

HAROLD LINDSAY

# Magnetic Recording

## Part I

*A tantalizing proposition—reproduce a machine with no information regarding its electronics.*

**T**HE YEAR 1977 marks one hundred years since the invention of the first demonstrable sound recording devices, and thirty years since an event that profoundly influenced the development and acceptance of magnetic sound recording—the first radio show to be aired in the United States from a magnetic recording of acceptable professional quality. This event was to revolutionize broadcasting transcription practice.

Early in the evening of May 16, 1946 my wife Margery and I drove the 35 miles north from Redwood City, California to San Francisco to attend an Institute of Radio Engineers (now known as I.E.E.E.) meeting to be held in Studio A of the NBC/ABC complex. Little did we realize as we set out that this event would serve to change the whole course of our lives and many others as well.

The speaker of the evening was John T. (Jack) Mullin and his subject the "Magnetophon." This was to be the first public presentation in the United States of this remarkable recording device, which had been first demonstrated in August 1935 at the Radio Exhibition in Berlin, Germany. The device, developed by Germany's A.E.G., in conjunction with I.G. Farben, used tape consisting of carbonyl iron powder coated on cellulose acetate. In Janu-

ary, 1938 the German Reichs-Rundfunk-Gesellschaft had adopted the Magnetophon and magnetic tape as the future standard for radio broadcast recording in Germany.

Further refinements in machines as well as tape continued throughout the war and somewhat beyond its end. In all, three different types of tape were produced along with at least six different models of the Magnetophon.

It is nothing short of astonishing that while researchers here were still struggling with steel tape and wire recorders, our wartime enemies were fully a decade ahead of us—and we didn't even know it. People engaged in the audio professions in this country were not even aware of the advancements that had taken place overseas until after the war's end. Only then did military intelligence and communications personnel take an interest in this "new" technology and recognize its potential.

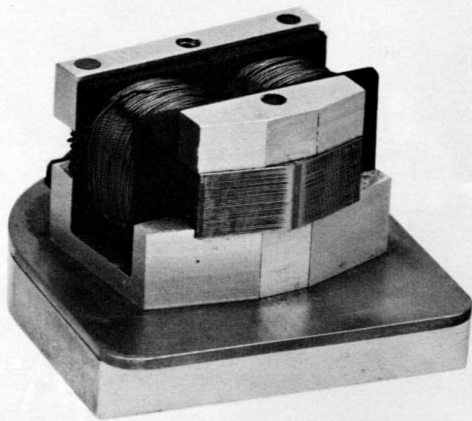
By that time, Germany's industrial capacity was in a state of near collapse. At least two of the "Magnetophone Union" factories had been bombed out, and production of recorders and tape was at a virtual standstill. One of the last operating factories to produce type "L" tape used in the machines was confiscated and shut down by Russian occupation forces.

Therefore, the machines on which Jack Mullin demonstrated the use of magnetic tape were exceedingly rare, representative of what had become an extinct species. And the tape on which they depended was rarer still; there was no possible way of getting more. The fact that Jack Mullins later shared some of his precious tape with the people from Ampex will always be remembered with gratitude.

### MULLIN'S DEMONSTRATION

The studio in San Francisco was packed to the foyer. We could sense the feelings of anticipation and excitement

*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.*



*Original prototype Ampex playback head (enlarged 3.5X). This is the actual head that was proportioned to allow mounting in Mullin's Magnetophon head housing for proof of performance.*

as the crowd viewed the puzzling array of sound equipment crowding the stage. Jack Mullin opened his presentation with a slide-illustrated technical description of the Magnetophon. Then came the demonstration.

Previously recorded musical numbers were played back while, intermittently, live music from a small jazz combo in an adjacent studio was switched with an A/B switch back and forth from live to tape. No one, but no one, in that audience of critical ears was able to detect a difference between live and tape. This brought forth a standing ovation from the spellbound listeners. Equally amazing was the demonstration of the fascinating capabilities of tape editing, including a one-minute stretch of program containing twelve splices, none of which was detected by the listeners.

A deluge of questions followed the formal presentation, and Jack fielded the queries in fine academic fashion. Adjournment brought a crush and jam of the technically inclined to the lecture platform for a close look at the fantastic Magnetophon.

Margery and I waited until the crush had thinned out before inspecting the equipment. Quite overcome with excitement, I burst out to Jack, "I've got the feeling this development is going to change the lives of millions of people. That's what I'd like to do someday—work with magnetic recording."

Jack smiled as he shook my hand. "I hope you do. If I can be of any help, look me up." As we parted, little did I realize that this offer, so lightly made, would be taken up in earnest only six months later.

My first contact with the Ampex Company came in September, 1946 while I was working in the engineering department of the Dalmo Victor Company in San Carlos, on the San Francisco Peninsula. Forrest Smith, general manager of Ampex, frequently visited Dalmo Victor in connection with the precision permanent magnet motors and generators Ampex had been supplying to Dalmo for assembly in the APS-6 airborne radar for Sperry Gyroscope and the U.S. Navy.

Mr. Smith and I became quite friendly. Then one day he surprised me with a message from his employer, Alexander M. Poniatoff, asking to meet with me at my earliest convenience for a technical discussion. The meeting arranged for the following week became another turn-

ing point in my life. Mr. Poniatoff explained that with the end of their war-time contracts in view, he and the people at Ampex were anxious to find a post-war product to help them stay in business. They were considering studio-type turntables, but felt they should have some consulting expertise to assist in the final decision. Mr. Poniatoff proposed that I serve in a part time consulting capacity to Ampex in this matter of new product selection. I accepted, and a series of meetings ensued.

### AMPEX CONTACTS MULLINS

After many weeks of discussion and review I finally conjured up enough nerve to suggest to Mr. Poniatoff that he consider looking into the German Magnetophon with the idea that the design be upgraded where possible and adapted to suit radio broadcast practice in the United States. His response was immediate and favorable, which was typical of Mr. Poniatoff when presented with a new and intriguing idea. I described the May 16th I.R.E. meeting to him and when I related Jack Mullin's parting comment, Mr. Poniatoff was fast to interrupt: "Let's phone him!"

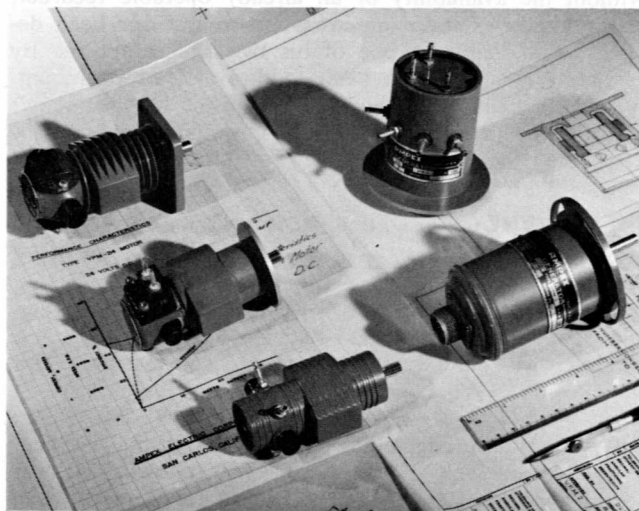
Jack was cordial but apologetic. He was all packed and ready to depart for Los Angeles to attend the annual convention of the Society of Motion Picture Engineers (SMPE—there was no "T" for television then). He suggested that Mr. Poniatoff try to make plans to come down to this affair where he could meet Jack and see the equipment demonstrated. After hasty arrangements, Mr. Poniatoff was on his way.

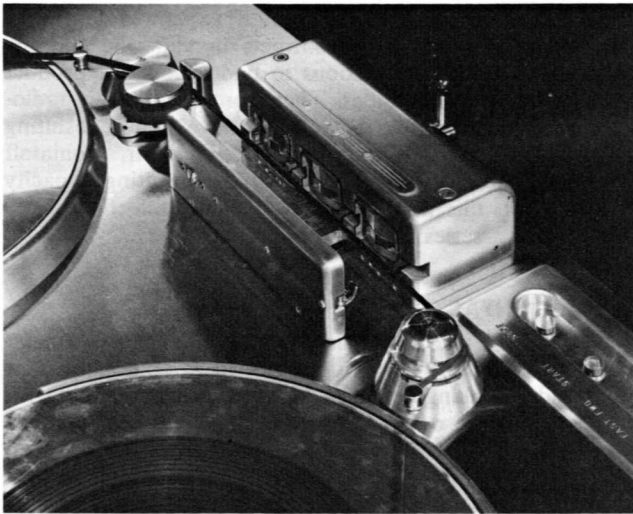
He returned with a display of enthusiasm for the tape recorder, which unmistakably meant Ampex was about to enter a new field. His first comment, directed to me, was, "I want you to become a full-time member of Ampex and assume responsibility for the development of our first magnetic recorder." How could I refuse? My wish had become a reality.

### THE DEVELOPMENT PROJECT

On the 10th of December, 1946, not quite eight months after that memorable I.R.E. meeting we were on our way toward the development of a magnetic tape recorder. None of us in our wildest dreams could have visualized the full

*Ampex's first products. Precision permanent magnet motors (left) and generators (1944-1946).*





*Partial view of top-plate showing cast Meehanite head housing with gate forcibly extended beyond its regular open position permitting view of magnetic heads. Note alloy inner shield cans. Far left head is play-back with laminated shield can. Also shows straight-line threading path of tape.*



*View illustrating plug-in feature of magnetic head assembly. Slotted cap screw at left of head gate covers hole for editing pencil insertion over playback gap.*

impact of what lay ahead, but I remember saying to Mr. Poniatoff, "If we succeed, one day people will be beating on our door to get these products."

At the outset of the development project, the immediate challenge was where to start and how to divide the work load. In fact, the division of labor was quite simple. There was Myron Stolaroff, the electrical engineer who had done much of the design work on the radar motors and generator, and myself. That was the entire engineering team at my disposal as project leader!

A good suggestion as to the best starting place came from Jack Mullin, whom we had phoned for advice. Based on his experience with the Magnetophons he had found there was no question that the most critical part of the entire recorder rested in the design and construction of the magnetic heads, especially the play-back head. With this in mind, he urged us to attempt a play-back head design and to construct a model for performance tests. Success with this should give encouragement to continue the whole project; but should we fail we would be better off dropping the idea of ever producing a magnetic recorder!

In proposing these early head tests, Jack of course realized that we would be in no position to perform them without the availability of an already operable recorder, so he kindly extended an invitation to test our head design, when ready, on one of his two Magnetophons. By designing our play-back head so that at least its mounting requirements would be adaptable to the Magnetophon's head housing, we would be able to make performance tests using the German erase and record heads.

## THE MOMENT OF TRUTH

In the spring of 1947, after several months involving construction of lamination dies, a hydrogen annealing furnace, core stacking and lapping fixtures, and many tedious hours of stamping, stacking, hand lapping and winding, we were at the point of final assembly and static testing. We believed we had gone as far as we could without tape—we were ready for that long sought, but now almost frightening moment of truth, the final test. I phoned Jack and set a date. The following evening found an excited but nervous Ampex group on its way

to the W. A. Palmer Studios in San Francisco, where Jack Mullin and Bill Palmer had been using the Magnetophons for over a year in their commercial film production.

The first tests were to be subjective listening tests using the best master taped material in the Palmer studio. We listened critically to this as it was played back with the normal Magnetophone head, using their best monitoring equipment. After replacing the German reproduce head with the Ampex prototype and rewinding the test material, we were ready.

I have always remembered that next moment, just before pressing the start button, as one of the most anxious

*Author Lindsay checking out Model 200 (January 1948).*



times in my entire life—so much hung in the balance: a dismal failure or the beginning of an exciting future.

The tape whipped up to speed; we were stunned, entranced, suspended in an eternity of mere seconds. Then cheers and hand shakes and clapping—the sounds of a wild celebration. Our ears had just told us what measurements later confirmed—we had outperformed the Magnetophon head. We were destined not to failure, but to fame.

We followed the playback head with a successful record head and finally one for erase. These head successes and Alexander Poniatoff's unbending courage and confidence served to carry us through the very difficult months ahead, months when finances would dwindle to the near vanishing point, plus loss of credit, inability to get supplies when needed, weeks without pay checks and experimental and developmental reverses. Nevertheless, in the face of all these obstacles we continued, stubbornly unwilling to give up.

During these rough months Jack Mullin was helpful in many ways and on many occasions, allowing us to examine the mechanical portions of the Magnetophon, but never the electronics. This puzzling situation was later explained when we were told of his previous commitment and contract with Col. Richard Ranger who was also hoping to produce a domestic version of the German recorder. Jack had made certain improvements in the electronic circuitry which were to be exclusively used in the Rangertone equipment.

While unable because of these commitments to show us any of the electronic assembly beyond the front panel, Jack did, however, help us in many ways. His moral support, encouragement when going was rough, loan of a number of reels of German "L" type tape when he had precious little on hand, design suggestions, and last but certainly not least, his promotional efforts in Hollywood on behalf of our forthcoming product were vital to us.

## THE TAPE CRISIS

As development of the prototype model of the Ampex 200 reached the tape pulling stage, we began to get very uneasy feelings. Up to now, Jack Mullins had been sharing his slender stock of type "L" tape with us. But the sources of the tape were no longer in existence. If we didn't develop a tape to go in our machine, we'd be all ready for production with no place to go.

But fate was moving along with us. One day a gentleman came into our office, introducing himself as a representative of Audio Devices, an eastern manufacturer of disc recording blanks. They'd heard through the grapevine about our project and wondered whether we would cooperate with them in using our new machine to test some new tape they were developing. Needless to say, we were more than happy to oblige.

It seems almost incredible, but a few weeks after the Audio Devices arrangement had been made, we again had an unannounced visitor. This man seemed to be in a great rush, somewhat nervous. In a hurried manner, he explained that his firm in the middle west believed that there was a great future for magnetic recording. They'd embarked on an intensive project to develop an acceptable tape product. However, like Audio Devices, they were stymied because they didn't have suitable recording equipment on which to test their tape. They also wanted to use our new equipment.

Without identifying the other company, we told him about our previous arrangement.

He was not shaken. "Why not help us both? The results can easily be kept confidential. Furthermore, if you have



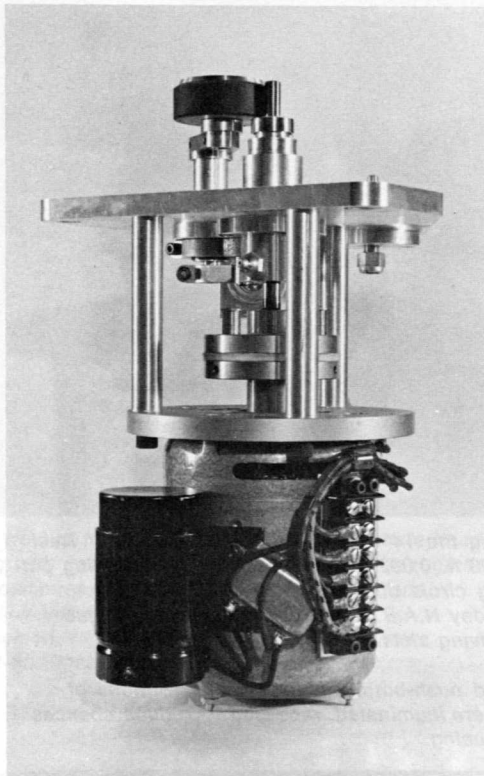
*Threading the 14"-diameter open-faced "reel." Reel held 5400 ft. 0.002" thick tape. Torque/threading pin mounting circle dimensions have carried over to present day N.A.B. Standard Hubs as inside (hub bore) driving slots.*

*Recessed push-button control center. Buttons of Lucite were illuminated, recessed to reduce chances of mis-cueing.*



*Front view with cabinet doors opened. Note modular electronic assembly on vibration-isolated base. Removable modules are (left to right) power supply, control logic assembly, record module, and playback module.*





Capstan drive sub-assembly removed from top-plate.

two tape sources, this will double your chances of arriving at the marketplace in time with tape."

This aspect of the proposal was too tempting; we couldn't turn it down. As he rushed to leave I called after him, "Pardon me sir, may we have the name and address of your company for our records?"

He replied, "I come from Minneapolis, and my company makes pressure sensitive tape products labeled 3M."

### MODEL 200 STEAMROLLERS

As mid-summer 1947 arrived, the Model 200 project was accelerating. Six- and seven-day work weeks, as well as many around-the-clock sessions were stepping up progress, but not without their toll on the participants. By this time (July) trials of Mr. Mullin's reworked Magnetophons were also accelerating at ABC/NBC's Radio Center in Hollywood. We had heard of the misfortune Col. Ranger suffered when the "Rangertone" failed in its comparative demonstration with the Magnetophon (held in the NBC recording department).

However, Jack Mullin's successful demonstrations for NBC and ABC as well as for the Bing Crosby/Philco radio show people had served to stir up great interest in the potential use of professional quality magnetic tape recording equipment for broadcast applications.

The next step would be an actual trial on the air, and the Crosby people were in a position to benefit handsomely from its successful use. They were willing to go ahead but had two principal concerns. With the failure of the Rangertone unit, who would supply the needed equipment for back-up should the German machine wear out, and where would be the source of new magnetic tape when the German "L" tape was eventually consumed by splicing operations?

Jack Mullin called us long distance and explained that since the Rangertone fell by the wayside the Crosby and Philco people were anxious for Ampex to succeed. It seemed we were being put on the spot to quickly produce

an acceptable unit, but it was also a fantastic opportunity for recognition and the establishment of credibility. There was an ominous mandate: we must not fail.

The Crosby people visited us at Ampex and, satisfied with what they saw in a partially completed machine, encouraged us to notify them when it was finished and to bring it to Hollywood to Crosby's "listening room" at ABC/NBC Radio Center for demonstration.

### THE CROSBY CONNECTION

After conferring with Jack Mullin, the Crosby/ABC people decided to go ahead with the Magnetophon taping of the Philco show. That decision was based on Mullin's assurance that he felt Ampex would produce an acceptable recorder within a reasonable period. The decision called for initially recording on tape, editing, and performing a single-generation dub to a Scully cut disc from which the program would be broadcast. It was hoped that when the additional recorders were available, the operation might be ultimately expanded to the use of tape playback directly to the network.

In August Jack Mullin set up his two Magnetophons in a small studio in the NBC building and started recording and editing an average of one show a week.

In the meantime, there was rapid progress on tape development. Audio Devices and 3M were moving along on somewhat parallel paths. Both concerns were supplying test samples at frequent intervals to Ampex for evaluation. 3M also supplied samples to Jack Mullin with the assurance that they were most anxious to cooperate in any way possible to help make the application of magnetic tape practical. Both firms arrived at the marketplace with acceptable tapes in time for use on the first Ampex machines.

Toward the end of August, our prototype Model 200 had reached the stage of final testing. We phoned Jack and a date was set for early in September for the Crosby demonstration. During the course of final testing and adjustment, a decision was made for a slight alteration in the record and bias circuits. To our dismay we experienced severe degradation of signal quality in the record mode. We feverishly worked night and day in an effort to restore the original circuits and performance, but to no avail. Our date at Radio Center was less than a week away and it appeared that we would have to cancel out. We needed more time to rectify our error.

In desperation we phoned Jack Mullin and explained our situation. His first question was, "Will it play back?" On being assured that the playback performance was excellent he implored us not to cancel the appointment. This was one of those rare opportunities which might never come again.

### TAPE SPEED

It was now that a decision made some eight months previously was to pay off. In our early discussions with Jack with respect to transport design direction, the question of tape speed was considered. It was thought that in the interest of interchangeability of recorded tapes between the Magnetophons, with their 76.2 cm/sec tape velocity, and the Model 200, that we should adopt the same speed. A simple conversion from the metric provided an answer of 30.0 inches per second. This speed was adopted in our design and it has continued as a reference base for tape speeds throughout the industry's expansion.

This simple decision made it possible to demonstrate our prototype on a playback-only basis in Hollywood, using excerpts from the Crosby show tapes as source material. The Ampex 200 was set up in Crosby's listening room at Radio Center, and to our surprise the event turned out

## MAGNETIC RECORDING: HIGHLIGHT SUMMARY

- 1898 The Danish physicist Valdemar Poulsen introduced the "Telegraphone," first of the early magnetic recording and reproducing devices of practical design. Danish Patent No. 1260, British Patent No. 8961.
- 1900 U.S. Patent 661,619 issued to V. Poulsen covering the "Telegraphone."
- 1907 U.S. Patent 873,033 issued to V. Poulsen and P.O. Pedersen covering the principle of d.c. bias.
- 1912 Dr. Lee De Forest's invention of the vacuum tube.
- 1918 Leonard F. Fuller was issued a patent covering the use of high frequency current for erasure of magnetic recordings.
- 1920 Dr. Kurt Stille of Germany recognized the real value of magnetic recording as applied to a variety of uses.
- 1921 U.S. Patent application by W. L. Carlson and Glen W. Carpenter for the use of d.c. bias on a wire telegraphone. This was finally issued as Patent No. 1,640,881 in 1927.
- 1927 J. A. O'Neill granted U.S. Patent No. 1,653,467 covering powdered recording media. December 20, 1927.
- 1928 Dr. Fritz Pfleumer, German Patent No. 500,900, January 31, 1928, British Patent No. 333,154, August 5, 1930, covering application of magnetic powders to paper or plastic backing media. Seeking technical help for the development of his idea he approached the German electrical company Allgemeine Elektrizitats Gesellschaft (A.E.G.) of Berlin. A.E.G. in turn interested I.E. Farbenindustrie Aktiengesellschaft of Ludwigshaven in the project. Concurrently with the tape development at I.G. Farbenindustrie the A.E.G. carried on a project resulting in a product to be known as the "Magnetophon."
- 1931 Ludwig Blattner, a German, exploited Dr. Kurt Stille's ideas and introduced the steel tape "Blattnerphone" to the British Broadcasting Co. where it was used for radio transcription purposes.
- 1935 The A.E.G. developed the Magnetophon using tape consisting of carbonyl iron powder coated on cellulose acetate. It was publicly demonstrated in August 1935 at the Radio Exhibition in Berlin. The eight models displayed were sold during the show.
- 1938 In January, German Reich-Rundfunk-Gesellschaft adopted the Magnetophon and magnetic tape as the future standard for radio broadcast recording in Germany. His "Telegraphic Patent Syndikat" obtained rights to various magnetic recording patents, along with some of its own, and issued licenses for commercial exploration.
- 1938 Dr. Hans-Joachim von Braunmuhl re-discovered a.c. bias and patented it.
- 1946 May 16, 1946, Institute of Radio Engineers (now I.E.E.E.) San Francisco Chapter local meeting featuring John T. (Jack) Mullin as speaker of the evening. Subject: "The German Magnetophon Magnetic Tape Recorder."

### PATENTS

British Patent	8,961	V. Poulsen	1899
British Patent	541	V. Poulsen	1903
British Patent	288,680	B. Richeouloff	1928
British Patent	319,681	Kurt Stille	1930
British Patent	331,859	Kurt Stille	1930
British Patent	333,154	Fritz Pfleumer	1930
Danish Patent	1,260	V. Poulsen	1898
German Patent	500,900	Fritz Pfleumer	1928
German Patent	*	Braunmuhl/Weber	
*(Published in U.S., U.S. Property Custodian Ser. No. 413,380) 1934			
U.S. Patent	341,287	S. Tainter	1886
U.S. Patent	661,619	V. Poulsen	1900
U.S. Patent	720,621	W. A. Rosenbaum	1903
U.S. Patent	789,336	V. Poulsen, P. O. Petersen and Carl Schou	1905
U.S. Patent	836,339	P. O. Pedersen	1906
U.S. Patent	873,033	V. Poulsen & P. O. Pedersen	1907

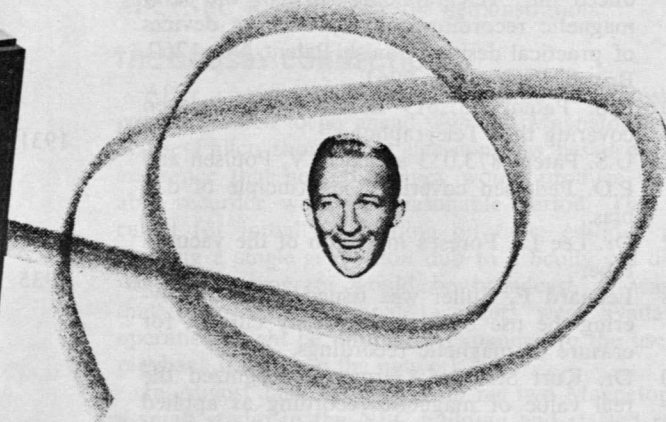
U.S. Patent	873,078	P. O. Pedersen & V. Poulsen	1907
U.S. Patent	873,083	P. O. Pedersen & V. Poulsen	1907
U.S. Patent	873,084	V. Poulsen	1907
U.S. Patent	900,304	P. O. Pedersen & V. Poulsen	1908
U.S. Patent	900,392	G. Kirkegaard	1908
U.S. Patent	1,213,150	H. C. Bullis	1915
U.S. Patent	1,459,202	Leonard F. Fuller	1918
U.S. Patent	1,640,881	W. L. Carlson & Glen W. Carpenter	1927
(A.C. Biasing)			
U.S. Patent	1,653,467	J. A. O'Neill	1927
U.S. Patent	1,758,531	Pfanhouser	1930
U.S. Patent	2,213,631	H. S. Heller & L. G. Butler	
U.S. Patent	2,235,132	D. E. Wooldridge	1941
U.S. Patent	2,351,004	Marvin Camras	1941
U.S. Patent	2,468,198	H. S. Heller	1949
U.S. Patent	2,619,454	P. P. Zapponi	1952
U.S. Patent	2,643,130	Kornei	1953
U.S. Patent	2,778,637	G. Eash	1957
U.S. Patent	3,052,567	Gabor et. al.	1962
U.S. Patent	3,761,311	Perrington et. al.	1973

to be much more demanding than we had been led to believe in the planning discussion. Early in the day play-backs were made for the Crosby principals and crew, and while they were in progress a waiting line began to form outside. It was composed of engineers and technical people from all over the area—from the networks, disc recording studios, and the motion picture industry, as well as others. The word had gotten around and they

were not about to miss what they were inadvertently helping to shape into an informal first showing of an exciting new product. The demonstration room was small, with room enough for only 12-15 guests per playing, and the demos went on all day!

As the last of the admiring visitors left, we of the Ampex crew were left in a state of amazement. We had fully anticipated that among that continuous stream of tech-

## Here's the machine that put Bing Crosby on tape...



## Ampex MAGNETIC TAPE RECORDER

The ability of the Ampex Magnetic Tape Recorder to maintain its unique high-level of fidelity has been fully demonstrated over the past season on the Crosby program. This "true-to-life" reproduction is the result of engineering improvements by the Ampex Company on the high-quality German magnetic tape machines. The American Broadcasting Company has purchased 24 Ampex recorders to date and is using them from 15 to 18 hours a day in con-

tinuous commercial network operation. The results, from the standpoint of quality and reliability, have been unbelievably satisfactory, and the cost of ABC's recording operation has been reduced substantially. There is no waste of material as with discs; there are no discards; and editing on tape is made simply with a pair of scissors. Based on average operation and personnel costs, the full price of this machine will be saved in a very short time. Write for full details.

### EXCLUSIVE DISTRIBUTORS

East of the Rockies:

#### AUDIO & VIDEO PRODUCTS CORP.

681 Fifth Avenue, New York 22, N. Y.  
Telephone Plaza 9-6031

West of the Rockies:

#### BING CROSBY ENTERPRISES, INC.

9028 Sunset Boulevard, Hollywood 46, California  
Telephone Crestview 11171

Our first advertisement.

nical experts, at least one engineer would have said, "The playback is beautiful, but how about a demonstration of recording!"

A few days after our return to Redwood City, some representatives of Crosby Enterprises called on us. Their comment, "We assume that you know you have taken Hollywood by storm," served to open the subject they had in mind: "Now, what are your plans for marketing it?"

### MARKETING

In a somewhat naive manner, we had to admit that we had been so preoccupied with development that there had been no discussion of such plans; as a matter of fact, I think most of us believed that the marketing might in some mysterious way take care of itself.

This seemed to be just the sort of answer they were expecting. They had a proposal: would we be interested in their representing us in the eleven western states as our distributors?

After a short discussion we agreed and signed the contract they had brought along. And then another document appeared from a hidden pocket—a signed order for twenty recorders! These (and ultimately four others) were to be for the American Broadcasting Co. Some were to be installed at each of three locations—New York, Chicago, and Hollywood, and all were to be ready in their respective installations by April 25, 1948.

A few days passed before we re-erred from the

euphoria induced by this event and were able to start in earnest on the task of planning for our first production run of Model 200s, which of course included parts and material ordering. It was at this point that we became abruptly aware of a serious shortcoming.

Ampex was almost completely devoid of working capital! There were not sufficient funds to purchase the materials and parts necessary to go into production, and the local banks were not ready to make loans for such a wild enterprise.

But good fortune was with us again. Quite unexpectedly an envelope with a Hollywood postmark brought us a check for \$50,000—with no strings attached or collateral requirements. The signature it carried: Bing Crosby. ■

### REFERENCES

- Mullin, John T. "Creating the Craft of Tape Recording" *HIGH FIDELITY MAGAZINE*, April 1976, pp. 62-67.
- Angus, Robert "The History of Recording" (six installments) *MODERN RECORDING*, 1976, (ends Aug./Sept.).
- Mullin, John T. "The Birth of Tape" *BILLBOARD*, July 4, 1976.
- Lane, Basil "The Thin Brown Line" *STUDIO SOUND*, June 1977, pp. 72, 73, 74, 76, & 78.
- Eisenberg, Norman "High Fidelity Pathfinders—The Men Who Made An Industry" Alexander M. Poniatoff (16th in a series) *HIGH FIDELITY MAGAZINE*, September, 1977, pp. 72-73.