BUFFALO FORGE COMPANY

A CASE STUDY IN SALES ENGINEERING MANAGEMENT

by

MICHAEL JOSEPH FOND

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE
DEGREE OF
BACHELOR OF SCIENCE
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MAY 12, 1977

Signature redacted

Signature redacted

Signature redacted
DISCLAIMER NOTICE

Due to the condition of the original material, there are unavoidable flaws in this reproduction. We have made every effort possible to provide you with the best copy available.

Thank you.

Some pages in the original document contain text that runs off the edge of the page.
BUFFALO FORGE COMPANY
A CASE STUDY IN SALES ENGINEERING MANAGEMENT
by
MICHAEL JOSEPH BOND

Submitted to the Department of Mechanical Engineering on May 12, 1977, in partial fulfillment of the requirements for the Degree of Bachelor of Science

ABSTRACT

This thesis deals with a sales engineering decision faced by a company which produced air handling equipment. In the first section of my thesis, the company's background is explored and in subsequent sections the problem faced by the company is described. This is meant to be the basis for class discussion on the decision making process of a sales engineer.

The second part of the thesis presents the author's analysis of the company's situation, as well as his recommendations for action.

The final portion of the thesis is a teaching note which is meant to serve as a guide to a discussion leader who uses the case in a classroom or other setting.

Mr. Robert T. Lund
Senior Research Associate, MIT Center for Policy Alternatives
Lecturer - Mechanical Engineering
ACKNOWLEDGEMENTS

I would like to thank the following people who helped me considerably with my thesis:

Mr. Robert T. Lund, my thesis supervisor, who had the infinite patience and understanding to see me through all the problems I faced in producing this thesis.

Mr. Joseph Johnson, Vice President of the Boston branch of Buffalo Forge, who assisted me in gathering all the information I needed to write this case.

I would also like to thank Peggy Garlick, the course secretary, who assisted me with all the technical problems I faced in finalizing this thesis.
<table>
<thead>
<tr>
<th>Title Page</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>2</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>3</td>
</tr>
<tr>
<td>BUFFALO FORGE COMPANY</td>
<td>4</td>
</tr>
<tr>
<td>Analysis of BUFFALO FORGE CASE</td>
<td>19</td>
</tr>
<tr>
<td>Teaching note for BUFFALO FORGE CASE</td>
<td>22</td>
</tr>
<tr>
<td>Epilogue to the BUFFALO FORGE CASE</td>
<td>23</td>
</tr>
</tbody>
</table>
The Buffalo Forge Company was a leading producer of air handling equipment. Late in 1967, the Boston branch of Buffalo Forge was chosen to supply the equipment necessary to complete the air conditioning system for the new addition to the Boston Public Library. Mr. Joseph Johnson, Vice President of the branch, was responsible for the sale. In 1972, after the equipment had been installed, Mr. Johnson's aid was requested in alleviating a noise problem caused by that equipment.

Products

Buffalo Forge produced a full line of air handling equipment and heat transfer equipment. These products, which comprised 90% of Buffalo Forge's total sales, included fans, blowers and heating and cooling coils.

Fan sizes ran from small ventilating fans with volumetric capacities as low as 50 cubic feet per minute (CFM), to heavy duty fans with capacities exceeding 1,000,000 CFM. These fans were sold for applications such as kiln exhaust, gas recirculation, air cleaning systems, gas exhaust and ventilation. The shapes, sizes and configurations of these fans varied according to the function performed and the physical constraints of the specific order. The shape of the fan blade, for instance, could be changed to provide tubeaxial, vaneaxial or centrifugal flow. Tubeaxial and vaneaxial fans were lighter and smaller than centrifugal fans of the same capacities and, therefore, required less operating space. They were also less expensive. Centrifugal fans, however, were more efficient and less noisy than tubeaxial and vaneaxial fans. Fans could also be altered to provide direct- or belt-drive.

Pressure blowers were designed to deliver gas or air at pressures of up to 5 psig and volumes of up to 100,00 CFM. These blowers were capable of handling gases at high temperatures. As with fans, Buffalo Forge produced blowers to fit varied specifications. The CB-type blowers were all related in basic design, while R-type blowers were modifications of the CB blowers, altered to meet special operating conditions. Because these blowers supplied air at large volumes and higher than normal pressures, they had a variety of applications. Furnace drafts, which must
provide large amounts of pressurized air for effective heat transfer typically consist of pressure blowers. Pressure blowers were also purchased as air compressors and gas boosters.

Heating and cooling coils were manufactured by Buffalo Forge for use in heating and air conditioning equipment. Buffalo Forge sold these coils individually or as part of one of their own systems. These coils could be produced to meet the consumer's size and geometric specifications.

Energy conservation and air pollution control equipment were sold by Buffalo Forge on a smaller scale for industrial use. Of all the air handling equipment produced by Buffalo Forge, these items comprised only 20% of the total sales. Energy conservation products, such as evaporative coolers, heat recovery apparatus and humidifiers, employed modern heat transfer techniques and could be combined to form efficient systems for cooling and heat recovery. Buffalo Forge marketed several types of dust collectors and air scrubbers for use in air pollution control. This equipment could be varied both in size and geometry to meet specific job constraints.

The remaining 10% of Buffalo Forge's total sales were derived from a line of pumps and machine tools. These products were produced on a very small scale and had limited capabilities. Although the pumps had a restricted adaptability to needs for which they were not produced, they were highly versatile with respect to the jobs they performed. Capacity, mounting position, material and parts could be varied to meet given specifications. Buffalo Forge pumps were used industrially typically for boiler feed and suction or discharge pumping.

Company Organization

The Buffalo Forge Company was based in Buffalo, New York and employed over 1700 workers. There were three manufacturing plants in the United States and one in Canada which produced all of Buffalo Forge's equipment. The equipment was marketed internationally by Buffalo Forge's own sales offices in the U.S., Canada and Mexico.

Buffalo Forge's main office and factory personnel consisted of the company's top executives, sales managers, applications engineers, support technicians and workers. The Buffalo facilities included a Research and Development Department, and Engineering Department, a factory shop
for manufacturing, an Assembly section and Support and Testing facilities.

The organization and size of Buffalo Forge's sales branches varied depending on the location and availability of business. Each office consisted of from one to six sales engineers, one or two secretaries, files and office equipment. Many of the offices were connected directly to the home office in Buffalo by a computer system and several of the branches were incorporated as subsidiary companies to take advantage of local tax breaks.

The Boston branch of Buffalo Forge, which covered all sales in Maine, Rhode Island and half of Massachusetts, handled the Boston Public Library order. The organization of the branch is depicted in Figure 2. Mr. Joseph Johnson, the branch Vice President, represented Buffalo Forge during this sale. Although all sales engineers of a branch participate in each sale, only one is ultimately responsible for developing a bid and ensuring customer satisfaction.

Mr. Johnson had been an employee for Buffalo Forge since graduating from Purdue University. After receiving his B.S. in Mechanical engineering, Mr. Johnson underwent a typical two year training program at the Buffalo Forge main office. This program trained the engineer in all phases of the manufacturing process in order to prepare him for a position as sales engineer in one of the company's sales branches. A detailed description of this training process is depicted in Figure 3. In 1958, Mr. Johnson was assigned to the Boston sales office.

**Competitive Advantage**

The Buffalo Forge Company began production almost 100 years before the Boston Public Library order. Since then, Buffalo Forge had expanded and improved both its facilities and engineering know-how. Mr. Johnson believed that several factors contributed to the continued successful operations of the company. Among the specific factors he cited were the fine quality of the machines produced and their consistent performance. This, he believed, was due mainly to the fact that all the parts for the air handling and pumping equipment were manufactured and tested solely by Buffalo Forge.

Other advantages mentioned included better training of sales representatives, superior manufacturing facilities.
and an excellent Research and Development Department. Buffalo Forge held several patents on their equipment design.

Finally, Mr. Johnson believed that because the manufacturing plants and sales branches interacted so closely on each sale, Buffalo Forge could alter the construction of most of its products to meet specific performance standards and physical constraints required by buyers. Mr. Johnson credited this flexibility with much of the success of Buffalo Forge to produce quality air handling equipment for almost any industrial or commercial application. This same relationship existed between the sales engineers within each branch. Each engineer contributed to each job, although only one was responsible. Salaries were not determined by individual sales, but remained relatively stable because of a profit sharing program. Each Buffalo Forge branch office received 10% of all sales produced by that branch as profit. The total annual sales for the Boston branch averaged 3 million dollars. The profit derived from these sales, $300,000 in this case, were split in a predetermined manner among the employees. Mr. Johnson believed that this method provided incentive to all the sales engineers to support each other and take advantage of individual skills, while simultaneously maximizing profits.

Boston Public Library Addition

Construction of the addition to the Boston Public Library commenced late in 1967. The job had been awarded to the Architects Design Group of Boston and Philip Johnson of New York. The architects subsequently selected Francis Associates, Inc. as consulting engineers to help design the mechanical portion of the addition, including the heating and air conditioning systems. Le Messurier Associates, Inc. was selected to handle the structural part.

The role of general contractor for the addition was awarded to the Turner Construction Company, who in turn awarded the mechanical portion of the contract to the Limbach Company. The Limbach Co., therefore, was responsible for the installation and purchase of all the mechanical portions of the addition. Sam Rogers, an engineer for the Limbach Co., was designated as project engineer.

Francis Associates, Inc. is one of many companies in the Boston area who are serviced by a Buffalo Forge
sales representative. Mr. Johnson, who was the representative in this case, had the responsibility of regularly providing Francis Associates with information concerning Buffalo Forge equipment and all new developments. Mr. Johnson had been doing this more or less on a regular basis for almost fifteen years and had developed a close friendship and trust with the people there. Because of this confidence, the Francis Associates, who did a lot of consulting work all over the world, frequently provided Buffalo Forge with opportunities to sell their equipment. During the course of the mechanical design, Francis Associates requested the aid of Mr. Johnson in developing an air conditioning system for the addition. The Francis Associates had developed data specifying the heating and cooling requirements for the addition. These specifications, shown in Figures 4 – 7, were presented to Mr. Johnson. Mr. Johnson subsequently went through all the data with the consultants at Francis Associates and indicated which Buffalo Forge equipment were capable of meeting the requirements. The Francis Associates had to take into account certain space limitations while designing the system. The Architects' design provided a limited amount of space in which the system was to fit. With this in mind, Francis Associates elected to use vaneaxial fans in the system design. These fans, being smaller and lighter, could satisfy the space limitations. Mr. Johnson advised Francis Associates that, although vaneaxial fans could meet the space and performance specifications, they would also be noisier and might cause problems in this area. The Francis Associates thought that the equipment would still have satisfactory noise levels and stayed with their original decision.

The equipment was subsequently bid through the Limbach Company. The total cost of the equipment was $85,000, a medium size order for the Buffalo Forge Company whose orders typically ran from 50 to 1,000,000 dollars. This equipment is pictured in Figure 8. The bid was accepted and the design utilizing the Buffalo Forge equipment was incorporated into the architects' design and given to the Turner Construction Company. Turner then directed the Limbach Company to purchase and install the equipment.

As the construction of the addition progressed, Mr. Johnson stayed in constant contact with the Francis Associates and Limbach Company. The job required drawings of the equipment and information concerning erection, operation and maintenance of the fans. Mr. Johnson was particularly concerned that the installation and operation
of the Buffalo Forge equipment in the addition ran smoothly. He knew that this job was very prestigious and, if done well, would give the branch a good chance of landing future job orders. Mr. Johnson also felt that Buffalo Forge had something to prove with this order. A couple years before the Boston Library addition was designed, Buffalo Forge had lost the new Rockefeller Library order in New York. The job had been awarded to a competitor who claimed to have superior equipment.

By September 1972, the 15 million dollar addition was near completion. At this point the air conditioning equipment was completely installed and operating. As had been anticipated by Mr. Johnson, however, the equipment was producing noise at unacceptable levels, both inside and outside the building. Francis Associates consequently requested the assistance of Buffalo Forge and Mr. Johnson in solving this problem.

1972 was an unusually busy sales year for Buffalo Forge's Boston branch and in September all the representatives were working on new orders. In order for Mr. Johnson to work out an effective solution to the Boston Public Library noise problem, he would have to divert much of his time away from the prospective order he was involved with. Mr. Johnson realized that a complete study of the problem was necessary. If the problem could be solved, the changes which would have to be made in the system would probably be minor. The extra items needed to correct the problem would be purchased from Buffalo Forge by the Limbach Company. The profit realized by Mr. Johnson's office, however, would be negligible. The cost of sending a trained engineer to the job site to take noise level readings and evaluate the problem would be approximately $2,000. This cost would be totally absorbed by Buffalo Forge, whether or not a solution was found or their advice was followed.
FIGURE 1
Buffalo Forge Fans

TYPE "B" AXIAL FLOW FANS

ADJUSTAX AXIAL FLOW FANS

CENTRIFUGAL INLINE FANS
Organization Chart of Boston Branch Personnel
September, 1967

President
Bob Muir

Vice President
Joseph Johnson

Sales Rep.
Tony Lockwood

Secretary
Betty Crane

Sales Rep.
Bert Jordan

Secretary
Eleanor Smith
BUFFALO FORGE COMPANY

Two Year Training Program at Home Office

Assignment to Engineering Dept. → Assignment to Design Office → Assignment to Research and Development → Assignment to Testing

Work in Shop → Contact with Sales Offices → Sales → Assignment to Permanent Sales Office
IN AL EQUIPMENT & COOLING COIL SELECTION

7TH. FLOOR MECH. RM.

IC SYSTEM No. 4. (Serving 3rd Floor)

Total Sensible
Total Latent

Total Supply Air = 64,000 cfm

4 Fans & Cooling Coils each @ 16,000 cfm

People = 500

Minimum Fresh Air = 7500 cfm (12.5% FA) (87.5% RA)

Room = 75°F DB

Outside = 95°F DB 78°F W.B. 50% - 40% R.H. 65 CR/LB.

4 - Supply Fan motors Motor & Driven Machinery in 40 HP each

40 HP x 2545 = 129,000 BTU/HR

DB Pick-up = 129,000 BTU/HR

(16000)(1.08) = 7.4°F DB pick-up from fan etc.

S.H.F = 1327000

1452000 = .94 SHF

Total Sensible = 1,327,000 BTU

50% light load = 470,000

857,000

= 857,000

(64000)(1.08) = 12.2°F ΔT (In Room)

75°F DB - 12.2°F = 62.8°F D.B. Ent. Rm.

Plenum: Assume 1/3 Plenum Load affects supply air temp.

50% Lighting Load = 479,000

157,000 BTU/3

= 157,000 BTU

4 Systems

= 39,500 BTU/HR.

16000)(1.08) = 2.3°F DB Pick-up in Plenum.
Heating and Cooling Specifications

Supply Air Temperature, Room = 75°F - (12.2°F + 2.3°F) = 60.5°F
Air Temp. Leaving Coil = 60.5 - 7.4°F = 53.1°F DB.

Assume no moisture pick-up in plenum.
GR/LB Entering Rm. = GR/LB Leaving Coil.

1) .94 SHF, 62.8°F DB, Wet Bulb entering room = 58.1°F W.B.

2) Air Enters Room @ 56.0 GR/LB.

3) 53.1°F DB @ 56.0 GR/LB = 51.3°F W.B. =

4) Air Leaving Coil @ 53.1°F DB, 51.8°F W.B. = 21.1 BTU/LB.


\[
\frac{470,000}{3} = 312,000 \text{ BTU pickup by return}
\]

Return Air = 87.5% x 64,000 = 56,200 cfm

\[
\frac{312,000}{56,200} = 5.5^\circ\text{F D.B. pickup in R.A. Plenum}
\]

6) Room Temp = 75°F + 5.5°F = 80.2°F D.B. Return Air

7) Room Design 65 GR/LB

8) Assume No Moisture pickup in plenum

9) @ 80.2°F DB, 65 GR/LB, R.A. W.B. = 64.2°F W.B.

10) 12.5% O.A. @ 95°F DB, 78°F W.B., 118 GR/LB.
Figure 6

Heating and Cooling Specifications

4) \[
\begin{align*}
(125) & \times (95) = 12.0 \\
(875) & \times (80.2) = 71.0
\end{align*}
\]

\[
\frac{83.0 \text{°F DB entering Fan}}{71.0 \text{°R/MB entering Fan}}
\]

5) 3rd Floor \# usable floor area = 46000 \#

\[
40000 \text{ cfm} = 1.4 \text{ cfm/\# floor area}
\]

6) 46000 \# x 9:5.54\# high = \[
\begin{align*}
414,000 \text{ ft}^2 & \times 9.3 \text{ AC/ft}^2 \\
& = 64,000 \text{ cfm}
\end{align*}
\]

7) Return Air Fans heat pick-up.

\[
30 \text{ HP} = 120 \text{ HP} + 60 \text{ HP} = 120 \text{ HP} \times \frac{2545}{120} = 40000 \text{ BTU/HR}
\]

Total R.A. all Fans. 130000 cfm

\[
\frac{40000}{130000 \times 1.0\#} = 2.8 \text{°F}
\]

2.8 \#/8 coils = .35 °F pickup each coil

5 \# 1/2 °F DB each coil.

Ent. Air = 89.7 °F DB CC. 8 °F WB = 315 BTU/LB.

\[
\frac{(16000 \text{)(4.5} \text{)} (31.5-21.1)}{17000} = 41.5 \text{TONS} \times 4 = 246.0 \text{ Total TONS}
\]

GPM = 149/Coil \# x 4 Coils = 596 GPM TOTAL

10(6) 80.7/66.8 to 53.1/51.8

45° water

O/T on people chart
**Power Consumption Specifications**

**APPROXIMATE**

**MOTOR H.P. LOADS**

**Basement Mechanical Room**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Circulating Pumps</td>
<td>285H</td>
</tr>
<tr>
<td>Duplex Condensate Pumps</td>
<td>20H</td>
</tr>
<tr>
<td>Air Compressors</td>
<td>30H</td>
</tr>
<tr>
<td>Supply Air Fans</td>
<td>287.5H</td>
</tr>
<tr>
<td>Return Air Fans</td>
<td>143.0H</td>
</tr>
<tr>
<td>Exhaust Fans</td>
<td>14.0H</td>
</tr>
</tbody>
</table>

Total = 50 HP

**7th Floor Mechanical Room**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Circulating</td>
<td>15 H</td>
</tr>
<tr>
<td>Supply Air Fans</td>
<td>265H</td>
</tr>
<tr>
<td>Return Air Fans</td>
<td>106H</td>
</tr>
<tr>
<td>Exhaust Fans</td>
<td>6H</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling Towers</td>
<td>240H</td>
</tr>
</tbody>
</table>

**Rare Books**
- 2 - 20 HP compressors
- 2 - 3 HP Blowers on emergency generator

**Motor Control Centers** Basement and 7th floor Mechanical Room.

**Central Temperature Control Center** Basement Mechanical Room.
FIGURE 8
Buffalo Forge Equipment
used in
the Boston Public Library
Addition

BIG BUFFALO HIGH CAPACITY AIR HANDLING SYSTEMS
The sales engineer faces a two-fold problem in doing his job. First, he must possess the technical expertise necessary to analyze complex engineering problems and subsequently find solutions through applications of his company's equipment. Secondly, he must sell this equipment to various companies and be responsible for its performance. In the case of the Boston Public Library addition, Mr. Johnson faced an additional problem due to a mistake by the purchasing company.

The most important issue of the case is whether or not Buffalo Forge should correct the noise problem created by their fans. There were many factors Mr. Johnson had to consider.

First of all, the responsibility for the problem had to be accepted entirely by the Francis Associates. Mr. Johnson, as was stated, worked closely with the Francis Associates throughout the job, providing them with all the details of the air conditioning equipment. Because of certain space limitations in the architect's design, the Francis Associates chose to buy vaneaxial fans for the air conditioning system. Mr. Johnson advised Francis Associates of the potential noise problem these machines might produce. At this point, Francis Associates might have avoided the problem either by seeking a competitor's equipment or buying Buffalo Forge centrifugal fans, which are quieter. This would involve, however, a change in the architect's design and spending extra money to buy the more expensive fans. Francis Associates decided to gamble that the vaneaxial fan noise levels, although higher, would still be acceptable. Buffalo Forge was not under contract and, therefore, not responsible to fix the machinery when the noise problem did crop up.

From a purely economic viewpoint, Buffalo Forge did not stand to make a substantial profit by selling the accessories needed to alleviate the problem. Sending a man to analyze the situation and recommend the suitable equipment was a cost that would slash the company's profits by $2000 alone. Add to this the possibility of losing current business orders by tying up a top sales representative, Mr. Johnson, and the economic prospects seem poor. The Boston Branch of Buffalo Forge was very busy at this time due to a high level of construction and subsequent opportunities for sales. Any extra time Mr. Johnson would have to spend correcting the noise problem would, of course, subtract from the time he had available to work on other orders. It was not even certain if the problem
was a correctable one. The order for the Boston Public Library addition, worth $85,000, cannot be considered a large order relative to other job orders which ran as high as $1,000,000. The total profit for the branch, 10% or $8,500 in this case, was not very high in the first place.

Mr. Johnson, however, knew that the Boston Public Library job was a prestigious one in this area. Successful performance by Buffalo Forge equipment on this addition would greatly enhance the chances of the branch being awarded future bids. The equipment involved in the order was part of a line of equipment which comprised 70% of Buffalo Forge's entire sales. Buffalo Forge would risk the reputation of this line by not acting, even though the fault was not theirs.

The fact that Buffalo Forge had lost the Rockefeller Library order the previous year made the job even more important. A competitor of Buffalo Forge claiming that his equipment was better must have weighed heavily in Mr. Johnson's mind. Mr. Johnson had to prove that Buffalo Forge did, in fact, produce superior equipment. The industry in which Buffalo Forge operates is very competitive and information concerning equipment quality and performance spreads rapidly to prospective buyers.

Finally, Mr. Johnson had to consider his relationship with Francis Associates. After regularly servicing this company for 15 years, Mr. Johnson had developed a close friendship with the top personnel there. The Francis Associates, who did a lot of consulting in the construction business, had confidence in Mr. Johnson and Buffalo Forge. Continued good relations with Francis Associates was desirable and would probably ensure more business from them in the future.

What this case points out is an example of the advantages of sacrificing a little time and money at the present to ensure customer satisfaction and good business in the future. By helping out the Francis Associates in their problem, Buffalo Forge would prove that it stands by its equipment in any case. This, coupled with quality products, would give Buffalo Forge a good business reputation.

Another issue, however, was if Buffalo Forge, in light of the fact that the job was so important, should still have sold the fans, knowing that a noise problem might exist? It was stated that Mr. Johnson knew of the potential noise problem. It seems evident, therefore, that a chance was also taken by Mr. Johnson that his equipment
would perform at adequate noise levels or that any problems could be corrected. Bad performance on this job would have proven exactly the opposite of what Mr. Johnson wanted to prove. Buffalo Forge equipment would have been proven to be inferior. A better alternative would probably have been for Buffalo Forge to send a man to make sure all the equipment had been acoustically sealed during the installation. In this way, any errors caused by faulty installation or construction would also be avoided. Consideration of this alternative may have been overlooked by Mr. Johnson. In any case, this issue points out that foresight should be followed up by action, not warnings. Mr. Johnson could have avoided the first issue entirely by making sure that the problem would never appear.
There are several points of interest which can be brought up for class discussion. These are:

A) Francis Associates relationship with the Architects: The question here is, should consultant firms interact more closely with architects during the engineering design process or accept what is given them as being final? The class could discuss the problem of time lost through overall design changes as opposed to time gained by simplifying a job.

B) Mr. Johnson's personal friendship with the Francis Associates. Discuss how much this relationship affected the eventual decision. Are these types of relationships desirable in business?

C) Would a decision by Buffalo Forge to correct the problem appear to an outside company as an admission of guilt? Should this be considered in the decision? What are the consequences if Buffalo Forge tried and couldn't fix the problem?

D) Should Buffalo Forge have sold the fans in the first place, in light of the foreseen problem?

E) The class could discuss the pros and cons of profit sharing as utilized by the Boston branch of Buffalo Forge. Does this method create incentive or create a complacent attitude? Would weaker sales representatives tend to rely on better ones too much?

It is useful, in this case, to point out how Mr. Johnson actually handled the problem and which, if any, of the future prospects for business eventually materialized. This information is given in the form of an Epilogue.
In light of all the factors involved, Mr. Johnson decided to try and correct the problem. Mr. Johnson consulted with the Francis Associates and Sam Rogers of the Limbach Company. He decided that noise level tests were in order and arranged to have Howard Fehr, of the Buffalo Forge Research and Development Department, come to Boston to perform them. His results and report are included in this Epilogue.

Francis Associates subsequently followed the suggestions in the report and the designated equipment was purchased and installed. In this way, the noise problem was corrected.

The possibility of future job orders materialized in the form of the U Mass Medical Building in Worcester, Mass. Mr. Johnson attributed the winning of that order directly to the good results produced by Buffalo Forge equipment in the Boston Public Library addition job.
SOUND PRESSURE LEVELS of
ADJUSTAX FANS for
BOSTON PUBLIC LIBRARY
S.O. #69L-17500-52

I visited the Boston Public Library on Wednesday, September 27, 1972 to obtain sound data at various places in and around the building. The major objective of this trip was to suggest remedial action for the presence of above normal sound levels in the area on the ground floor near the main entrance.

The data obtained is presented in this report as one-third octave band sound pressure levels in dB re 0.0002 microbar. Figs. 2 through 19 are the sound pressure spectra of the tests obtained at the location defined on each figure.

LIBRARY STATUS

At the time of my visit the building was very near completion and almost ready for occupancy. No major construction was being done and all the workmen were doing "finishing", i.e., readying the elevators, completing light fixtures and electrical outlets, placing shelves, and cleaning up. As for the fans, all are installed and in use. However, Bill Demeris, Limbach foreman, mentioned that there was some minor system balancing to be completed.

GROUND FLOOR ENTRANCE

Of major concern on this job are the sound levels which a patron experiences upon entering the library.
The entire center area (seven floors high) is faced with marble walls which form a reverberant space which carries any noise present on the seventh floor walkways down to the ground floor with minimum reduction.

Fig. 1 is a sketch of the seventh floor walkways which form the upper perimeter of the center area. The circled numbers are test locations and numbers.

Fig. 2 is the sound pressure spectrum on the ground floor near the entrance to the library. These levels are above normal and easily distinguishable as coming from the fans on the seventh floor.

Fig. 3 is the sound pressure spectrum on the second floor landing and is not significantly different from Fig. 2 due to the reverberant quality of the walls. The sound does not decay sufficiently in this type of an environment to expect much reduction by distance alone.

**SEVENTH FLOOR WALKWAYS**

In order to define the source of the noise, data was obtained on each of the four seventh floor walkways. Figs. 4 through 7 are the sound pressure spectra on these walkways. There is no appreciable difference between these levels except that Fig. 4 shows slightly higher levels due to the presence of more doors along the south walkway.

The noise radiated to these walkways is a result of leakage through doors which lead to the fan shaft areas in
Boston Public Library
Seventh floor walkways
About center over entrance
No scale 10-20-72 H. Fehr
**Figure 2**

*LP is sound pressure*

**Boston Public Library**
Test 9 - 9-27-72
Center of ground floor

FREQUENCY IN HERTZ

Third-Octave Band Level in dB re 0.0002 microbar
Boston Public Library
Test 10 - 9-27-72
Second Floor Landing

Fig. 3
BOSTON PUBLIC LIBRARY
TEST 8 - 9-27-72
MIDWAY ON SEVENTH FLOOR
SOUTH WALKWAY.

Fig. 4
Boston Public Library

Test 17-9-27-72
Midway on North Walkway
of Seventh Floor.
Boston Public Library
Test 15 - 9-27-72
Midway on East Walkway of Seventh Floor.
Boston Public Library
Test 19 - 9-27-72
Midway of West Walkway
On Seventh Floor.

Fig. 7
each corner. All the doors are poorly sealed and have large spaces at the floor level. The high noise levels in the fan shaft spaces, which are discussed later in this report, are leaking through to the walkways and into the highly reverberant area above the library entrance. Conclusive proof of this leakage could be obtained by tests in the area before and after sealing the doors with some type of heavy metallic tape.

**CORNER SHAFT AREAS**

Figs. 8 through 11 are the sound pressure spectra inside the return air fan shafts. The fans are either in-wall or are in the equipment room immediately adjacent to the walls forming these shafts.

The levels and spectrum shape are much the same in each shaft and these sound levels are the source of the sound present in the entrance hall via leakage through the doors.

**SUGGESTED ACTION**

After all the data was obtained, Sam Rogers and I met to discuss the problem and come up with suggestions to remedy the situation.

The obvious place to start is to acoustically seal all the doors between the corner shaft areas and the seventh floor walkways. If this does not sufficiently reduce the
Boston Public Library
Test 14 - 9-27-72
Inside SE corner of
Seventh Floor.
Fig. 9

Boston Public Library
Test 16 - 9-27-72
Inside NE corner of
Seventh Floor.
BAND NO.

16 17 18 19
20 21 22
23
24 25
26 27 28 29 30 31 32 33

-------------

34 35 36 37 38
39
40 41 42

-------------

ADD 49 DB TO OBTAIN OCTAVE BAND LEVEL

THIRD-OCTAVE BAND LEVEL IN DB RE 0.0002 MICROBAR

FREQUENCY IN HERTZ

Boston Public Library
Test 18 - 9-27-72
Inside NW corner of
Seventh floor.

Fig. 10
Boston Public Library
Test 20 - 9-27-72
Inside SW corner of Seventh Floor.
levels present in the entrance hall, something has to be done about the levels inside the corner shaft areas.

Two of the shafts have fan inlet ducts terminating about 5 ft. above the floor level and one shaft has the inlet side of the fan flush with the shaft wall. This latter fan has a rubber vibration isolation connection which should be changed to some material with a higher transmission loss coefficient.

For the two shafts where the inlet ducts terminate 8 to 10 ft. below floor level, it was suggested to cover the shaft walls by adhering an acoustical absorbing material such as "Ultra-liner" to the shaft walls about 5 or 6 ft. above and below the duct termination. This could also be accomplished by spraying the shaft walls with an acoustical absorbing material.

For the two shafts where the inlet ducts terminate above floor level, the ducts could be extended into the shafts and treat these two shafts as the other two. Another possibility is additional attenuators on the inlet ducts.

Sam Rogers suggested a steel covering over the shafts. This is a good possibility and if used, it naturally entails extending the overhead ducts into the shaft and acoustically sealing all cracks around the ducts.

By incorporating some of the remedial suggestions, the levels on the ground floor near the entrance should be reduced sufficiently so that the fans on the seventh floor could not be heard.
BASEMENT EQUIPMENT ROOM

The levels in the basement equipment room are generally high (88 dBA) and peak much higher (98 dBA) depending on the distance from the outlets of fans and/or other equipment. The room is actually a collection plenum for return air and the fans return air by discharging directly to the room with nothing on the outlets.

These high levels within the equipment room do not present a problem because there are no personnel regularly assigned to this space.

Fig. 12 is the sound pressure spectrum about 35 ft. in front of the outlets of RAF-7 (48B7) and RAF-8 (48B7). RAF-9 (48B7) returns air perpendicular to RAF-7 and 8 about 28 feet away. Fig. 12 shows the highest levels at frequencies from 500 to 2500 Hz. This is caused by a mixture of sound from the fans and miscellaneous equipment.

Fig. 13 is the sound pressure spectrum taken in between air conditioning cabinets 5 and 6. The 500 Hz "spike" is due to the blade frequency of SAF-18 (25A9) on AC-6 and SAF-14 (25A9), 15 (25A9), and 16 (29B9) on AC-5. This tone is leaking through the rubber vibration isolation connections on the fans and is present in the area. It was previously suggested and reiterated here that the connections could have been an acoustical type or wrapped with lead impregnated vinyl to reduce the amount of noise leakage.
Boston Public Library

Test 1 - 9-27-72

Basement Equipment Room

Near door of AC-6

Refer Limbach Dwg. B-D-6

Fig. 12
Add 40 dB to obtain octave band level.

Third-octave band level in dB re 0.0002 microbar

FREQUENCY IN HERTZ

Boston Public Library

Test 2 - 9-27-72

Basement Equipment Room

Between AC-5 and AC-6

Refer Limbach dwg. B-D-6

Fig.13
LIBRARY EXTERIOR

Some minor complaints have been received from a hotel across the street behind the library. The levels present behind the library are a result of the upstream noise of the fans on the AC units in the basement. The sound is traveling through the cabinets, out the fresh air intake louvers, and up to the street.

Figs. 14 and 15 are the tests taken inside AC-5. These air conditioning units have four fans drawing from a common plenum and the units are equipped with charcoal filters which provide some sound reduction across the filters.

By comparing Figs. 14 and 15, we see a significant reduction of sound levels across the charcoal filters with the most reduction at frequencies of 630 Hz and higher.

The "spike" in Fig. 15 is the blade frequency which is radiated through the fresh air intake louvers up to the street behind the library.

Fig. 16 is the sound pressure spectrum at the inlet louvers of AC-2 in the seventh floor equipment room. This figure should be similar to Fig. 15. A comparison of the two figures show them to be very similar in both level and frequency distribution.

The sound at street level could hardly be called objectionable but this could have been eliminated by our original suggestion of "Acoustilouvers" in place of the standard louvers.
Figs. 17 and 18 are the sound pressure levels on the street behind the library. Fig. 17 is directly over the grating and the 500 Hz blade frequency of the fans is noticeable but not predominant. Fig. 18 is a test taken across the street in front of the hotel. This shows a rapid decay of the sound level as a function of distance.

FRIEDMAN HALL

Fig. 19 is the sound pressure spectrum in Friedman Hall at about the center of the room. This test was taken because a tone was audible as I passed through on my way to the ground floor. The tone detected is at 500 Hz and is the blade frequency of the fans on the AC units in the basement. This tone is traveling through the upstream ductwork and out the ceiling louvers into Friedman Hall. The 500 Hz tone is not at a high level but is easily detectable by the human ear.

At present, without all the shelves and books in, Friedman Hall meets the NC-50 curve but this would be expected to improve slightly when the room is finished.

Signature redacted
HOWARD FENR
Research Department

Approved: 
Director of Research
Boston Public Library
Test 3 - 9-27-72
Inside AC-5 between filters and fan inlets.
Refer Limbach dwg. B-D-6
Boston Public Library
Test 4 - 9-27-72
Inside AC-5 Between Filters and Intake Louvers.
Refer Limbach Dwg. B-D-6

Fig. 15
Third-Octave Band Level in DB Re 0.0002 Microbar

Frequency in Hertz

Boston Public Library
Test 6-9-27-72
Seventh Floor Equipment Room
At inlet louvers to AC-2
Refer Limbach Dwg. D-7-5

Fig. 16
Add 40 dB to obtain Octave Band Level.

Third-Octave Band Level in dB re 0.0002 Microbar.

FREQUENCY IN HERTZ

Boston Public Library
Test 11 - 9-27-72
Above grating over inlet louvers behind library.

Fig. 17
ACPR055 STREET OPP006,67E ST/Fic.

FREQUENCY IN HERTZ

BOSTON PUBLIC LIBRARY
TEST 12 - 9-27-72
ACROSS STREET BEHIND LIBRARY
OPPOSITE TEST 11.

Fig. 18
BOSTON PUBLIC LIBRARY
TEST 5 - 9-27-72
FRIEDMAN HALL - GND FLR.