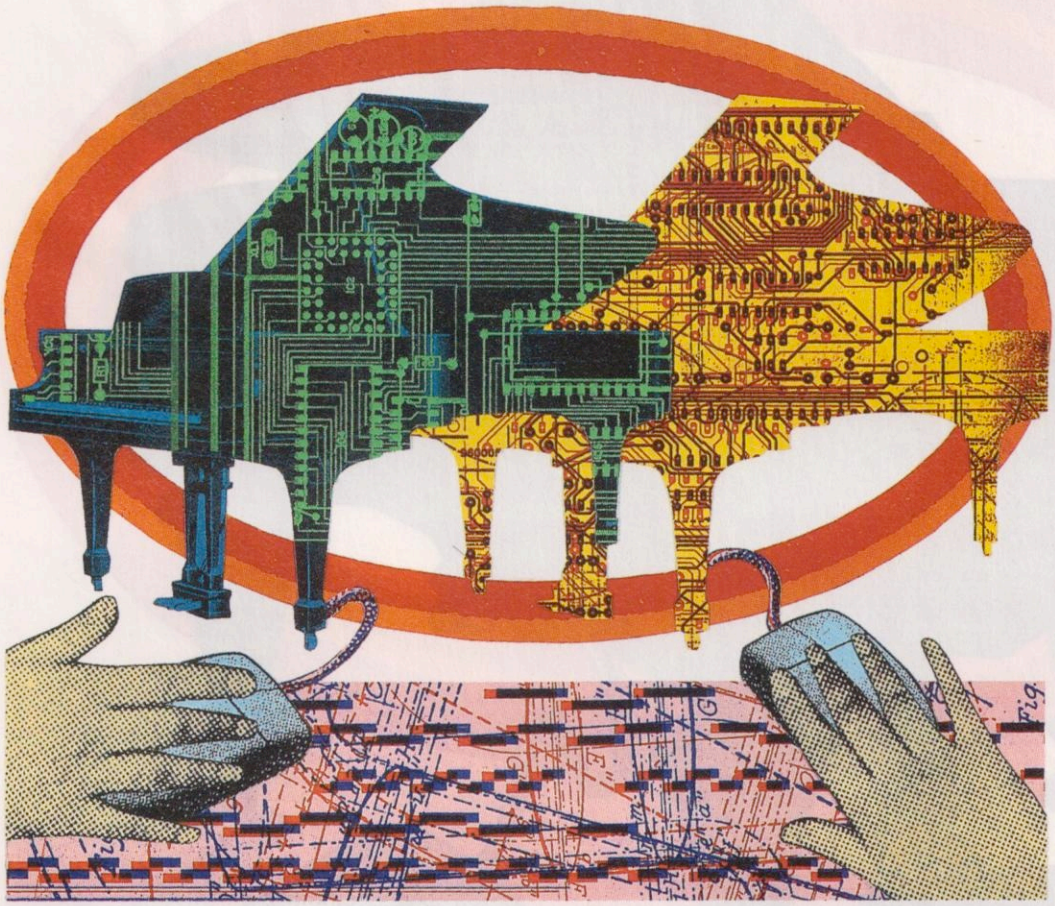
a collection of pipes and valves to a suction pump. Normally the paper roll stops air entering the plumbing through the tracker bar, but when a hole in the paper coincides with a hole in the bar, the inflow of air operates a pneumatic valve that plays a note, or operates some other function of the instrument, such as a pedal.

In its most widely found form, the Ampico piano divided the keyboard into two—roughly corresponding to the left and right hands. It had a three-bit coding system for dynamics, which allowed each half of the keyboard to be set at seven different volume levels by increasing or reducing the strength of the suction. These levels were in steps of roughly 3 decibels, giving the piano a dynamic range that varied from the whisper of pianissimo to a loud fortissimo. A mechanism allowed the machine to slide from one volume to another, so it could reproduce a crescendo. The volume could also be changed rapidly, so the piano could accent notes and pick out a melody. But unlike modern computer-controlled pianos, the machine could only play—not record.

To make his recordings, Rachmaninoff used a recording piano in Ampico's New York studio. Each key was linked to a stylus poised over the moving paper of a master roll. When a key was played, the corresponding stylus marked a line on the roll that continued until the key was released. After the recording, a technician took the master roll of paper and punched holes in it where there were marks.

This process recorded only the notes. The dynamics were mostly added by editors, who listened to the recording session and marked which passages were soft and loud on a musical score. The technician used this information to punch holes that controlled the dynamics. It was all a bit subjective.

Various companies claimed to have automatic systems that recorded dynamics, but they seem to have been largely a figment of their public relations. The only documented system, from the Ampico company, made its debut in 1926 (*Journal of the Acoustical Society of America*, vol 1, p 138). The people at Ampico realised that the volume of any note depends solely on the speed of the hammer as it hits the string. If it strikes at high speed, the note is loud; low speed gives a soft sound. Ampico's recording piano had a silver wire embedded in each of its hammer shanks (see Diagram, right). As the hammer headed towards its string, the wire brushed against two electrical contacts in turn, producing a signal that the recording mechanism translated into marks on a second, moving roll of paper. The size of the marks depended on the speed of the hammers. Technicians later married up these marks with those on the master roll. "The results were absolutely astonishing," says Stahnke. "These people were no dummies."

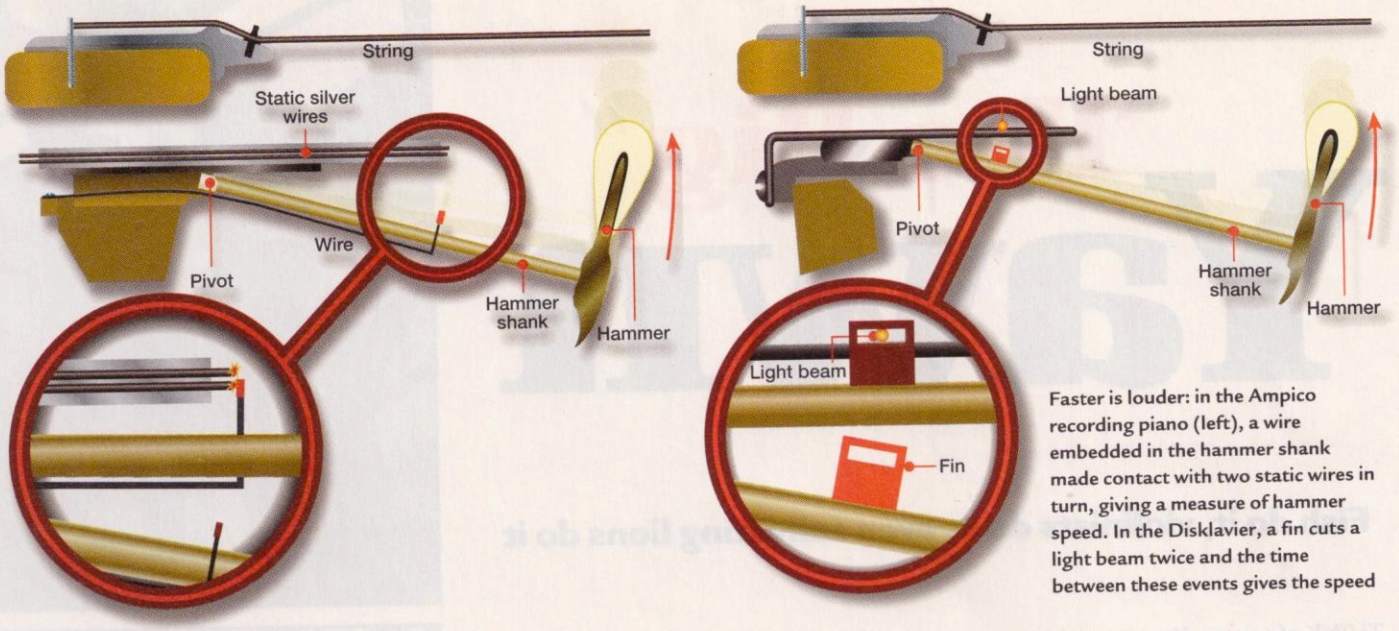


Rachmaninoff became Ampico's star performer. A company arranger would go to the pianist's Long Island home and work with him, correcting a roll by hand until he was happy with it, says Stahnke. It was perhaps not surprising that the company took such pains: in the late 1920s, Rachmaninoff was being paid $1000 a roll.

The heyday of the piano roll came to an abrupt end. By the late 1920s, the radio was already replacing the piano in the parlour, and gramophone recording had improved dramatically with the switch from acoustic to electric recording. The Wall Street crash of 1929 signalled the end. Sales of player pianos in the US slumped from a peak of nearly 350 000 in 1923 to 50 000 by 1931. Ampico was taken over and its recording pianos destroyed. That didn't stop the new owners issuing rolls and claiming that they were made by a real pianist, when in fact they were made by expert operators wielding punch machines.

Only one of the few dozen recording pianos from this era is known to have survived. The QRS recording piano, dating from 1912, owes its existence to the company's arranger, who saved it from the scrapheap. QRS, which still makes piano rolls in Buffalo, New York, reacquired the piano and even used it to record new rolls in the late 1960s. In 1992, the American Society of Mechanical Engineers gave the piano a heritage award in recognition of its contribution to binary recording.

Though the player piano industry was dead, it refused to lie down. In 1978 it stuttered back into life when the electronics



Faster is louder: in the Ampico recording piano (left), a wire embedded in the hammer shank made contact with two static wires in turn, giving a measure of hammer speed. In the Disklavier, a fin cuts a light beam twice and the time between these events gives the speed

company Marantz put its Pianocorder system on the market. Like the reproducing pianos, it divided the keyboard into two halves. But with a five-bit system for dynamics, it could reproduce 32 different levels of volume. Like modern player pianos, it used solenoids to work the keys, but stored its digital music data on cassette tape rather than floppy discs. Marantz issued a few fresh recordings, including ones by the jazz virtuoso Oscar Peterson and, the matron's heart-throb Liberace.

But the Pianocorder enjoyed only a short life. Advances in computer technology and the advent of Midi quickly overtook it, and Marantz quietly killed it off in the mid-1980s. Within a few years, the latest generation of machines started to arrive. The Viennese piano maker Bosendorfer began marketing Stahnke's piano and Yamaha launched the Disklavier.

These instruments have distinct advantages over their predecessors. Both can record music as well as play it back. The solenoids in the Disklavier can produce 127 different levels of hammer velocity, although the lowest 25 or so are silent because the hammer does not even reach the string. Each note can be given a different velocity—which makes it possible to accent just one melody note in a chord. The Bosendorfer SE has even greater resolution than the Disklavier, with 1018 levels of hammer velocity.

In recent years, the competition has hotted up. QRS and Music Systems Research of Sacramento, California, sell kits that can be fitted to almost any make of piano. MSR, which has sold 30 000 of its PianoDisc systems over the past ten years, claims to be the world's biggest supplier of computer-controlled player pianos.

A little light music

Many of the world's leading pianists have made the trip to Yamaha's studios in California and Japan to record for the Disklavier. Yamaha has bought the rights to many of the patents that Stahnke held—notably the one for recording the hammer velocity. Stahnke is now a key member of Yamaha's Disklavier design team, which is based at Hamamatsu, Japan. His system for recording piano dynamics recalls the one used by Ampico half a century ago—although that was not mass-produced.

Each hammer shank on the Disklavier carries a tiny fin, with a small slot cut in it. Light from an LED at the bass end of the piano is picked up by a photocell at the treble end. When the hammer starts towards the string, the leading edge of the fin breaks the beam. The slit in the fin restores the beam before the second leading edge cuts it again. "The velocity is recorded from leading edge to leading edge," says Stahnke. The output of LEDs can vary enormously with temperature, he says, but this very simple technique provides an elegant solution because the LEDs have to stay constant for only a matter of milliseconds. "I was very proud of it when I thought of it," he says.

One potential weakness of modern machines is that the performance of their solenoids deteriorate as they warm up, says Stahnke. The result is that the hammer velocities can wander slightly from those specified by Midi files. Stahnke solved this problem on the Bosendorfer SE and Yamaha's latest model, the Disklavier Pro, with fast-acting feedback. Electromagnetic sensors monitor and adjust the velocity of the solenoid strokes as they push the keys so that notes sound exactly as loud as they are supposed to.

Since its public debut 10 years ago at a burger bar in Limon, Colorado, the Disklavier has come far. This year it was on stage with the Boston Pops orchestra, playing converted piano rolls recorded by the late great composer George Gershwin. And its most recent starring role is in the Oscar-winning film *As Good as it Gets*. The title is appropriate. "I think the technology is now pretty much mature," says Stahnke. "The reproduction is so close to the original that the human ear cannot tell the difference."

Mick Hamer

Further Reading: You will find an excerpt from the *The Flight of the Bumble Bee* at **www.radiodesign.com/rolls.htm.**

Other useful addresses: **http://boesendorfer.com/se/** and **www.yamaha.com/pianos.htm** Music Systems Research are at **www.pianodisc.com/** while QRS are at **www.qrsmusic.com/**

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