

A Thirty-five Year History And Evolution of the Recording Studio

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A THIRTY-FIVE YEAR HISTORY
AND EVOLUTION OF THE RECORDING STUDIO

by

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Abstract:

An historic review of the three and one half decades from the mid forties to 1980, provide a most interesting period of development of the recording studio, control room, and reverberation rooms and devices.

Some basic fundamental techniques have weathered the test of time. The evolving changes in design concept occurred as a result of the drastic shift in the music idiom, the major improvements in recording technology, and the need for cosmetic and esthetic alteration to accommodate the performers' wishes.

*UREI, United/Western Studios, Coast Recorders, Inc., Teletronix Information Systems, United Recording Corp.

The "major" labels predominated the record industry in the mid-1940's, as World War II ended. RCA, Columbia and Decca, along with the younger, burgeoning Capitol Records, constituted the majority of the record industry. There were some lesser known "independent" labels, but in sum total, they were a very small part of the industry. In 1946 Mercury Records, in Chicago, (now Phonogram) arrived on the scene and within two years became an important label. MGM started about the same time.

By 1947 more and more "independent" labels came into being. There was a trend for the small independent label to specialize in certain music markets; rhythm and blues, country, gospel and spiritual. Jazz and even skating rink records became a market sufficient to sustain a worthwhile volume of business.

The studio facilities of the major record companies were somewhat similar and the discipline of the recording process and studio techniques were quite rigid. RCA maintained their own studios in New York, Chicago and Hollywood; the same for Decca; however, in Chicago Decca was using Universal by 1947. Columbia Records owned their own studios in New York and used the WBBM (CBS) radio studios in Chicago and later Radio Recorders in Hollywood. Capitol Records operated it's own studios on Melrose Avenue in the old Don Lee Network Building in Hollywood and did not build studios in New York until 1953.

On a nation-wide basis, there were not very many independent studios which were well known in the late forties. Among the leaders, Radio Recorders in Hollywood, was in the forefront. In Chicago, Universal Recording Corporation was founded in 1946, and began to make its mark by 1947. In New York, Bob Doherty and Doug Hawkins were recording for many "independents" at the WOR Radio Studios. Soon came Bob Fine, Fulton and Gotham Studios. Nashville began to break out later as an independent recording center, with Owen Bradley's "Barn", paving the way.

THE STUDIO STYLE OF THE LATE FORTIES AND EARLY FIFTIES

The majors, RCA, Columbia, Decca and Capitol were content for the most part to confine most of their "pop" recording to disciplined procedures in their respective studios. Columbia, however, did pioneer in the use of Liederkrantz Hall for "pop" records. Many famous big band records were recorded with this distinctive big room sound and some were splendid by comparison to the "pinched" sound of the conventional studio recordings. Some recordings from England of pop artists, such as Richard Himber Orchestra, were also characterized by the large hall "open" sound.

RCA occasionally used Webster Hall in New York for "pop" dates. The Sauter-Finegan recordings from Webster Hall are most outstanding examples of this sound. Decca recorded some of its larger dates in the Pythian Temple in New York as the search for "the new sound" continued. There was beginning to develop a deliberate change in the "record" sound with more use of reverberation, as well as experimentation and improvement in mic placement. Another most distinctive studio sound was identified with "World" (vertical) Transcriptions. The studios and techniques World used produced a super "live" sound that was excellent for some types of music, particularly when the "in studio" orchestral balance was good. Perhaps the technique used by World was that which was proposed by J. P. Maxwell of Bell Telephone Labs in his paper, "Liveness in Broadcasting".

Typical of the "in house" studios during this era, were rooms of 15,000 to 35,000 cubic feet. Common acoustical treatment included drapes, Johns-Manville perforated transite panels, backed with rock wool batts, Celotex C2 and other acoustical tile was commonly used, sometimes applied directly to the boundary surface with little or no air space behind. Band selective diaphragmatic absorbers were not yet in widespread use by recording studios and Rettinger's "slat absorbers" were waiting to be born. Polycylindrical diffusers (1) were more prominent in the design of studios for RCA and NBC than elsewhere, but soon became common-place in other independent studios. Many large motion picture scoring stages incorporated more advanced acoustic technology than did this generation of phonograph record studios (2).

Isolation screens, vocal booths, drum booths, "gobos", rugs and umbrellas were conspicuous by their absence. Some studios of this generation were consistent with the optimum reverberation time (Figure 1) in the mid and high frequency range, but there was less than adequate absorption at the low frequencies.* The lack of definition or presence of the instruments in the lower music register was sometimes countered by the mixer having to reduce the level of the direct sound pickup on the bass, out of mere frustration. This only added to the "mud". (The kick drum was not meant to be heard or allowed to escape.) In the case of some studios using only perforated panels and batts, wild perturbations occurred in the reverberation time vs frequency curve. In extreme cases the coloration was audible.* A typical "problem" studio is shown by Everest (3) in Figure #2.

I suggest that there were two principal reasons for the low frequency "mud" and the lack of separation that characterized some of these 1940 recordings. First, that the coloration offered by the room itself with longer reverberation time at the low frequencies magnified the ratio of indirect to direct sound in the range of the lower frequency instruments; and second, that the "off axis" response of some microphones whether bi-directional or cardioid also caused unpleasant time and spectral coloration of a signal arriving after the direct sound, but well within the limit of fusion. Many "directional" microphones became virtually omni-directional at low frequencies. In addition, the microphone placement was "handed down" technology from broadcasting and was ripe for improvement, insofar as records were concerned.

THE COMING OF "HI FI SPECTACULARS" AND THEIR EFFECT ON STUDIOS

There was a period between the early fifties to the mid-fifties which brought significant change and improvement in many facets of studio technology and ultimately impacted beneficially on recorded quality. The factors which stimulated these changes were:

1. The LP/45 battle had been resolved with the CBS 33 1/3 RPM becoming the standard for the album package and the RCA 45 RPM becoming the standard for singles (4). By 1951 RCA and Columbia made peace.
2. Mono feedback cutter heads, such as the Westrex 2B (5), Steve Temmer's Grampan system and the "QC" system developed by Emory Cook, greatly improved the quality of disc recording.
3. Many independent record companies, as well as the majors, were capitalizing on the potential of the discriminating audiophile market for both classical and "pop" records.

4. Stereophonic recordings were recorded during this period for release in $\frac{1}{4}$ " tape format (1) which stimulated innovation and experimentation in new studio techniques.
5. The quality of record pressings improved.
6. New exotic condenser microphones, such as the Telefunken U-47 and other Neuman types, became popular and afforded great improvement in the recorded sound.

There did exist a lack of standardization, of record/playback characteristics, during this period (8). These included: AES, NARTB, RCA Ortho, Columbia L.P., London, European. The RCA Ortho ultimately became the RIAA Standard.

The foregoing caused those of us concerned with operation of the independent recording studios to awaken to the fact that we were perhaps the "weak link" in the chain and that studio design and techniques had not kept up with the pace of other related technology.

The "Hi Fi Spectacular" audiophile market caused a level of competition between studios to develop, which was a very positive force. We were compelled to produce better recorded sound than we did in the 1940's.

In the interest of reporting accuracy, a recitation of the author's own personal experience at Universal Recording Corporation in Chicago in this period might be best for illustration, rather than speculating what happened at other studios, since there was little information being exchanged (2).*

Commencing in early 1950 Universal did the following:

1. To improve separation we lowered the reverberation time of the studios, added substantial amount of absorption at lower frequencies, using diaphragmatic panels in convex splays. We increased the thickness of the

(1) The first stereo ("binaural") recordings which were available in reel to reel format, did not represent a viable market to the record companies, but ping pong enjoyed new popularity. The term "binaural" was sometimes incorrectly used to describe any and all two track recordings, even though the mic placement was not that which was classically ascribed to "binaural", vis-a-vis mike spacing. Not until the Westrex 45/45 system and the English Decca vertical/lateral system made stereo disc recording a reality (in 1957), did the record companies gain the visibility of potential financial reward. An interesting chronology of these events is presented by E. H. Roys, "The Coming of Stereo" (6). Some early "binaural" recordings, which were marketed in the early 1950's, were recorded in a staggered head format on $\frac{1}{4}$ inch tape on Magnecord's two track PT-6. The chronology of magnetic recording and two track $\frac{1}{4}$ " tape recording is documented most comprehensively by John T. Mullin (7).

(2) During this particular period, there were many individuals who offered their encouragement and supported our experimental work at Universal. Among those were: the late Benjamin Bauer, and Messrs. Lee Gunter and Bob Carr of Shure Brothers, Mr. Hale Sabine, Jr., then with the Celotex Corp., Mr. Marvin Camras, Mr. Steve Temmer, Mr. Rein Narma, the late Mr. Russ Tinkham of Magnecord and Ampex, Mr. Lou Burroughs of Electrovoice, and Mr. James Cunningham who pioneered in the field of stereo recording. I am eternally grateful for their help. *The author was President of Universal at this time.

blankets behind the perforated panels, by furring out the frame for added depth.

2. We began using separation screens and rugs for absorption of higher frequency reflections. We installed a "roll around" vocal booth which was also used as a drum cage on occasion. (The first recollection I have of the drum booth use was on the Stan Kenton "Prologue" album for Capitol Records in 1952.)
3. We began using a carpeted "roll-around" raised platform for the rhythm section.
4. We constructed a "roll-around" band shell with interior polycylindrical diffusers to prevent focusing, shown in figure #3. This quickly gained approval from the string players.
5. We devoted more effort towards improving the studio set up and mic placement, departing from most of the "handed down" practices of the past.
6. We directed our attention and made considerable effort to improving the quality of reverberation rooms to reduce coloration and achieve smoother decay and eliminate periodicity. We experimented in delaying the echo send to more effectively simulate the "early" sound.
7. We attempted to improve the acoustics of the control room and even measured monitor speaker response. We made primitive attempts at equalization.

The matter of stereophonic recording was still in a state of apathetically inspired limbo (I). The tape market for two track was insignificant. The stereo disc was somewhere in the future. Record companies were, for the most part, unwilling to permit any exposure to added cost over and above the monaural session in order to accommodate stereo. Unless a date was being specifically done for one of the few small companies that sold two track tape product, mono came first and under no circumstances were we to compromise the mono quality or balance, or delay the session and increase studio costs in order to facilitate stereo recording!

To accommodate these strict ground rules, Universal used a separate control room to which we fed the output of the mono buss from the mono control room, as well as a bridge off the vocal and bass mike containing the mono master mix. In addition, we fed separate mic outputs (called OA/OC mics) independent of the mono buss. This is shown in figure # 4. The producer heard the mono mix only, in the regular control room, unaware of the stereo mix.

This procedure tends to point up the "underground" techniques we were forced to resort to at that time, because of the lack of faith in the future of stereo (at least in the minds of those who held the purse strings). In the instance of one major label recording some of their top selling artists at Universal in Chicago, we proceeded on total speculation to record "underground" stereo without even being reimbursed for the extra tape costs. I hasten to add, however, that this speculation brought substantial rewards some years later when the stereo disc hit the industry right "between the grooves" in 1958 and the mad rush for stereo disc product began.

In concluding the comments concerning the period from early to mid-fifties, it is worthy of note that the competitive battle for technical "one upmanship" grew, in a constructive way, even though some record labels insisted that "louder was better".

The problems of mastering extended band width, using either RCA Ortho (now RIAA), or AES preemphasis, caused us to begin experiments in half speed mastering of L.P.s from 30 I.P.S. tapes in 1955.

The first demonstration was made for the Shure Bros. Engineering Group and others. The first release on Mercury was the mono version of David Carroll's percussion spectacular in 1955. The stereo version was first released on reel to reel $\frac{1}{4}$ " tape, then on stereo disc in 1958. As a note of historic interest, the microphones used in this era are listed in Figure #5.

One other event of note occurred during this period, but it did not further the commercial advancement of stereo, for obvious reasons. In 1954, Universal Recording Corporation, in cooperation with the Pentron Corp. of Chicago, demonstrated 8-track recording and playback in a staggered head configuration (with a signal to noise ratio of almost 30 DB). The speakers were placed in the original position of the instruments for playback. This 8-track medium also failed to produce a mass market, but it did serve to trigger our imagination as well as to demonstrate that studios designed for monaural recordings would ultimately be unsatisfactory for multi-track recording.

THE CAPITOL TOWER

A significant advance in studio design occurred in 1956, when Capitol Records completed the "Capitol Tower". Mr. Michael Rettinger was commissioned by Capitol and pioneered the embodiment of "state of the art" acoustical techniques and materials in a facility designed specifically for the recording of phonograph records. Provisions were made for varying reverberation time, (T_{60}) by using "hard/soft" hinged splays. The T_{60} table is shown by Bayless (9):

		<u>Hard</u>	<u>Soft</u>
Studio A	57,000 feet ³	1.00 sec.	.74 sec.
" B	47,000 "	.80 "	.55 "
" C	6,200 "	.71 "	.46 "

Although Bayless (9) does not indicate the contour of T_{60} vs frequency, he states that T_{60} rises approximately 30% at 100 HZ.

Using Rettinger's latest recommended optimum (10) for multi-track studios where $T_{60} = 0.15 \log V$ but not be allowed to increase at low frequencies, Rettinger shows that:

$$\begin{aligned} T_{60} \text{ opt for Studio A} &= 0.71 \text{ sec.} \\ &B = 0.7008 \text{ sec.} \\ &C = 0.56 \text{ sec.} \end{aligned}$$

Mr. Rettinger must have had a vision of 24-track recording! Since this thesis proposes a logarithmic ratio in determining T_{60} optimum, the rate of T_{60} increase as a function of volume, was smaller, than recommended in the earlier literature, as shown in Figure #1.

Over the past 40 years, Mr. Rettinger has consistently recognized and attended to the changing nature of the requirements of the recording studio, giving attention to the requirement for greater separation and reducing the T_{60} at the lower frequencies, at the same time recognized the validity of the artists' desire to perform in a comfortable acoustic environment. Rettinger also gave cognizance to the wide variety of uses, as well as the great variations in the number of performers in the studio.

In 1961 Rettinger published a most comprehensive paper (11) in which he recommends T_{60} optimum slightly greater than $0.22 \times \text{Log } V$ for mono and approximately 10% higher for stereo. As multi-track recording became the predominant style, and separation requirements increased, Rettinger revised this recommendation to: $T_{60} = 0.15 \text{ Log } V$ (10).

It is somewhat of a paradox that what has proven to be a successful criteria for T_{60} , based on today's recording techniques, was not accepted with total enthusiasm in 1956, when the panels were in the "soft" position.

Musicians and performers were not used to the lower reverberation time, and some felt that the studios were too dry, from the standpoint of the sound within the room itself. Remember, however, that the recording techniques in the mid-1950's were not done in multi-track "building block" style. Over dubbing was the exception, not the rule.

CAUGHT WITH OUR CONTROL ROOMS DOWN

By the mid-1950's, we were at the threshold of commercial mass market stereo, yet, there was no concrete sense of direction in terms of the specifics of facility planning. There were visionaries and prophets, but their visions were often blurred by the reluctance of the record marketing people to make solid forecasts. In addition to the need of advancement in studio design, the control room dilemma was the most in focus. A typical monaural control room suffered limitations, such as:

- A. Insufficient floor space and volume.
- B. Unsatisfactory acoustics and non-symmetrical room geometry.
- C. Poor monitoring conditions, vis-a-vis, the quality of the monitor speaker, it's location, insufficient power to drive it, and lastly, poor response.
- D. Inadequate space and poor position for producers (some felt this was not a limitation).
- E. Inadequate electronic facilities.

As reported earlier, one solution was to mix mono in one control room and stereo in another, on the basis of "what you hear is what you get".

Some attempts were made to adopt existing control rooms to provide satisfactory stereo monitoring, but were unsatisfactory compromises and not permanent solutions.

The Capitol Tower (9) was completed before the resolution of the stereo control room problem. (The Capitol studios were remodeled in late 1959 and the control rooms were reconfigured (12), and described by Davis in 1963.)

In early 1958, United Recording Corp. began construction of its new studios in Hollywood (13). The timing was good, since by then the visibility re the future of the stereo market was making heroes of many. The 1958 vintage control room is shown in architectural section in Figure # 6 and pictorially in Figure # 7. The monitor speaker response is shown in Figure # 8. Figures # 7 and # 8 are reprinted from the original paper (13) presented by the author, October 5, 1959, at the eleventh annual convention of the Audio Engineering Society, New York. Figure # 6 was not used in the original published paper.

The monitor speakers were ALTEC Model 604D in 10.5 cubic feet ported enclosures. The theory of the design was to provide symmetry and create a "quasi" horn loading to extend the low frequency response and reduce the driving power required at low frequencies. The horn was trapezoidal in architectural "plan". The acoustical treatment inside the "soffit horn" was designed to provide good structural rigidity and reduced absorption at the lower frequencies with adequate mid-range and high frequency absorption to avoid disturbing reflection at shorter wave lengths. The distance from the speakers to the mix position was approximately 11 feet. The loading provided was 0.5π steradians (directivity factor of 8), for the left and right speakers and 1.0π steradians (directivity factor of 4) for the center speaker. Recent T.D.S. investigation concerning reflections from the control console show that this configuration may have reduced this problem by serendipity (not foresight).

After the sawdust cleared and the first generation of stereo control rooms were in operation, many skilled technical experts began to apply their talents towards refinement of the control room as well as stereo mix down rooms.

Research was directed to the specifics of these needs. Much was based on early literature (14). Building from the foundation of this research, many specialists came to the forefront with innovative and imaginative ideas. This is shown in the following digest from the late fifties to the present:

Mr. Rettinger contributed much to the contemporary literature dealing with control room acoustic design and described in specific detail the treatment for many acoustic and sound reproduction ills (11) and (15).

Dr. Harry F. Olson, in his paper entitled, "The RCA Victor Dynagroove System" (16), deals comprehensively with every aspect from the sound source to the reproduction in the home; in doing so he touches on many facets which concern the control room and auditioning. John E. Volkmann (17) provides further specific data concerning the control room performance characteristics.

Mr. Tom Hidley recognized the necessity for treating the control room and monitor loud speaker intrinsically. In addition, he brought a fresh new architectural look and innovations in the use of new materials for acoustic treatment. Even through little literature has ever been published concerning his works, many have attempted to copy his designs, which is evidence of great success.

Mr. George Augspurger designed and developed custom monitor speaker systems and control rooms to work well together. His measurement techniques have shown excellent correlation with subjective listening tests and room performance. (18)

Mr. Donald Davis pioneered in the field of room equalization and related technology dealing with control room monitor systems.

The work of Mr. Richard Heyser paved the way for new measuring techniques which provided new time domain data (19), useful in control room design.

Mr. John Eargle advocated the standardization of control room monitor response and the monitoring environment (20).

Mr. Rettinger proposed specific details of room design (21) for control rooms.

Mr. E. M. Long, in collaboration with M. T. Putnam of UREI, developed the 813 Time Aligned™ Monitor Speaker System, under license from E. M. Long and Associates. (23)

Mr. Donald Davis proposed and developed the LEDE Control Room concept, and in collaboration with Cecil Cable developed T.D.S. measurement techniques (22).

Mr. Jack Edwards, AIA, has provided imaginative architectural styling and design in this field, and introduced the use of new types of materials.

Many others, through their experience, innovation and application of new measurement method technology, contributed greatly.

Mr. Allen Sides, represents well the community of younger contemporary mixers whose continued experimentation and pragmatic approach to improving control room monitoring quality has been most noteworthy.

REST ROOMS, STAIRWELLS, AND OTHER REVERBERATION CHAMBERS

The luxury of a reverberation room specifically designed, built, and dedicated as such was enjoyed by few studios in the late forties. Columbia was using a stairwell in New York, and the cubic in the spire of the Wrigley Building at WBBM, Chicago. When Universal was still in the Civic Opera Building, we found an excellent men's room and, except for the times when trespassers ignored the "out of order" sign, we had few problems. (These moments are recorded for posterity on several records.)

In 1947, one of the first "pop" records, which exploited reverberation for artistic effect, was "Peg-O-My Heart" by the Harmonicats on Universal's own label. After this time, there seemed to develop a trend towards using more reverberation than in the earlier "pop" records.

In 1953, when Capitol completed their New York Studios, they built a superb reverberation room, which was always recognizable on records because of its excellent sound. In the Capitol Tower (9), Hollywood, the underground

trapezoidal shaped rooms represented a dramatic step forward in improving the quality of reverberation. The Studio A chamber at United Recording in Hollywood also gained popularity because of its pleasing characteristics.

By the mid-nineteen sixties, many refinements had evolved as literature provided a more solid foundation for experimentation and refinement (24). (This extensive reverberation bibliography* (5.2) presented by Penner is probably the most complete of all current work.) His paper is an outstanding example of the merging of youthful contemporary thinking, coupled with scientific disciplines.

Some chambers, which have been built over the years, exhibit coloration and are unpleasant to listen to when added to the direct sounds. An example is shown in Figure # 9 (before and after correction).

Advancement in techniques to more realistically simulate the "early reflections" have made great improvement in the naturalness of reverberated sound in recordings. Modern digital reverberation devices have shown the potential for further improvement of reverberation and sound quality, and perhaps forecast the ultimate demise of the acoustic chamber, because of comparative costs.

SUMMARY & CONCLUSION:

As multi-track, and close microphone technique became the way of life for contemporary recording, the SPL within the studio increased to levels that were not contemplated twenty years ago. The matter of maintaining adequate separation became a severe one as the music idiom changed. With the necessity for close miking, separation screens, isolation booths, etc. there evolved the predictable phenomena of a reduction in time-"spatial" information being recorded. Except in those instances where a particular sound source, or sources is selected for stereo pickup, little "spatial" information is received when the instrumentation is combined electrically (and maybe not even in real time). This, then, becomes a mixture of monaural sources which are musically concerted, sans stereo information. The contemporary studio, therefore, is primarily designed to best accommodate this style of recording.

Some of the information concerning techniques of Studio and Control Room design and construction, has been "handed down" in a most informal manner. In some instances there is a void of specific detail or a lack of accuracy in communication which has caused unnecessary expense to many. It has been shown that the predictability of satisfactory performance is much greater when the basic proven scientific fundamentals are adhered to. This in no way inhibits experimentation, innovation or cosmetic or architectural change but serves as the foundation from which evolves progress towards a common goal.

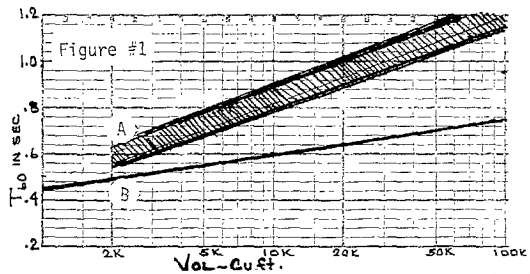
In retrospect there seems to have existed, throughout this period, some lack of togetherness between those who were involved at the artistic end, those who were involved in technical research and development and those who were involved in day to day operations. This exists to a lesser degree today, as many have initiated effort to bring these groups together in a constructive way. Through new publications and seminars and the available abundance of high quality technical writing, great progress has been made.

ERRATA
TO
"A THIRTY-FIVE YEAR HISTORY
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(M. T. Putnam)

- PAGE 3, par. 1, line 2: "Common acoustical treatment included drapes, Johns-Manville perforated transite panels, backed with rock wool batts, Celotex C2 and other acoustical tile was sometimes applied directly to boundary surfaces with little or no air space behind."
- PAGE 3, par. 3, line 5: - - - "that the off axis response of some microphones, whether bi-directional or cardioid, also caused unpleasant time and spectral coloration of a signal arriving after the direct sound," - - -
- PAGE 8, par. 2, line 2: "The timing was good, since by then the visibility re the future of the stereo market was making heroes of many who had been waiting cautiously."
- PAGE 8, par. 3, line 9: "The loading provided was 0.5π steradians, (directivity factor of 8), for the left and right speakers and 1.0π steradians (directivity factor of 4) for the loudspeaker located in the center."
- PAGE 9, par. 7 : "Mr. Donald Davis developed the LEDE Control Room concept (22). In collaboration with Mr. Cecil Cable he utilized the techniques developed by Mr. Heyser (Time Delay Spectrometry) for measuring the performance of these rooms.
- PAGE 11, Bibliography,
Ref. (19) : Add; J. Audio Engr. Soc.

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FROM THE LITERATURE:

- A. Averaged from data by Morris & Nixon 1945, Knudsen 1950, BB & N literature 1954.
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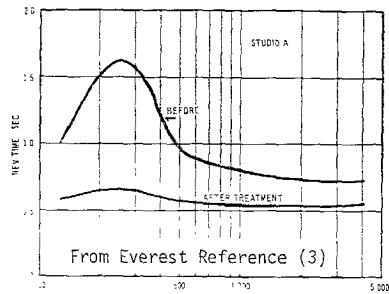


Figure #2



Figure #3

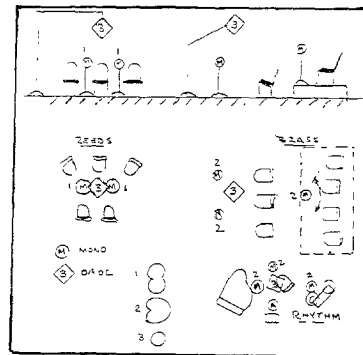


Figure #4

(VINTAGE MID-FIFTIES)

HI-Finformation

This stereophonic recording session was cut at Universal Recording Corp., with Bill Putnam engineering. Accent mikes utilized included; Caesar Giovanni's piano, RCA 44BX and Telefunken U-47; John Frigo and Harold Siegel, bass, B&O Fentone 50; vibraphone, Shure 335; xylophone and marimba, Telefunken U-47; drums, Telefunken 201; miscellaneous percussive instruments, RCA 77DX; harp, Telefunken U-47. In addition, two Telefunken U-47's were suspended above and on either side of the musicians for the overall stereo pickup. Recording was made on an Ampex 350-2 stereo tape machine running at 30 inches per second. At times during this recording, the following drummers were working alone, in groups or all together: Dale Anderson, Hugh Anderson, Bobby Christian, Frank Rullo, Dick Schory and Harry Brabec.

David Carroll

David Carroll
Musical Director

A PRODUCT OF MERCURY RECORD CORPORATION, CHICAGO 1, ILLINOIS

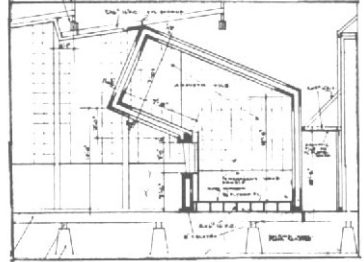


Figure #6

Figure #5



Figure #7

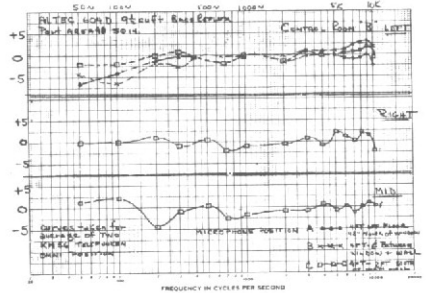


Figure #8

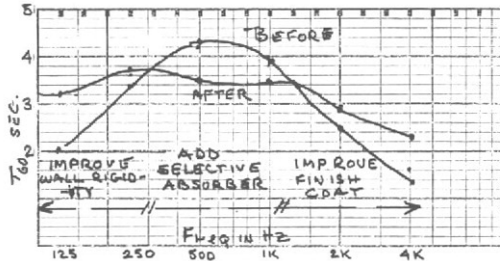
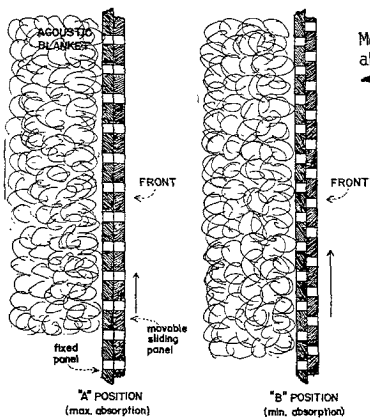
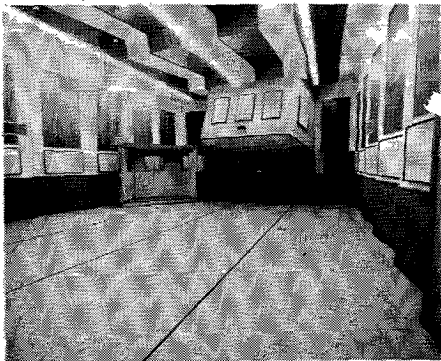
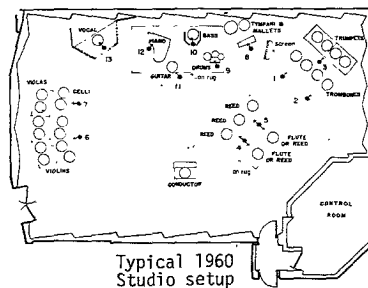


Figure #9



Method for varying absorption (Ref. 13)

Motor driven reversible panels



Typical 1960 Studio setup

