

SOUND RECORDING TECHNOLOGY

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Minimize Successive Copying in Overdubs  
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Jay McKnight, Chair  
AES Historical Committee,  
2004-02-13

## Sel-Sync and the “Octopus”: How Came to be the First Recorder to Minimize Successive Copying in Overdubs

*Early in 1957 Ampex Corporation delivered the first multi-track professional audio recorder to be equipped with a scheme called Sel-Sync to the recording artist Les Paul. Paul nicknamed it The Octopus, for its eight channels. It has become something of a landmark in recording history, since it appears to have been the first tape recorder to make possible performances consisting of many parts – these to be recorded not in real time – now greatly reducing the compromise of quality that was formerly imposed by the necessity of extensive successive copying of copies. This article recalls the invention of Sel-Sync. The author is grateful to others who attended the machine's creation and have augmented my memory of the story.*

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Les Paul is famous for records consisting of many parts, each played by himself. Many of the early recordings were with vocals by his then wife, Mary Ford. All parts were added together in the final record. The process has been called “sound on sound,” or “overdubbing”. For some time Paul accomplished this by taping a first track on his Ampex Model 300 recorder, then playing it back on the machine, modified to have four heads arranged as follows: 1) playback, 2) erase, 3) record and 4) playback. The earlier part now was played from the first head and simultaneously dubbed to the recording head, but also fed to the artist's headphones. Thus he would perform an additional part whose microphone would add it in perfect synchronism with the first. Both now were fed to the recording head, creating a new, two-part record. As this second, combined part was being recorded, the earlier one was erased. The process was repeated until the final recording had as many parts as desired. With this precarious procedure, any error would necessitate starting over from the beginning. Moreover, as each new part was added, all the earlier ones became copies of copies of copies, ad infinitum, each adding some corruption. Subsequently, the process employed two conventionally configured Ampex Model 300 recorders, one feeding the other as parts were added, but each time preserving the earlier summation tape. Degradation from successive copying remained a problem, however.

In 1955 and 1956 I was manager of the Special Products Section within the Professional Products Division at Ampex. I clearly recall one day, sitting in my cubicle in the 860 Charter Street building in Redwood City, being struck by the Sel-Sync idea. The sound-on-sound process, or “overdubbing,” needed relief from that endless, successive copying, each generation adding degradation. It would be well also to help abandon anyone's use of the earlier procedure, wherein each new addition endangered all the former ones.

Ampex had special ability to construct precise, stacked, vertically aligned, multi-channel magnetic heads. Various ones of these had been made for years for instrumentation uses. Many seven-channel units had been built since 1949, both for AM and FM instrument recordings. Unusual talents, like those of the late Edith Dinsmore, made possible heads of complexity, performance and precision others envied. Thus there was a history of vertically stacked, multi-channel recording and playback heads. By 1956 the technology could produce such heads with rejection of track-to-track cross talk sufficient to deliver performances clearly separated. Also, new erase heads could efface tracks individually. These accomplishments made the Sel-Sync scheme newly workable; it would not be possible without them. Its time had come, as it had not, earlier.

The Sel-Sync invention was mine. Nothing like it had been discussed earlier, but the technology now encouraged its creation. Certainly I invented the scheme intending to improve the recording process for those doing overdubs for any reason, and Mr. Paul was on my mind. I had high hope he would find it a useful contribution to his art and was gratified when he received our description, saw its advantages and accepted our proposal. The eight-track recorder we offered would be the first of this new kind, an "Octopus" with Sel-Sync. I knew, of course, that recording heads have wider gaps than playback heads, restricting short-wavelength (high frequency) response. I reasoned that a recording head, nonetheless, would serve well enough for playback that its amplified output could surely be used by an artist with headphones to hear a previously recorded track while recording a new performance part, perfectly synchronized, onto another recording head in the same vertical stack. Thus, all tracks would later be available as synchronized originals, to be mixed at leisure. Selective switching of the newly available individual erase heads would be needed, and of recording and playback signal connections.

The scheme needed a name, I thought. "Selective, successive, synchronous" would describe it, but who could remember that? I decided on the spot to dub it "Sel-Sync," and the name stuck. As for the invention, I mistakenly thought its usefulness somewhat narrow, and did not dispute Ampex's patent attorneys' advice that it might be taken as obvious art, thus probably not patentable. At a meeting on magnetic recording history by the Los Angeles Audio Engineering Society section in the summer 1994, Mort Fujii described his circuit design for the scheme. I asked him who invented it. He replied instantly, "you did!" confirming my memory. I described the scheme to Byrne Hull, then manager of the Professional Products Division's modification lab, and it was he who assigned circuit design to Mort. I asked Byrne if he could confirm that and, subsequently, he wrote:

*This is to answer your letter, asking about my memory of your inventing "Sel-Sync". I headed the modification laboratory, inside the Ampex Audio Division, in 1955 and 1956, and supervised construction of the 8-channel "Sel-Sync" recorder we built, late in 1956, for Les Paul. I can't nail down the date, but long before any of that work began, you explained to us your idea, and your reason for calling it "Sel-Sync". I assigned design of the necessary elements of the scheme to Mort Fujii, then of my staff. My memory is that no one outside Ampex was involved until we offered it as a product.*

James Byrne Hull  
Menlo Park, CA  
16 February 1999

This would have been late in 1955 or early in 1956. It was Mort who directed design of the ingenious electronic circuitry needed. This would extract clear, useful signals played back from any of the recording heads in a stack, while one or more of the others simultaneously recorded new material; it would select erase as needed, and switch conveniently among these functions.

There were formidable problems harmonizing impedances, minimizing hum, noise and cross talk in the interconnections. Fujii credits Akio Hosoda with solutions to many of these challenges. Switching was accomplished with relays to select routing of individual recording and playback head signals for each channel, depending on switch settings. Development involved endless refinements, large and small. Akio remembers experiencing loud "pops" on moving from normal to sync mode, necessitating changing all relays to make-before-break types, for example. Low-impedance heads were necessarily used for recording in all such multi-channel recorders; employing them for playback thus required transformer coupling to deliver adequate signal voltage to the preamplifier circuitry designed originally for high-impedance playback heads. This entailed hazards of hum and other artifacts. To reduce hum pickup to acceptable levels, Akio added extra magnetic shielding around the head cables and rearranged some components; finding this still not enough, he devised special head cables, with tightly twisted conductors and double shields.

The question has arisen, why did we propose eight tracks? This was not a specification by any client, but a decision we based on experience with multi-track, high performance audio recording. Tape of one-inch width was the widest readily obtainable for audio purposes, and, indeed, the widest accommodated by the tape transport mechanisms then at hand. Tracks about the width of those on conventional one-channel, half-track, quarter-inch-tape machines were considered the narrowest acceptable for the needed signal-to-noise ratios. Thus eight tracks would be the maximum.

Robert K. Englehart has recently added to the story. Bob recalls that Walter Goldsmith, a former RCA Records product manager who had joined my Special Products Section, sent proposals for such a machine to as many as twelve recording artists. Bob's memory is that only Paul responded at first. Bob was the bird-dog on the project, snagging assemblies and parts, maintaining the schedule, and, interestingly, dealing with Mr. Paul on the telephone often; Bob reports he called anxiously again and again to inquire about progress.

A reflection of the importance Ampex management attached to the project and a hint of the character of the organization arise from Englehart's memory of a conversation about it he chanced to have with the then Comptroller of the corporation. Bob was grousing a bit about the difficulties and interruptions of normal business imposed by the special offering. Bob reports he was told: "Get it done. This is a capital gains corporation, profit is less important. That machine's prestige will help the stock." Englehart may not have known by what high authority he had been addressed; the Comptroller was also a principal of Ayala Corporation. While Alexander Poniatoff was Ampex founder and president, Ayala held controlling interest in the company.

The machine was built in Hull's lab late in 1956. David Sarser, today of Northport, New York, accepted my assignment of the sale to him, as our contractually required dealer. The dealer's role is to assume responsibility for warranty service and to deter-

mine if the need should arise to invoke factory resources, thus becoming the client's champion at court, so to speak. Dave came into the eight-track Sel-Sync recorder project after my staff had proposed it to Mr. Paul, thus it was not he who proposed it to the client. Today he is reluctant to contribute at length to this history, perhaps to avoid offending Les Paul, whom he correctly counts an old and valued friend. He insists, nonetheless, that I am the Sel-Sync inventor. [Some differences necessarily exist between this report and certain published accounts by and about Mr. Paul.] Sarser has a copy of the invoice and, actually, a manual on the machine. Also reflecting the importance the firm attached to the project, some drawings, dated August and September 1956, bear the initials (believe it!) "amp" and "rjt" – Alexander M. Poniatoff, the Ampex founder, and Russell J. Tinkham, head of Audio and my superior at the time. Dave also has a copy of the invoice to Paul. The price was ten thousand 1956 dollars. Sarser's files appear to contain the only surviving documentation on the project. Certainly today's Ampex has none.

Sarser, as a party to late improvements in the bias circuitry of all Ampex multi-track audio recorders, wanted to make sure of their incorporation into his client's eight-track machine. These were improvements made hurriedly in three-channel recorders Sarser had sold to RCA. Mort Fujii recounts this tale. These machines were sent to Republic Studios in Burbank, CA, in September 1956, to record an October 1st session with the great artists violinist Jascha Heifetz and violist William Primrose. Izler Solomon would conduct the RCA Victor Symphony Orchestra. Works to be recorded were the Benjamin Romantic Fantasy and the Mozart Sinfonia Concertante. For this ambitious undertaking it was a matter of urgency that all equipment function rightly, and time was short. Alarmed at unexpectedly noisy recordings, RCA insistently summoned their dealer, Sarser, from New York, as well as Ampex managers. Fujii, met by anxious officials as he arrived at work early one morning, determined that design changes would be required. The bias buffer amplifiers in slave electronic units were generating second-harmonic distortion of the bias signal, this then reflected as noise in the recordings. Fujii quickly devised a fix for the buffers, a second-harmonic rejection filter. He flew to Burbank with the necessary parts. Akio Hosoda awaited him there to perform the changes, while Fujii held off Sarser and his client's recording chief, William Miltenburg, who had flown in.

With more time, Fujii came up with push-pull bias amplifier circuitry that suppressed all even harmonics. This further redesign then went into the RCA three-trackers, the "Octopus" and later all Ampex multi-channel professional audio recorders. A machine with so many innovations perhaps should not have been expected to be free of glitches. The "Octopus" had its share. Here is the worst, discovered only upon its delivery: Sarser, Hull and I drove to Les Paul's estate in Mahwah, NJ, at the time Model 5258 – the designation assigned by Ampex to the 8-channel Sel-Sync machine we built for Paul – was delivered there early in 1957. It was some seven feet tall and weighed well over 250 pounds. Using an instrumentation tape-transport chassis, it had eight electronics units of the type found in the contemporary Ampex Model 350. One-inch tape on fourteen-inch reels was intended to run at 15 or 30 inches per second. We fired it up, only to find the large-size reel ran out in 15 minutes. No one in Byrne's lab had noted the need to remove the 30-60 capstan sleeve. Fitted precisely over the basic capstan, it increased the

diameter so as to double the tape velocity to 30 or 60 ips for instrumentation uses. This sleeve was normal on many instrumentation chassis, one of which was the basis of the "Octopus". It was running at 60 ips! They had noted that low frequency "head bump," tape-speed-dependent, unnatural peaks in low-frequency response, characteristic of faster-running tape recorders, was excessive and had compensated it. Much embarrassed, we trundled the whole machine back to Redwood City for corrections. These would exceed any we could have performed on the spot. Beyond the simple matter of removing that capstan sleeve, the machine's equalization electronics had to be restored to audio 15-30 ips normal. As would any new recorder after warranty adjustments, it would undergo complete checkout procedures. As noted above, we also added the noise-reducing bias modifications Fujii had devised for multi-track audio machines.

Maybe it was as well that upper-level Ampex officials put prestige ahead of profit for this development. By now any hope of financial gain was down the tubes!

*Ross H. Snyder is a native of Wyoming, but since 1932 he and his family have lived in California. An audio engineer, Ross worked for a number of radio stations before joining Ampex Corporation and later Hewlett-Packard Company, retiring in 1986. Educated at the University of California, he is a Fellow of the Audio Engineering Society, and former vice-president and board member of the international organization.*



Ampex engineers clown remorse at return of "The Octopus" to Redwood City after the discovery, at its delivery, that it was running at 30 and 60 inches per second, not the intended 15/30. A tape drive designed for instrumentation purposes was used to accommodate 14-inch reels and 1-inch tape. The capstan sleeve that gave the instrumentation drive its 30/60 configuration had been retained inadvertently.

The indistinct figure wielding a hammer is the late Russell J. Tinkham, head of Ampex Audio at this time. Walter Goldsmith, upper right, who initiated the first offer of the machine to Mr. Paul, aims soldering iron at his head.