HAROLD LINDSAY

Magnetic Recording: Part II

From Todd-AO to digital recording; one thing led to another.

PART ONE, published last month detailed the beginnings of the fledgling Ampex Company and how its ailing finances during the development of the first American tape recorder were solved by a check bearing the signature of Bing Crosby. . . .

The first two Model 200 machines assembled went to Jack Mullin to help relieve the much overworked Magnetophons. The twenty machines for the A.B.C. installations were operated in their key locations for time-delayed broadcasting of network shows across the country. Their performance in this first application is best related in the following letter which was sent to Mr. Poniatoff at the close of the season:

. . . commencing April 25, 1948, and continuing through September 25, 1948 (a total of twenty-two weeks), the American Broadcasting Company in Chicago recorded on the Ampex, approximately seventeen hours per day. For thse 2618 hours of playback time the air time lost was less than three minutes, a truly remarkable record. We believe that a large share of this successful operation was due to the use of the Ampex tape recorder manufactured by your company.

We wish to thank you for your splendid cooperation in supplying us with this fine piece of equipment capable of withstanding the severe conditions imposed during our delayed daylight saving time program.

Very truly yours,
Frank Marx, V.P. in charge of engineering
American Broadcasting Company

In all, 112 Model 200's were manufactured. At about the halfway point in their production (the fall of 1948), we had acquired enough experience and knowledge, as well as input from our customers, to realize that we should consider the design of a new model. The Model 200 had served to demonstrate conclusively that magnetic recording had a lasting place, not only in radio broadcasting, but as a more convenient and flexible means of mastering recordings for phonograph record manufacturers.

In creating this first product in a field new to us, the key premise in our design philosophy was "uncompromising quality and unsurpassed reliability." In our intense desire to assure that these elements were not jeopardized we found ourselves with a product that was somewhat over-designed.

With our newly developed knowledge and skills, especially in the matter of magnetic head design, we were in a

Harold W. Lindsay, a distinguished audio pioneer and internationally recognized authority on magnetic recording, helped lead Ampex Corporation to success and growth and is currently special consultant to that company's magnetic tape division.

position to produce a recorder to follow the 200 at half the price; it could also be substantially smaller in size and operate at half the tape speed (15 in./sec.). It was thought that the lower operating cost of 15 in./sec. and the reduced physical size would appeal also to users with smaller monitoring and control rooms.

MODEL 300

In November, 1948, we set to work on a new project, the result of which was to be our Model 300. Tape speed would be halved and the dimensions reduced, but performance and reliability kept as close to the 200 standards as possible. By halving the tape speed, we could reduce the reel size and tape length and still maintain the playing time of the Model 200. This new 10½-inch reel, with later modifications, eventually became the NAB standard. This challenging assignment was pursued on an all-out basis and the first production run was conducted in July of 1949 when fifty units were manufactured. The first machine off the line went to our good friend Jack Mullin.

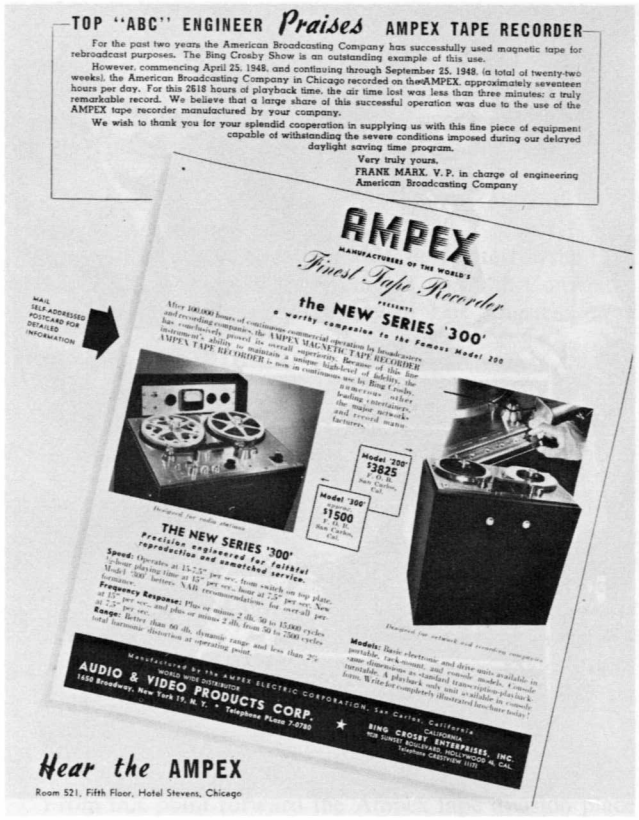
The response in the market place was beyond our most hopeful expectations. As a result, we were now faced with a new set of problems—how to supply an unending rush of orders. The "300" was an immediate success, and within the first few years of the design's long lifetime in the market place it was to be found in all of the major radio networks as well as widely used in the smaller nets and individual stations. The big name phonograph label record manufacturers were all using the "300" for mastering and editing.

The basic design of the "300" remained virtually unchanged throughout its lifetime until the late '60s; its solid state version was introduced in 1966. In all, somewhere around 20,000 Model 300s were manufactured during this time.

The Model 300 received recognition in October 1950 when the publication *Electrical Manufacturing* presented to Ampex a Certificate of Award for "outstanding achievement in product development, design and engineering."

As noted earlier it had been decided in embarking on the "300" development project to lessen the over-design of the "200." Our goal was reduced size, weight and cost.

An Ampex alignment tape circa 1948. This is probably the first professional alignment tape made in this country. Ampex made these tapes available to purchasers of Model 200 machines. Photo from Jack Mullin's product museum, as shown at a recent AES Convention.



The Ampex 300 appeared in early 1949, running at 15 in./sec. speed (also 7.5) and at both reduced size and price from the 200. This was the first ad. Note the specs.

while retaining reliability and outstanding performance. Fortunately, the Model 300 retained a certain amount of over-design, which some two years later, in 1950, proved to our great advantage.

MODIFICATIONS

By 1950, after the first year of "300" production, Ampex started to receive requests to supply special modifications of the basic "300" to be used, not for normal audio purposes, but for data recording in industrial, military and scientific research. These highly specialized applications were so tempting to us that we succumbed and entered headlong into a development program which spurred us into the new field of instrumentation data recording.

This is where the "excess" capability of the original "300" design paid off. We were able to modify the transport to handle tape speeds from 1⅞ in./sec. to well over 120 in./sec. By this time our skills in magnetic head design and fabrication had advanced sufficiently to enable us to produce narrower gap reproduce heads and multi-channel heads with acceptable crosstalk.

MODEL 3200 DUPLICATOR

These developments enabled us to introduce the Model 3200 tape duplicator system (based on Model 300 modifications), consisting of a high speed tape master playback machine feeding banks of slave recorders. Thus it became possible as well as practical to duplicate master tapes at reasonable cost for retail sales of prerecorded high fidelity tapes.

For instrumentation applications we also introduced frequency modulation recording, as well as pulse code modulation systems. We were then in a position to supply

The author (left) with Alexander M. Poniatoff at the introduction of the Ampex ATR-100.

record/reproduce equipment covering a wide range of data requirements from direct current levels and digital coded information, to high frequency signals well above the audio range. This capability resulted in Models 301, 302, 303/311, and others. Instrumentation magnetic tape recording was here to stay and Ampex was to remain as an important influence on the growth of this new technology.

Entrance into the instrumentation field did not de-emphasize our efforts in the audio field. New audio models were forthcoming. The 400 series, which had been first manufactured late in 1949, was upgraded to become the 401 but turned out to be the least successful of the early introductions, having a relatively short life in the audio market place. In 1952, Model 350/351 was first introduced and became a very popular professional recorder, evolving through the years and a number of revisions.

THE MYSTERIOUS VISITOR

It was at this time (1952) that an interesting incident occurred at Ampex. Mr. Poniatoff received a phone call from a New York banker who stated that an important visitor would soon be coming to our facilities. Though he could not disclose the identity of the mysterious guest or the purpose of his visit, he did indicate that it could result in important new business for Ampex.

On arriving, the visitor introduced himself as "Mr. Edwards," without bothering to disclose why his large gold cuff links and tie pin carried the initials "M.T."

Early in the conversation that followed, "Mr. Edwards" inquired whether the people at Ampex had seen Cinerama (the initial public screenings had occurred just before the visit) and if we could record sound on photographic film prints with magnetic striping.

His next inquiry, whether Ampex had done any work in stereophonic sound recording, was effectively answered by a very impressive demonstration. Our demo of three-channel stereophonic playback, using theater-type loudspeaker systems, satisfied our visitor, who finally confessed that his name was not Edwards at all, but Mike Todd!

Mr. Todd was so impressed with what he had seen (and heard) that he made an on-the-spot decision to select Ampex to produce the sound system for the Todd-AO motion picture system (a further improvement on the Cinerama development).

While working on the Todd-AO project, Ampex developed a four-track multi-directional sound system which was introduced in 1953 and was featured in the first Cinemascope film, *The Robe*. Two years later, *Oklahoma!* was premiered with Ampex six-track sound; it was literally an Oscar-winning performance. Other design advances emerged, and by 1967 Ampex had installed sound systems in theaters around the world.

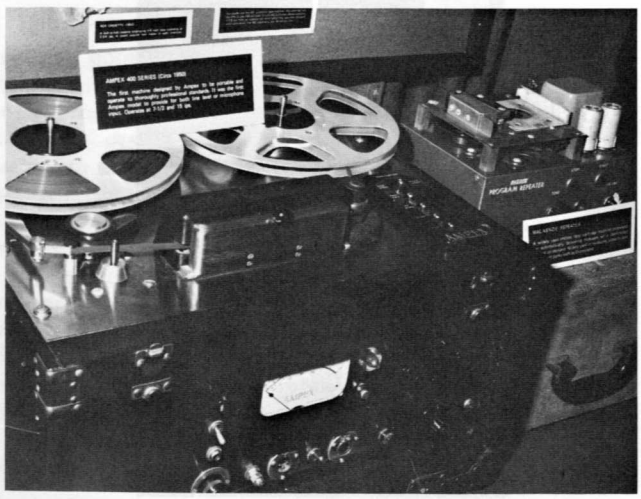
In 1967 we introduced a solid state, improved version of our wide screen multichannel systems. But these systems, though widely acclaimed, remained on the market for only about two years. The interest in super-wide screen presentations was diminishing and sales were dropping off. Ampex had to face facts and retire from the motion picture sound business.

CONSUMER AUDIO

Let us look back now on an earlier year—1954. It was in this year that Ampex introduced the Model 600, intended initially for the professional market as rack-mounted modules or as a single case portable assembly. This recorder became the second Ampex product to achieve distinction by receiving an award for design excellence and has become the Ampex audio product wtih the greatest total sales volume.

The adaptation of this design to produce the Model 612 brought about the company's entry into the consumer audio field. The 612 was shown at the Ampex booth at the National Association of Music Merchants Show in the summer of 1955 and created broad interest as the world's first stereophonic music system for home use. Subsequently Ampex established a consumer division, separate from professional audio and continued with a long series of

A new model appeared in 1950. This is an Ampex 400, the first portable machine designed to professional standards. It was also the first machine to provide for both the level and microphone input. It operates at 7.5 or 15 in./sec. speed. Photo from Jack Mullin's product museum as shown at a recent AES Convention.



product introductions for a period of sixteen years before phasing out of what had become a highly competitive market place.

To cover all of the consumer products developed through that period is beyond the scope of this article. However the following account has such historic significance that it is included.

FOUR-TRACK STEREO TAPE

In attempting to develop interest in home music applications for prerecorded tape, Ampex, in introducing the stereophonic Model 612, had by 1957 come to the realization that tape could not compete price-wise with phonograph records unless higher tape packing density could be achieved. The resulting engineering effort brought forth in 1958 the four-track stereophonic head. With the introduction of this new head Ampex hoped to coax tape duplicators into immediately bringing out four-track prerecorded tapes, and thereby stimulate sales of stereo tape recorders. The idea didn't take hold, so Ampex decided to take the initiative and enter the duplicating field. The importance of such a facility to the developing home music industry is suggested by the fact that within eighteen months following Ampex's introduction of four-track stereo heads, 750,000 tape recorders had been sold by major manufacturers!

In June 1959, Ampex formed United Stereo Tapes (later Ampex Stereo Tapes) and acquired duplication rights for some of the leading phonograph record labels. These included Verve, MGM, Warner Bros., Mercury, and later London. Elk Grove Village, a suburb of Chicago, became the company's custom duplication center. Equipment consisted of Ampex 3200, and later ADM-500 and AD-150 duplicators. Through the years this facility has developed into one of the largest and most complete establishments of its kind.

During the decade 1955-1964, Ampex audio engineering personnel found themselves under heavy pressure to carry on the development programs in which they had become involved. These were the consumer product lines, tape duplication equipment and motion picture sound systems. For the most part new product introductions in professional audio had slowed down.

Only two new professional recorders were introduced in this period; the PR-10 in 1959 and the MR-70 in 1964. The PR-10 enjoyed good acceptance and was continued until its successor, the AG-500, was marketed in 1967. The MR-70, an outstanding design concept for its time, was to have been a state-of-the-art recorder at its introduction, incorporating many mechanical refinements and the best that advanced tubes and nuvistors had to offer. Unfortunately, the development project was timed badly, starting too late to put the recorder in the market place before the onset of the solid-state audio era.

The last of the 350 series, the AG-350 (with transistor electronics), became the basis for the design of a new line of very successful recorders, the AG-440, released in 1967. The years 1967 and 1968 brought many new product introductions. During this time the AG-500, AG-440, AG-440-8, AG-600, the 3400, and the large (12, 16 & 24-track) multichannel AG-1000 and MM-1000 machines were released.

MULTICHANNEL RECORDERS

The decade which followed 1967 to the present brought great emphasis on engineering large multichannel recorders and high speed duplication equipment. Duplicators appeared in 1969 with the BLM-200, in 1971 the CD-200 and in 1972 the AD-15. Introduced in 1973 was the multichannel MM-1100.

The years 1974 and 1975 were without new audio product introductions and some concern was shown in the industry; was Ampex about to give up its position of leadership in professional audio? What was not known by outsiders at the time was that this two-year stretch was devoted to perfecting products to be announced in 1976. a new and improved multitrack, the MM-1200, a highly perfected portable, the ATR-700, and a state-of-the-art analog audio recorder, the ATR-100.

The public display and demonstration date for the latter unit was the May 4, 1976 opening of the 54th Convention of the Audio Engineering Society in Los Angeles.

ORRADIO INDUSTRIES

It is pertinent at this point to recall an event in 1949, although at the time it was not related in any way to Ampex. It was destined in years ahead, however to play a prominent part in the affairs of the company.

We have already referred to the two German Magnetophons that had been sent home after World War II by John T. Mullin and how they influenced Ampex's entrance into the field of magnetic recording. Somewhat paralleling this development was the establishment of ORRadio Industries in Opelika, Alabama, in 1949 by Major Herbert Orr. Orr had also sent home a war souvenir Magnetophon and had, in addition, acquired a formula for making tape. Ten years later the firm, then known as Orr Industries, producing *Irish* brand tape, was acquired by Ampex and eventually became the magnetic tape division.

From this point forward the Ampex tape division placed increasing emphasis on tape development and improvement of manufacturing processes along with the development of a responsive marketing organization. All of this over the

years added up to wide acceptance and the winning of an important share of the tape market.

ATR-100

The acquired skills of tape design, formulation ,and processing which allowed the tailoring of a new product to specific performance parameters paid off in a big way during the development of the ATR-100. For now Ampex had the advantage of being a company with design skills in both recorder and tape technologies. The result was the introduction of the ATR-100 and Ampex 456 Grand Master tape as "go together" products. One was designed to be used with the other to bring out the maximum performance of each in true synergistic relationship.

History had repeated itself, for just forty years before, the German A.E.G. & I.G. Farben companies had teamed up with their respective skills to create the Magnetophon and its tape.

As we pause at the close of this commemorative year, it may be useful to survey the state of our knowledge and accomplishment, and address the question: Just how far have we come in these past thirty years? Perhaps some insight can be derived from a simple comparison of the performance specifications of two products representative of then and now, i.e. the Model 200 and the ATR-100.

DIGITAL VS. ANALOG

As I look over my shoulder at some thirty-plus years of trying to meld art and science in this expanding industry, a thought keeps recurring: in a rapidly evolving technology, today's state-of-the-art can be ancient history by tomorrow.

Model 200 vs. ATR-100: Comparative Performances

Measurement	Ampex Model 200	ATR-100 Ampex
Overall Frequency Response at @ 30 in/sec	Within ± 1 dB 30 to 15 kHz	Within ± 0.75 dB 200 Hz-20 kHz Within ± 2.00 dB 35 Hz-28kHz
Signal-to-noise-ratio taken at 30 in/sec AES full-track.	30 Hz to 15 kHz Unweighted over 60 dB	30 Hz-18 kHz Unweighted 77 dB
System Distortion	Using 3M Co. Type 55 Tape 4% intermodulation distortion at peak meter reading with "harmonic" distortion not exceeding 5% 10 dB above peak meter reading.	Using Ampex 456 (Grand Master) tape SMPTE intermodulation distortion < 1.0% at recorded flux level of 370 nWb/m(OVU)
Flutter & Wow	"Undetectable wow and flutter content even in the most susceptible program material"	NAB rms unweighted at 30 in/sec 0.03%
Speed Accuracy	± 0.03%	± 0.03%
Rewind Time	5,400 ft. (0.002" thick tape) (36 min. P.T.) 1.75 minutes	2400 ft. (0.0015" thick tape) 2.7 minutes

Already the industry is looking to digital audio recording. Digital-to-analogue conversions of 15 bit/50 kHz scan and greater need no longer be regarded as "humpty-dumpty" propositions. It is now possible to make the analogue-digital conversion and put all the pieces together properly. High performance systems are at hand and these most certainly will find their first use in super-critical mastering applications.

Will analogue audio recording survive the challenge of the digital assault? As a practical and relatively simple approach, analogue recording should continue unretarded in its amazing growth. Its position in the industry should be strengthened through supportive interaction with the newer technology rather than being reduced to obolescence. We can all recall that the advent of magnetic tape did not spell doom for the disc, but instead helped greatly in its revitalization.

In the foregoing we have glanced back some thirty years. At this point do we dare guess what may lie ahead over a similar period?

Other audio recording possibilities have already suggested themselves. Vastly improved optical and electron beam recording systems are just around the corner. But where will the next giant step take us? We should not overlook the progress which has already taken place in the development and miniaturization of magnetic core memories. With their almost limitless potential as memory storage devices, there are exciting possibilities for magnetic recording/playback static systems, sans-tape, where motion stability will no longer be a concern, when the only moving system elements will be magnetic lines of force and electrons. ■

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