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Acoustic Features of Organ Concert Halls: Trends and Problems

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Abstract—The main acoustic requirements in organ concert halls, their evolution in recent decades, and the problems arising in the creation and rebuilding of these halls are considered. The problems associated with the specific features of organs in the acoustic design of halls are briefly discussed.

Keywords: acoustics of concert halls, organ halls, organ building

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INTRODUCTION

Organ is a stationary musical instrument, which is specifically designed according to room and, more than other instruments, depends on its acoustics. In turn, the hall must be adapted via building or reconstruction for organ installation. For this reason, acoustic characteristics of concert halls used for solo organ concerts (in this work, these halls will be called "organ halls") are a key issue from the viewpoint of the sound quality of the organ.

In this paper, the main requirements for organ hall acoustics are briefly considered (only the principal acoustic parameters, foremost, the standard reverberation time, were taken), as well as discussions on existing problems and possible solutions. Here, we will not touch upon the effect of the acoustic characteristics of a hall on the spatial scheme of an organ and other parameters of this instrument, as this subject is worthy of special consideration.

REVERBERATION TIME IN ORGAN HALLS (EVOLUTION OF RECOMMENDATIONS AND REGULATION PROBLEM)

The most important regulated parameter of a concert hall is the standard reverberation time (the time required for the sound pressure to decrease down to 60 dB). As known, the simplest estimation, which is sufficiently reliable for live halls, may be given to the standard reverberation time via the Wallace C. Sabine formula (1898):

$$T_{\mathrm{r}} = 0.161\frac{V}{A},$$

where T_{r} is the reverberation time, s; V is the volume of a room, m^3; and A is the total sound absorption, m^2. The constant 0.161 specified by Sabine in the formula is dimensional and, generally speaking, its value may also be slightly different depending on the air temperature and humidity in a hall. The review and comparison of more precise formulas for the standard reverberation time are given, e.g., in the paper [1].

In most countries, there are no strictly regulated standards for the reverberation time in organ halls, however there exist numerous recommendations for acousticians and organ experts. The study of these recommendations shows that, first, they are widely variable; second, the clear trend to increase the recommended reverberation time for organ halls is observed over the past 75–80 years; and, third, the Russian recommendations correspond to the lowest values of the optimal reverberation time (i.e., the most acoustically "dry" halls) in comparison with the recommendations published in the European countries over the past 40 years. These conclusions are illustrated by Figs. 1 and 2.

The recommended dependences of the optimal reverberation time on the volume of rooms for organ halls are shown in Fig. 1 (the solid line represents the Brüel & Kjær Company recommendations [2], and the dashed line represents the Russian recommendations [3]) alongside reverberation times in foreign halls and churches, which are good sound environments for organs, and selected Russian halls (the data sources on the first 13 halls were taken from paper [4], and the author obtained the other data in cooperation with M.Yu. Lane). From the data described, it is possible to derive at least two conclusions: (1) almost none of the following well-known European and Japanese organ halls satisfy Russian recommendations (the foreign halls are livelier) and (2) the real acoustics of the organ halls in Russia are much more problematic even compared to "dry" acoustics, which are recommended Russian standards: almost all the organ halls in Russia are more or less muffled, with rare exceptions[1]. This

[1] This matter does not include concert halls created in former churches, where natural acoustics were initially favorable for an organ.

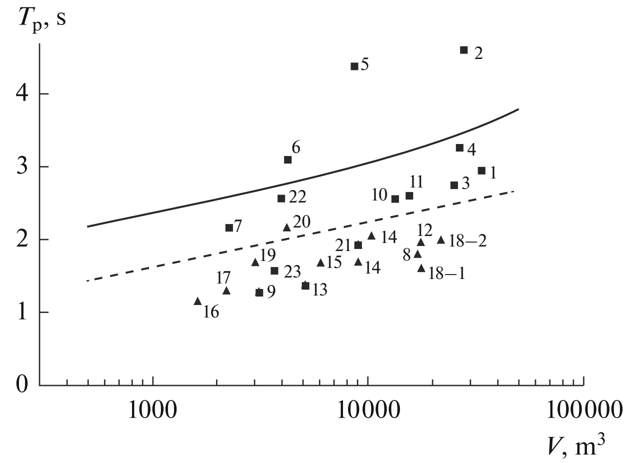

Fig. 1. Reverberation time in organ organ halls and churches in Russia and abroad (recommendations [2] (solid line) and [3] (dashed line): (1) Michaeliskirche, Hamburg, (2) Domkirche, Freiberg, (3) Thomaskirche, Leipzig, (4) Frauenkirche, Dresden, (5) Domkirche, Arlesheim, (6) Lukaskirche, Bonn, (7) Lutheran Kircher Reinhardsgrimma, (8) Grand Hall of the Moscow Conservatory, (9) Small Hall of the Moscow Conservatory, (10) Fukushima City Concert Hall, (11) Concert Hall of the Tokyo National University of Fine Arts and Music (mode of organ concerts), (12) Svetlanov Hall of the Moscow International House of Music, (13) Chamber Hall of the Moscow International House of Music, (14) Grand State Concert Hall of the Republic of Tatarstan (modes of organ and symphonic concerts), (15) Concert Hall of the Saint-Petersburg Academic Capella, (16) Concert Hall of the Nizhny Novgorod State Conservatory, (17) Organ Hall of the State Central Museum of Musical Culture, (18) Tchaikovsky Concert Hall in Moscow (1) before and (2) after repair, (19) Organ Hall of the Perm Philharmonic, (20) Concert Hall of the Astrakhan Conservatory, (21) Organ Hall in Naberezhnye Chelny, (22) Rodina Organ Hall in Chelyabinsk, (23) Concert Hall of the Murmansk Philharmonic.

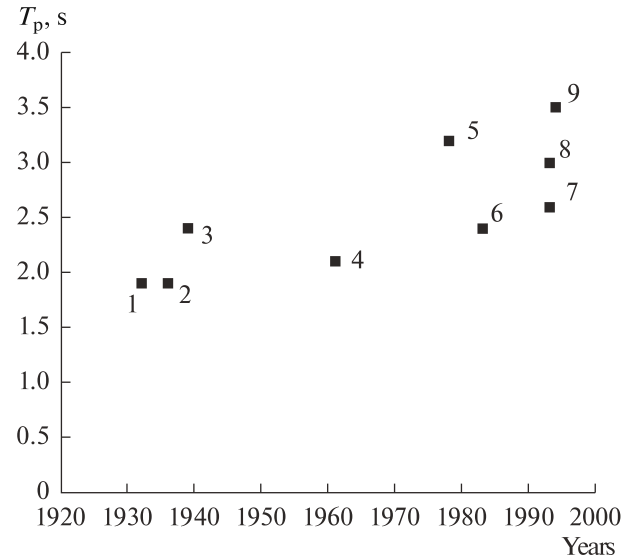

Fig. 2. Trend to increase the recommended reverberation time of organ halls in the 20th century (for rooms 20000 m^3 in volume): (1) V.O. Knudsen, 1932, 1.9 s, (2) W. Ellerhorst, 1936, 1.9 s, (3) J. Engl, 1939, 2.4 s, (4) L. Cremer, 1961, 2.1 s, (5) K.B. Ginn, 1978, 3.2 s, (6) recommendations of the Council for Mutual Economic Assistance, 1983, 2.4 s, (7) W. Ahnert, F. Stefen, 1993, 2.6 s, (8) D. Templeton et al., 1993, more than 3 s, (9) F.A. Everest, 1994, 3.5 s.

conclusion is also confirmed via interview of known organists, who have toured Russia in recent years. An exception is the only recently opened Organ Hall in Chelyabinsk (2014), and relative exceptions are the halls of the Academic Capella of Saint-Petersburg, the Astrakhan Conservatory Concert Hall, and halls put into operation from 2003–2005 (Perm and Naberezhnye Chelny), where organ sound was a subject of special care in acoustic design, and the acoustics of these halls is closer to optimal for an organ.

Nevertheless, almost all of the Russian organ halls are involuntarily compromised by acoustics, as they must be used, not only for organ concerts, but also for symphonic, chamber, and, sometimes, variety concerts according to customer requirements.

The problem becomes much more obvious when taking into account the contemporary trend to increase the recommended reverberation time in organ halls (Fig. 2). This trend is worthy of attention. In our opinion, it is caused by the evolution of the stylistic preferences of musicians, organ builders, and the audience. Some acousticians have previously pointed to the dependence of acoustic preferences on the character of played music. Thus, L. Beranek cites the following optimum values for the reverberation time of a room [5]:

5–10 s in the preclassical period (Gregorian singing);

1.6–1.8 s in the classical period (orchestra);

1.9–2.1 s for romantic music (symphonic orchestra); and

~ 1.4 s for contemporary music (orchestra).

Close optimal reverberation time values for orchestral music are also given by acousticians Y. Ando (Japan) [6] and R. Johnson (United States) [7].

The cited values may explain the contemporary trend to increase the reverberation time in concert halls. As known, interest in ancient music appreciably grew in the 1920s to 1960s, and contemporary music of that period was also very popular (this period was characterized by the appearance of various ensembles and the orchestra of "ancient and contemporary music"), and the shortest reverberation time was recommended by acousticians for concert halls just in this period of time (American acoustician V.O. Kundsen directly pointed to "the contemporary trend to nonreverberating rooms" in 1932 [8]). The 1960s to 1970s and later years were characterized by the revived interest in romantic music (especially noticeable in organ art). In our opinion, the trend to increase the reverberation time recommended by acousticians for concert halls, especially clearly observed from the latter half of the 1970s, is explained just by this fact.

Hence, the optimal reverberation time for organ halls is not a constant and is liable to certain variations depending on the stylistic preferences predominating in one or another period of time. In view of the aforesaid, it becomes clear that the current Russian recommendations for the reverberation time in concert halls, which are close to the Knudsen recommendations, actually correspond to the sound traditions of the early 20th century, when preference was given to halls with a short reverberation time.

We note that the reverberation time recommended by organ builders and experienced organ experts exceeds the values recommended by acousticians in many cases. Let us give a brief summary of the reverberation time values recommended by foreign specialists in organ building:

—W. Adelung (1953, 1972): the optimum is 2 to 3s depending on the volume of a room;

—The same author (1991): the optimum is 3 to 5 s depending on the volume of a room;

—W. Supper (1959): the optimum is 2 to 2.5 s depending on the volume of a room, and reverberation time below 1.7 s is unacceptable for an organ in any case;

—W. Oberlinger (1980): from 2 s for small rooms to 6 s for great volumes;

—J. von Glatter-Götz: 3 to 7 s; and

—H.-G. Klais and P. Klais (1990): the optimum is between 3 and 4 s.

Here, we also point to a certain trend to increase the recommended reverberation time: it is especially characteristic that the recommendations given by German specialist W. Adelung in 1953 (and repeated by him in 1972) [9] essentially differ from the recommendations given by the same author in 1991 [10]. The recommended reverberation time values appreciably exceed the values specified according to Russian standards in almost all the cases.

Similar conclusions can also be made for the "specific" volume per listener: in the Western European and Japanese halls, this parameter is usually much higher than in the Russian halls ($V/N \approx 12$–20 m^3 per listener in foreign halls and 6–11 m^3 per listener in Russian halls).

These appreciable deviations between the acoustic characteristics of foreign and Russian organ halls cannot be explained by the difference between organ music playing traditions, which are sacred in the West and secular in Russia (the presented repertoire and acoustic preferences are similar in both cases). In addition, some textural features of organ works are immediately related with the long reverberation effect [11], and the appropriate perception of these compositions under the conditions of "dry" acoustics is merely impossible.

It is clear that the problem of the incomplete correspondence of acoustics to requirements imposed by organ music in Russian concert halls requires a solution. This is much more relevant because sacred organ concerts in the churches with good acoustics have become increasingly more popular in recent years despite the secular tradition of organ performance in Russia and, as a consequence, secular concert halls risk a turn out "on the margins" of organ culture in Russia.

WAYS OF SOLVING ACOUSTIC PROBLEMS IN ORGAN HALLS

First of all, in our opinion, we must cite Russian recommendations for organ hall acoustics in compliance with international practice. This problem was partially solved by the recent introduction of a note in "Acoustics of Rooms" of SP (Set of Rules) 51.13330.2011 (in the actualized edition SNiP (Building Norms and Regulations) 23-03-2003) stating that the reverberation time in specialized organ halls may be longer than the value stemming from the general requirements of concert halls under the same norms [12] (the author is grateful to M.Yu. Lane for his support and help in introducing this supplement into the Set of Rules). However, the problem of regulation would only be completely solved via the classification of organ halls as a particular category and a description of acoustic requirements similar to halls used for other purposes.

Second, it is desirable to create specialized organ halls or at least organ-symphonic halls, where reverberation time is a compromise between the values recommended for symphonic and organ music, where possible (e.g., in large cities having several concert halls). An example of a specialized organ hall, where acoustics completely correspond to organ music requirements, is the recently opened Rodina Organ Hall (Chelyabinsk), where the reverberation time in the completely occupied hall (volume $V = 3860$ m^3; number of seats $N = 327$) is 2.45 s (T.I. Maevskaya (chief architect), P.N. Kravchun and M.Yu. Lane (acoustic design), 2014) [13]. Among construction examples, where acoustics are relatively favorable for an organ, are the recently opened halls in Perm [14] and Naberezhnye Chelny [15], in which reports on organ sound are positive.

Third, when creating multipurpose concert halls for classic music, we must more actively pass transformable acoustics to the halls. This, in our opinion, is topical for Russia, where multipurpose halls are the most common. Despite their complexity and high cost, these solutions are promising, as shown through international practice. Unfortunately, Russia has not been successful in building halls with transformable acoustics, however the results attained in Birmingham, Tokyo, Kuala Lumpur, Singapore, Edmonton, etc. are very impressive and may serve as a starting point for new Russian projects.

Finally, the existing halls with unfavorable natural organ acoustics, which do not yet seem possible to change, may be reasonably completed using special electronic insonation systems ("electronic architecture systems" or "systems of variable acoustics"[2]). As known, "electronic architecture systems" are complicated electroacoustic systems, which are controlled via computer with the multichannel processing of signals from several tens of microphones and have a distributed system of numerous weak emitters able, not only to change the reverberation time, but also the structure of "reflections" perceived by a listener (perceived reflection pattern). These systems provide the possibility, not only to adjust the perceived reverberation time, but also to change the impression of hall size (the listener perceives the music as though it resonates in another "virtual" hall). The experience in the application of contemporary foreign systems of this type in Russia is still unique, however their use has already been ranked among topical questions. Reports from the musicians who have performed in these halls are favorable as a whole, thus indicating the high quality of similar systems in their careful adjustment.

The first experience in the installation of an "electron architecture" system in Russia has been gained only in the Svetlanov Hall of the Moscow International House of Music (the system "Constellation", Meyer Sound, Berkeley, United States, 2012). The author of this paper has tuned the organ operational mode of this system in cooperation with specialists from the United States (the project manager was John Pillow), and the experience in its application during organ concerts has demonstrated that the acoustic results perceptibly depend on the degree and nature of filling a hall with listeners. In an incomplete hall, especially when few listeners are located at the secondary emitters zone, the operation of this system in organ mode can increase the reverberation time nearly 1.5 times (up to $T_r = 2.8$ s, which corresponds to a good hall quality) and essentially improve the acoustic impression, however the efficiency of this system decreases in a completely occupied hall, when the listeners located closely to the mentioned emitters immediately absorb the created secondary occupied. This circumstance requires careful design of the system with consideration for the arrangement of spectator seats.

SOME PROBLEMS CAUSED BY SPECIFIC ORGAN FEATURES IN THE ACOUSTIC DESIGN OF ORGAN HALLS

We now turn to problems associated with the characteristic features of organs in the acoustic design of organ halls.

A specific organ feature important for acoustic design is a high sound absorption coefficient. In some cases, the reverberation time in a hall after the installation of an organ decreases by 0.25–0.5 s [16]. The undervaluation of this factor frequently leads to the additional muffling of a hall in comparison with the project. The organ sound absorption coefficients introduced into the acoustic calculation must be high, as the organ pipes are efficient resonant sound absorbers for the sound incident with tuning frequencies covering almost the entire audible frequency range. The coefficient of sound absorption by an organ cannot be usually correctly measured (as a rule, the installation of an organ changes the interior of a hall in one way or another, and the role of an organ in the additionally appearing absorption of sound cannot be unambiguously determined). There are almost no corresponding data in the literature on acoustics, thus necessitating the special study of this problem. Our study and comparison of the available data have demonstrated that organs have appreciably different sound absorption coefficients in different halls, however these values correspond to strong sound absorption in all cases. In contact with foreign acousticians (M. Nagata, F. Kawakami, M. Vorländer, etc.) and organ builders (Markussen, Klais, Suto, Beckerath, etc.), we have found the averaged values (over a number of halls and organs) for the sound absorption coefficients of an organ and, as shown through experience, these values can serve as a reliable estimate for the real absorption of sound by an organ. This question is worthy of further study and, at present stage, it is only possible to communicate that the coefficients of sound absorption by the prospectus of an organ must be no less than 0.55–0.6 in all the frequency bands to provide the rough estimation of sound absorption by an organ in a nearly diffuse field.

Another organ feature important for the acoustics of a hall is the great dimensions of this instrument. Of special importance is the organ height determined by the length of sounding pipes and the structure of this instrument. In large halls, the organ height may not be less than 13–14 m, otherwise its sound will not have the bass support necessary in these halls (the length of 32-ft open bass pipes exceeds 10 m). This instrument height requires the installation of ceiling sound-reflecting structures at a much greater height, which leads to a decrease in efficiency. This situation is standard in large halls with great organs. To solve the problem of early reflections in these cases, we must provide some additional "compensating" sound-reflecting structures on the sides of an organ (as a rule, at a height of 9–11 m) for the creation of rather efficient "side" reflections oriented towards the listeners from the direction close to the directions of the reflections, which would take place if the ceiling sound-reflecting structures were installed at a low height. Moreover, when designing an organ, it is useful in similar cases to provide sound-reflecting and sound-diffusing surfaces

[2] The Russian name of systems of this type has not yet become well accustomed.

and parts manufactured of hardwoods also on its prospectus (for example, using this very method, we have managed to improve the acoustic properties for performers on the stage of the Svetlanov Hall of the Moscow International House of Music). The described methods make it possible to provide a favorable reflection pattern.

Another factor important for good perception of organ sound in a concert hall is the width of this instrument. A reasonable compromise is necessary when selecting this parameter. On the one hand, a very large width of an organ under relatively short reverberation conditions leads to discomfort in the perception of sounds coming to a listener at strongly different angles. A typical example is the big organ divided into two parts remote from each other in the Palace of Arts (Kondopoga, Karelia, 2000) [13]; the same danger has emerged upon the recent installation of a new organ in the Murmansk Philharmonic Hall (2016), thus requiring some special measures on the moderation of consequences from the division of the organ into two parts [17]. On the other hand, organs with a small width do not create the impression of ambisonic, extensive, and "stereophonic" sound. The width of an instrument is sometimes necessarily limited due to the desire of architects to arrange balconies for listeners or performers on either side of an organ (close to the organ). Such a solution, which is usually favorable for instruments placed on the stage (the balcony parapets serve as diffusers for the sound emitted from the stage), seems to be erroneous for an organ, as it, not only worsens the extensiveness of organ sound via limitation of its width, but also creates a strong absorption of sound in immediate proximity to the instrument. Depending on the volume, proportions, and acoustics of a hall, we must strive to find an optimal solution in every case when selecting the height and width of an organ.

It is impossible to consider the dimensions of an organ without taking into account the number of its registers and pipes. From the acoustic viewpoint, the impression of organ sound depends to a much greater extent on the arrangement of organ registers rather than their number. Sometimes, organ builders (usually under the pressure of performer organists, who have little knowledge of acoustics and organ building) try to increase the number of instrument registers to the maximum determined by the feasibility of "cramming" as many pipes as possible into an organ at the specified volume of this instrument. This is an absolutely erroneous, leading to poor-sounding organs, since closely arranged pipes have a strong effect on each other, thus worsening the sound, increasing the spatial sound absorption inside the instrument, and complicating the tuning of strongly interacting pipes. This approach leads to an instrument with a sound that is "strangled", harsh, and not very harmonic even under favorable hall acoustics. A good organ is an instrument in which the number of freely arranged registers is not maximally possible, but optimal for a given hall. Let us remember the words of Aristide Cavaillé-Coll: "The organ, in which a person can freely pass around each pipe, sounds best of all" [18].

THE SITING OF THE ORGAN IN A HALL

It would seem that there is no need to repeat the obvious truth that an organ and a hall represent an integrated ensemble, and an architectural project must take into account the conditions dictated by the regulations of organ building and acoustics. Nevertheless, at present times, as well as 100 years ago, the words of Albert Schweitzer, "Architects usually push an organ in the hall corner convenient for them, where it cannot properly sound in any circumstances" [18], are relevant. The opinion that an organ must be designed and built "for a hall" leads, as a rule, to serious consequences. A manifestation of this mistake is the attempt of architects first to design a hall with an organ according to their own ideas and invite organ experts only at the terminal stage of design (or even after the beginning of building works). This hall may be most often considered lost for organ music.

When creating a hall with an organ, we must strive to ensure that the organ is placed on the central axis of the hall on the platform above the stage and is a freely standing instrument (i.e., surrounded by a free space at least on three sides). In this case, we must take into account that the organ has a considerable depth (as a rule, 2.5–3 m for small instruments to 5–7 m for large instruments). Free space must remain above the organ for an outlet of sound from the pipes (at least, from basic manual pipes and some pedaller pipes) with a sufficient number of sound-diffusing elements (a complicated ceiling profile, decor of different scale, etc.). A special sound-reflecting panel above the organ should be provided in the structure of its housing only if the acoustic characteristics of the ceiling shape above the organ are unfavorable.

A "classic" mistake is the installation of an organ in a niche, especially in a niche with a cornice or a portal. In this case, the sound of many instrument pipes proves to be unprovided with efficient early reflections from the ceiling and side hall surfaces. Examples for the installation of an organ in a niche are provided by a great many Russian concert halls, such as the Tchaikovsky Concert Hall in Moscow, the Grand Hall of the Saint-Petersburg Philharmonic, the Nizhny Novgorod Conservatory Hall[3], the State Altai Philharmonic Hall in Barnaul, etc. (the installation of organs in niches in the above-listed halls was a compulsory measure, since the building of an organ was not initially planned). An example of the same type is the

[3] When reconstructing the hall in Nizhny Novgorod from 1994–1995, an improvement in organ sound was made by changing a number of interior elements in the organ installation zone and the major hall volume.

installation of an organ in the altar apse (as often done in the Soviet Union when creating organ halls in the rooms of former churches, e.g., in the House of Organ and Chamber Music in Kiev, in Krasnoyarsk, the former organ hall in Chelyabinsk, etc.). Such an installation, with rare exceptions, worsens the sound of an organ. The installation of an organ in niches and other similar recessions is strongly criticized almost in all the published classic works on the theory and history of organ building over the last 150 years.

The installation of an organ in a hall corner should also be recognized as extremely ineffectual. In practice, no similar hall is used for solo organ concerts. Moreover, no good artistic result can be attained in these cases even when an organ is used together with an orchestra or a choir due to the absence of spatial integrity for their sounds (a known example is the Grand Hall of the Berlin Philharmonic, by architect H. Scharoun).[4] Slightly better results are also attained when an organ is installed at a very great height above the orchestra (a recent example is the Concert Hall of the Mariinsky Theatre, by architect X. Fabre). In general, any remoteness of an organ from an orchestra is negatively perceived by performers and listeners [19].

The only deviation from the principle of the spatial integrity of an organ is Rückpositiv of the Baroque epoch organ and Fernwerk of the Romantic epoch, however these organ parts are typical of church organs, not of concert organs, as they are inextricably related to the architectural features of churches and the functions of an organ used in worship. Moreover, the appearance of these organ parts was associated again with the desire to bring the organ closer to the singing community or the priest conducting worship.[5]

Finally, when installing an organ, we take into account the difficulties associated with the effect of sound delay on performance. This is especially important when the organ key action has great "inertia" or the organist console is located at a significant distance from Pfeifenwerk (the set of instrument pipes). An organ sound delay of 50 ms from the moment of pressing the keys is clearly felt by an organist and, when the delay is 100 ms and longer, playing becomes difficult even for experienced performers [20] (in addition to the sound propagation time, the delay is also influenced by a relatively slow attack of sound from organ pipes and, sometimes, the delayed action of organ keys). In other words, when the distance between the organist and the pipes is more than 10–15 m, the delay of sound may essentially complicate the playing of the organist. The most difficult situation arises when the organ sound reaches the organist and the orchestrators (choristers) with significantly different delays. Precisely such a problem takes place in the new Concert Hall of the Mariinsky Theater [21], where the organ is placed high and far from the stage, and the instrument and the organist are actually "separated" from the orchestra and the choir. The same problem also arises in the new Zaryadye Concert Hall in Moscow (the acoustic design was provided by Y. Toyota (Japan) at both halls). The partial solution of this problem may be the application of a mobile organist console on the stage near the orchestra to put the organist in the same conditions as the orchestra and the choir (however, without eliminating the separation of the organ from the choir and the orchestra), but this requires the use of either an electric key action (which is most often negatively appraised by performers) or a double key action (which leads to the essential complication and appreciation of the instrument).

Hence, the interaction of an organ with an orchestra and choir require relative close proximity to each other. The organ in a symphonic hall must comprise an integrated unit with the orchestra and be a spatial continuation of the orchestra. We note that many scores for an organ with an orchestra or choir are designed with this fact in mind.

CONCLUSIONS

Practice shows that, even if the acoustic solution of a hall completely corresponds to all normative requirements, good results can be attained only under the continuous control of acousticians over the course of building works in a hall. Deviations from an acoustic project or violations of a prescribed technology of building works is a frequently encountered phenomenon, so the significance of the author control of acousticians could hardly be overestimated. We cite just two examples from personal practice. In the Organ Hall of the Perm Philharmonic, a month before it was put in operation (2003), the acousticians (M.Yu. Lane and the author of this paper) revealed the substandard manufacturing of its back wall (a weak frame under the wall panels) and, by our recommendation, the construction of this wall was completely replaced by one more high quality, thus providing the possibility to "add" nearly 0.5 s of reverberation at low frequencies (in the octave bands with central frequencies of 250 Hz and lower) and bring the reverberation time to its designed value (the old and new walls did not exteriorly differ from each other) [14]. Thanks to the careful control of the author over the restoration of the coffered wooden ceiling in the Concert Hall of the Saint-Petersburg State Academic Capella from 2003–2005, it became possible to eliminate the earlier existing unfavorable low-frequency "valley" in the reverberation time of the hall (a decrease in T_r by 0.3 s in the octave band with a central frequency of 125 Hz) due to the grad-

[4] In the Berlin Philharmonic, a small mobile organ rolled out onstage is generally used for performances with an orchestra.

[5] The only example of Rückpositiv in Russian concert halls is the Philharmonic Hall in Kaliningrad, which represents a former Catholic church adapted into a concert hall. The application of Rückpositiv in this case is artificial, as the organ is installed at a short height, and Rückpositiv does not fulfil its usual function (a part of the organ, which is placed close to the community and designed to accompany community singing).

ual (for many decades) cracking of wooden caissons and the worsening fastening of the rafters [22].

The cooperative work of architects, acousticians, and organ builders predetermines in many respects whether anyone in the 21st century will repeat the words said 100 years ago by Albert Schweitzer: "Organs in concert halls have never been as interesting to me as church organs. The best organs in a concert hall do not make a strong impression" [18]. An organ is an instrument, which has encapsulated the architectural and acoustic experience of two millennia and, when creating organ halls and performing their reconstruction, it is necessary to study this experience and use it as a basis. Just in this case, it is possible to achieve harmony between an instrument and a hall.

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