POLYSONICS

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PLANNING
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ACOUSTICAL SURVEY, ANALYSIS AND DESIGN RECOMMENDATIONS TO IMPROVE ROOM ACOUSTICS

FRIENDS MEETING HALL

WASHINGTON, D.C.

REPORT #2389

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Acoustical surveys were conducted at the Friends Meeting of Washington on June 20 and 23, 1985. The purpose of these surveys was to measure existing acoustics, exterior noise interference, and analyze the impact on the normal use of the facility in order to develop recommended modifications to improve audibility/intelligibility. Tests on the June 20 survey consisted of measuring the reverberation time of both the empty main meeting room and the empty social hall below. The background or ambient noise level with windows and doors closed was also measured along with the noise level created by the heating system. The facility was inspected for possible modifications that could be implemented with minimal disruption to appearance. During the second June 23 survey, an actual meeting was analyzed to incorporate typical room function with the data obtained during the previous survey. The ambient or background noise created by exterior traffic was also measured during the second survey with windows and doors open, which we understand is typical during the summer months.

SURVEY RESULTS

As shown on Figure 1, the main meeting room reverberation time averaged approximately 1.3 seconds. Measurements of the background or ambient noise indicated that with windows closed, typical outside automobile traffic creates levels in the 35dBA range with peaks to slightly over 40dBA. With windows open during a typical Sunday afternoon, traffic noise measured in the 50dBA range with peaks to over 60dBA. The heating system under normal operation created a noise level of approximately 40dBA thus increasing the typical ambient with windows closed. The social hall has an average reverberation time of slightly under 1 second.

ANALYSIS AND CONCLUSIONS

In evaluating the above measurements, it is important to understand that the decibel scale is logarithmic. A 3 decibel change (increase or decrease) is therefore equal to a factor of 2 in energy (such as increasing a hi-fi amplifier from 5 watts to 10 watts) but subjectively is only slightly perceptible. A change of 10dB is a factor of 10 (increasing a hi-fi amp from 5 watts to 50 watts) and subjectively is twice (or one-half) as loud. The decibel A scale is the most universally used single number rating for human response to sound.

Normal to slightly elevated conversation is typically in the 65-75dBA range within 3' of the speaker. At greater distances such as the other side of the hall, this level would be reduced to the 50dBA range. For reasonable speech intelligibility the sound level of the spoken word should be at least 10dB louder than the background ambient noise to avoid interference. The measured ambient noise levels with the windows open of 50-55dBA will therefore interfere with speech requiring either a substantial increase in the speech level or preferably a reduction in the interfering noise level. The 40dBA level with the windows closed is a significant and likely acceptable improvement although ideally the recommended maximum background noise level for a facility of this type is 35dBA which is achieved in between traffic peaks with windows closed and the heating system off.

A reasonable improvement could therefore be obtained by leaving windows closed and thus reducing exterior traffic noise interference to the 40dBA range. This could be improved further by the addition of storm windows or modified existing windows which should achieve the 35dBA range. This additional 5dBA improvement, however, may not be considered cost effective.

Room reverberation serves several functions but also causes some problems in achieving good speech intelligibility. Some hard wall and ceiling surfaces will increase the signal level at distant seats by providing reflected sound which will combine with and reinforce the direct line-of-sight sound. Excessive reverberation caused by too many hard surfaces, however, allows a sound to persist blurring the next word spoken thus reducing intelligibility. The measured nominal 1.3 second reverberation time is moderately live but could be considered acceptable for a trained public speaker. For spontaneous unprepared and inexperienced speakers, however, this moderately long reverberation time may cause some blurring of speech. A modest reduction in reverberation time to slightly below 1 second is therefore recommended to improve speech intelligibility while still retaining an adequate number of hard surfaces to reflect sound to the more distant seats.

The lower slightly under 1 second reverberation time in the social hall is quite adequate for speech intelligibility if used for a single speaker as noted above for the meeting hall. For social functions however, where there is a significant increase in noise level due to a large number of people talking simultaneously a very low reverberation time (less than .5 seconds) is preferred. To accomplish this goal a significant additional amount of sound absorptive treatment is required and may be incorporated into wall treatment in addition to the existing ceiling and/or replacement of the existing ceiling with a more efficient material. The existing ceiling was likely only moderately effective originally and is presently even less effective because it has been painted.

During consultation an interest in a sound reinforcement system was expressed that could help improve speech intelligibility. As discussed a sound reinforcement system for the meeting hall, because of the normal method of operation, is not as simple as a more traditional auditorium design with a single source location for the microphone. Ideally, microphones for sound reinforcement should be placed close to the person speaking (within 18"). To accomplish this for the Friends Meeting room would require a large number of microphones with an automatic microphone mixing system which would likely be prohibitive in cost and complexity. An alternate approach consists of a few ceiling mounted overhead microphones which will provide less quality but has been successfully used on past projects with proper control of room acoustics and background noise.

For the sound reinforcement system to be moderately effective within budget constraints it is necessary first to reduce room reverberation time and exterior noise interference. Without these modifications the overhead microphones would amplify the interfering noise along with the spoken word thus providing little improvement. Due to the distance from individual speakers the system would also amplify the overly reverberant blurred sound and thus would not be an effective system.

During consultation it was discussed and agreed that the reinforcement system would not consist of loud speakers amplifying the sound for all participants but would only amplify the sound through some type of earphone system for those that required additional amplification. This approach is considered more practical and cost effective because amplification for all participants is not compatible with an overhead microphone system due to the inherent feedback of this arrangement.

There are many types of earphone systems available including direct wired, inductive loop, infrared and FM. Each system has its advantages and disadvantages. Some of these aspects will be set forth under the recommendations section. We will assist selection of a system but a final decision must be based on other considerations and may require consultation with sound system contractors. Assuming a quality system is purchased and properly installed the actual performance of any of the above will be limited by the microphone system and room acoustics and not by the particular electronic transmitting/receiving earphone system.

RECOMMENDATIONS

Because as noted above it is essential to reduce exterior interfering noise and improve room acoustics before implementing an electronic sound reinforcement system, the following recommendations may be installed in steps. It is possible that the improvements from reduction of exterior noise and improved room acoustics may be considered adequate without the additional sound reinforcement system (because many hearing impaired already have hearing aids which basically are a form of sound reinforcement).

Traffic noise during summer months is the most serious exterior noise interference source. Leaving the windows and doors closed will reduce the 50-55dBA exterior traffic noise levels to 40dBA which is a substantial improvement. Air conditioning will likely be necessary to achieve acceptable comfort with windows and doors closed. The air conditioning system must be properly installed so as not to increase ambient noise levels thus defeating the improvement obtained by closing windows. This will include low velocity sound lined ductwork with remote fans, compressors and condensers and diffusers or grilles selected for a maximum NC30 rating. If the existing air distribution system is used we recommend that ductwork in the mechanical room be replaced on the supply side for a distance of at least 10' from the fan with 2" internally sound lined duct to reduce supply noise. The return air fan intake plenum should also be 2" sound lined.

Even if the existing system is not used for air conditioning these modifications would also help reduce heating noise during winter months which raised the 35dBA ambient noise level to approximately 40dBA.

This concept can further be improved by adding storm windows to the existing windows. The storm windows will provide not only an additional nominal 5dBA improvement in noise reduction performance but also will provide improved thermal performance. Storm windows should provide a tight fit and use relatively thick glazing (minimum double strength preferably 3/16" - 1/4") with as large an air space as possible between the windows and the storms. The 5dBA improvement in noise reduction performance will result in a 5dB reduction in traffic noise within the meeting hall lowering the 40dBA peaks measured during the first survey to the 35dBA range.

We understand that a relatively high price was obtained for the addition of storm windows. It may be possible to obtain a lower price by using a different type of glazing such as a fixed piece of glass for the upper 3/4 of the window and an awning type operable hopper for the bottom 1/4. This suggestion is based on observing the typical Sunday meeting where windows were opened only approximately 25%. Custom glazing for unusual windows of this size has been done successfully on other projects by Allen Glass Company 971-1624, and Associated Glass 591-9441. We therefore suggest that a price be obtained from these two sources in addition to any other sources previously investigated.

Another alternate consists of installing better weather stripping around the existing windows such as a vinyl sweep and then attaching 1/4" plastic (acrylic or polycarbonate) panels to the wood perimeter of each window (separate panel for top and bottom sections). This would provide improved thermal and some improvement in acoustics at a modest cost while retaining operability.

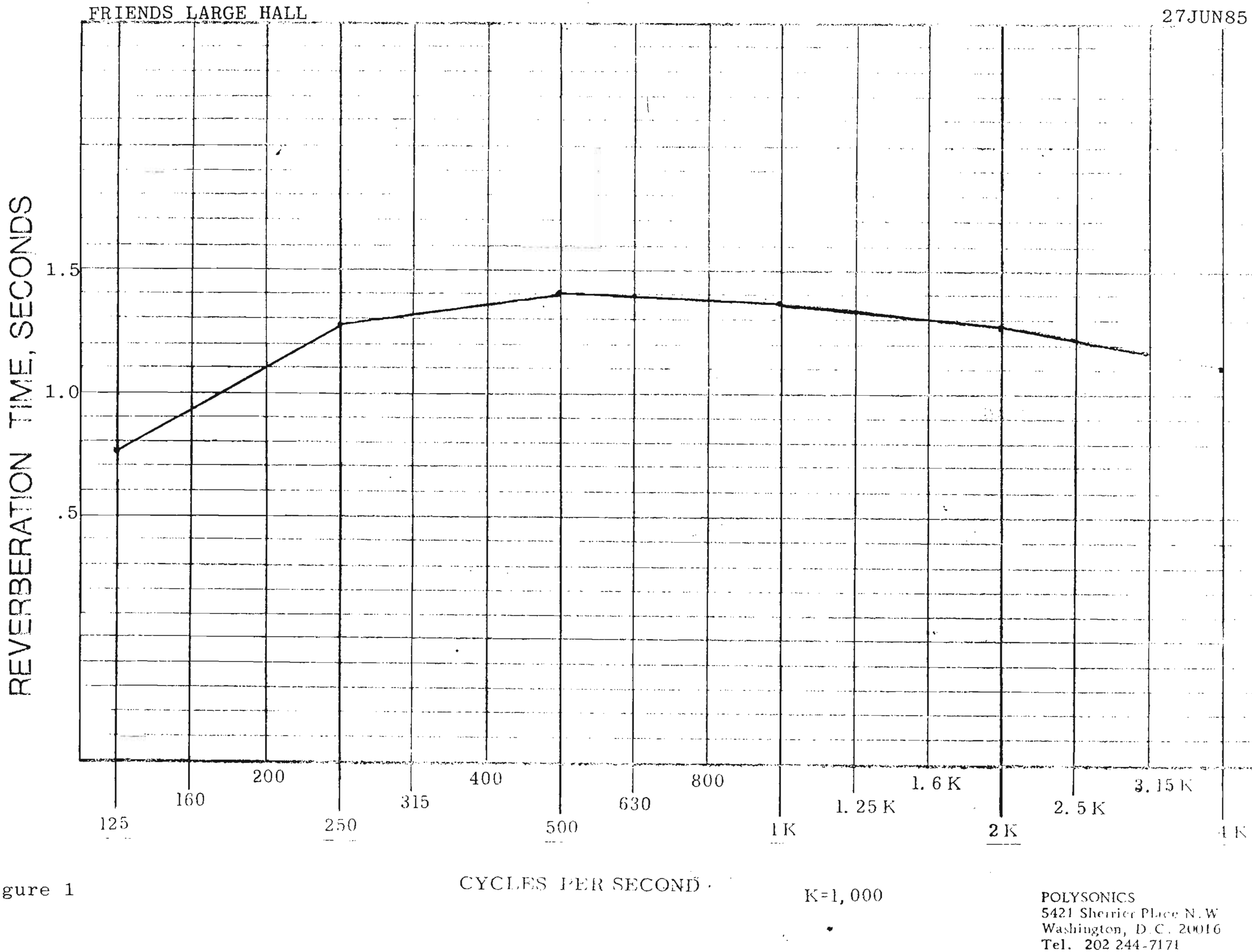
As noted above, once exterior traffic noise has been reduced, the second acoustical problem is the moderately high reverberation time. Calculations indicate that a modest improvement can be obtained with no visual impact on the room by installing 2" thick fiberglass duct liner (Owens Corning Aeroflex 150B or equal) on top of the curved overhang and on top of the three door vestibules. This modification alone, however, will not reduce reverberation time to the preferred slightly below 1 second range. To accomplish the ideal reverberation time would require some wall treatment in addition to the above.

We understand that consideration may be given to applying sound absorptive treatment to one or both end walls above the wood wainscoat. Calculations indicate that installation of a 1" fiberglass treatment to one of these end walls in addition to the above mentioned 2" treatment will lower room reverberation time to the preferred 1 second range. Wall treatment may be either custom built or factory fabricated panels. Custom built panels have lower material costs but higher labor costs. Factory fabricated panels are available with many different finishes in both monolithic designs and wrapped edge panels where butt seams are visible between panels. This type of panel costs in the $4-7 range and is available from many sources including Armstrong (301)621-1006 (Soundsoak 85), Decoustics 262-4848, and Owens Corning 390-6900. The panel selected should be a nominal 1" thick with a minimum .8NRC rating (Noise Reduction Coefficient). Panels are available in nominal 4x10' size with cloth, perforated vinyl or ribbed monolithic finishes. Samples should be obtained from the manufacturer or alternately some samples are available for review at our office.

The combination of the reduced exterior traffic noise and reduced room reverberation time should provide a noticeable improvement in speech intelligibility throughout the meeting hall. If a sound reinforcement system is considered necessary in addition to the acoustical improvements, the recommended system, considering the operational constraints, consists of installing two ceiling mounted PZM-6LP microphones connected to a solid state preamplifier/amplifier and associated transmitting system for use by the hearing impaired. The microphones should be flush mounted on the ceiling equally spaced at the third points. As noted above, the transmitting system may be direct wired to earphones at selected locations, an FM wireless system, an infrared system or an inductive loop system. Additional details and/or assistance can be provided if the sound reinforcement option is implemented. The preamplifier system should ideally incorporate a full octave equalizer to allow adjustment of the frequency response to best suit the hard of hearing requirements. The direct wired systems are usually the least expensive but also the least flexible with fixed locations and limited ability to expand. The infrared and FM systems normally allow almost complete freedom in location throughout the room as long as adequate transmitter power and orientation are provided. The loop systems require installation of the loop in or under the floor and normally are limited to moderate coverage areas and not the entire room. Within the coverage areas, however, reasonable freedom of location is available.

To reduce social hall reverberation time and thus control noise, the existing ceiling should be replaced or covered with a new ceiling providing a minimum .8NRC rating. A low cost easily installed material that meets these requirements is 1" thick Owens Corning Nubby. This tile can be installed in a standard T grid or alternately could be installed directly over the existing tile by installing nominal 1" thick wood furring strips, inserting the tile between the furring strips and then securing the tile in place with a 1"x4" cap strip as shown on the enclosed detail. This approach can be installed against the existing tile and around existing lights with minimal disruption or modification. This modification alone should provide a significant reduction in room reverberation time and associated improvement in room acoustics.

A further improvement could be obtained, if considered necessary, by covering approximately 50% of the available wall area with the 1" thick fiberglass wall panel treatment noted above for the main meeting room.



FRIENDS LARGE HALL
27JUN85
REVERBERATION TIME, SECONDS
1.5
1.0
.5
125
160
200
250
315
400
500
630
800
1K
1.25K
1.6K
2K
2.5K
3.15K
4K
CYCLES PER SECOND
K=1,000
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Figure 1

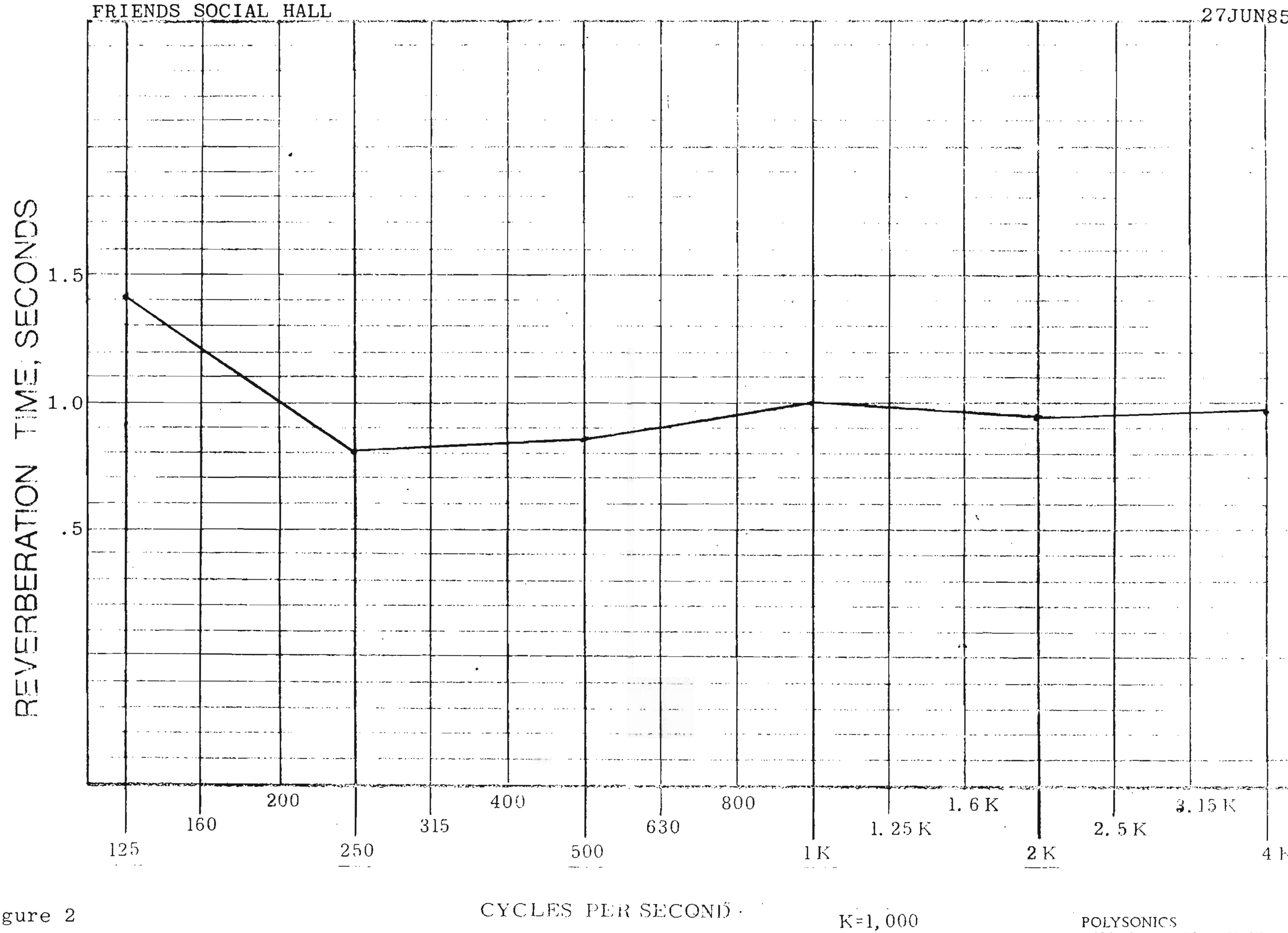

Figure 2

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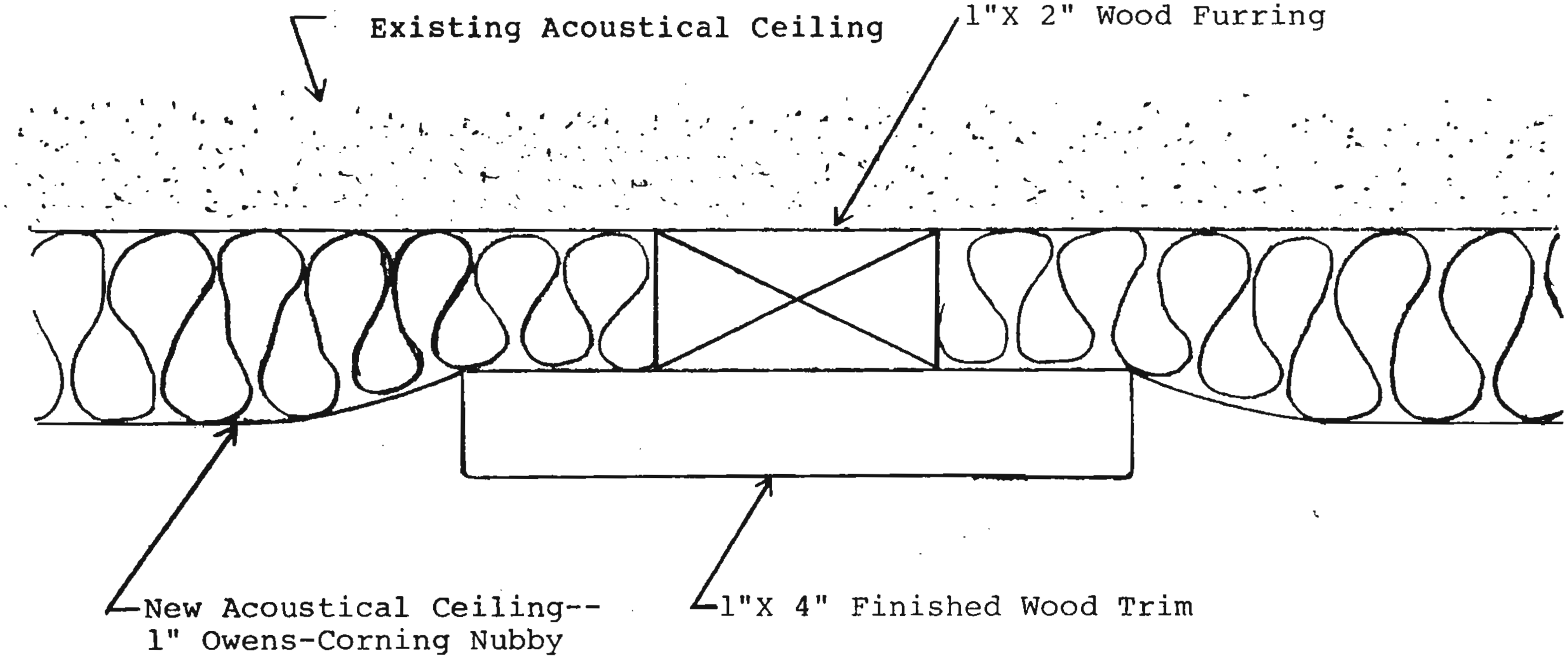
Figure 3



FRIENDS MEETING OF WASHINGTON
SOCIAL HALL ACOUSTICAL CEILING MODIFICATION DETAIL
(Full Scale)