SOME ACOUSTICAL CONSIDERATIONS IN THE DESIGN OF THE CONTEMPORARY ORGAN CASE

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PREFACE

The organ case is basically a structural component of the organ which partially surrounds the pipes and performs the dual functions of reflection and resonance. At one time, the case was considered to be a major component of the instrument. Although it fell into disuse in the past, most contemporary organ builders now include it in their instruments. Part of the reason for this is the visual effect, but builders have also come to realize the important acoustical functions performed by the case.

A survey of contemporary case design shows a wide range of practices among builders. Part of this variance is the result of differing concepts of visual aesthetics. Neither is there agreement on exactly how the organ should sound; thus, acoustical principles are applied differently to get different results. But it is essential for the builder to understand what principles are in operation in the functioning of the case, so that he may use them to create the effect he wants, leaving as little as possible to chance. This paper presents some of the most important of these acoustical considerations.

Since the contemporary case has its foundation in the Orgelbewegung, and since this movement is based on the North German tradition, the common German names for the divisions of the organ have been used throughout when possible.

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CHAPTER I

THE HISTORICAL ROOTS OF THE CONTEMPORARY ORGAN CASE

The contemporary organ is the result of gradual modification and enlargement of early concepts of organ design. While the basic concept was known as early as approximately 100 B.C., organ building was apparently forgotten after the decline of Rome until the Middle Ages brought a degree of social stability to Europe.[1]

The early Medieval organs had no cases.[2] However, once builders began encasing the pipes, the case remained as an integral part of the instrument until the nineteenth century. After a period of neglect, the case, in the twentieth century, is again recognized by most builders as a necessary part of the instrument.

Since the first organ cases, greater degrees of flexibility in design have been gained as advances in the mechanical aspects of organ building appeared. The first such development was the invention of the roller-board, probably in the late

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[1] Poul-Gerhard Andersen, Organ Building and Design, translated by Joanne Curnutt (New York, 1969), p. 105.

[2] Cecil Clutton and Austin Niland, The British Organ (London, 1963), p. 156.

fourteenth century.[3] Chests wider than keyboard-width were made possible, and builders were freed from the necessity of arranging chests in strict chromatic sequence. Most organ historians agree that at about this same time the first Rück-positivs appeared.[4] The Rück-positiv is a separate division encased apart from the rest of the organ, placed behind the organist, and controlled by its own keyboard. In the most common arrangement for the church organ, in the gallery at the rear of the nave, the Rück-positiv was located on or near the gallery rail. Thus, the concept of the organ as an instrument with two or more divisions encased as separate units, each controlled by its own keyboard, was developed.[5]

Concurrently with these innovations, builders began to experiment with ways of arranging the pipes within the case. In addition to the flexibility gained from the roller-board, pipes were freed from the necessity of standing directly on the chest. Tubing was used to conduct air from the toe-board (where the pipe normally stands) to the pipe's foot. With the aid of this device, pipes were grouped together within the case in towers and flats.[6] Towers are

> . . . groupings of large pipes which usually rise above the adjoining flats . . . In a flat, the pipes are set in a straight line in plan. The member in which the pipe toes are placed, called the toe-board, may

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[3] Ibid., p. 159.

[4] Joseph Edwin Blanton, The Organ in Church Design (Albany, Texas, 1957), p. 47.

[5] Clutton, p. 161.

[6] Ibid., p. 160.

> be level or inclined or it may have more than one inclination such as a chevron or inverted chevron, or it may be curved, but the pipe group is still a flat as long as the pipes are in a straight line in plan.[7]

For the façade rank, that is, the rank of pipes, usually the lowest-pitched principal stop, placed in the front of the case, flats could be arranged in two tiers, one above the other. The elevation and longitudional section of an organ at Oosthuizen, Holland, built in 1521, are shown in Fig. 1.

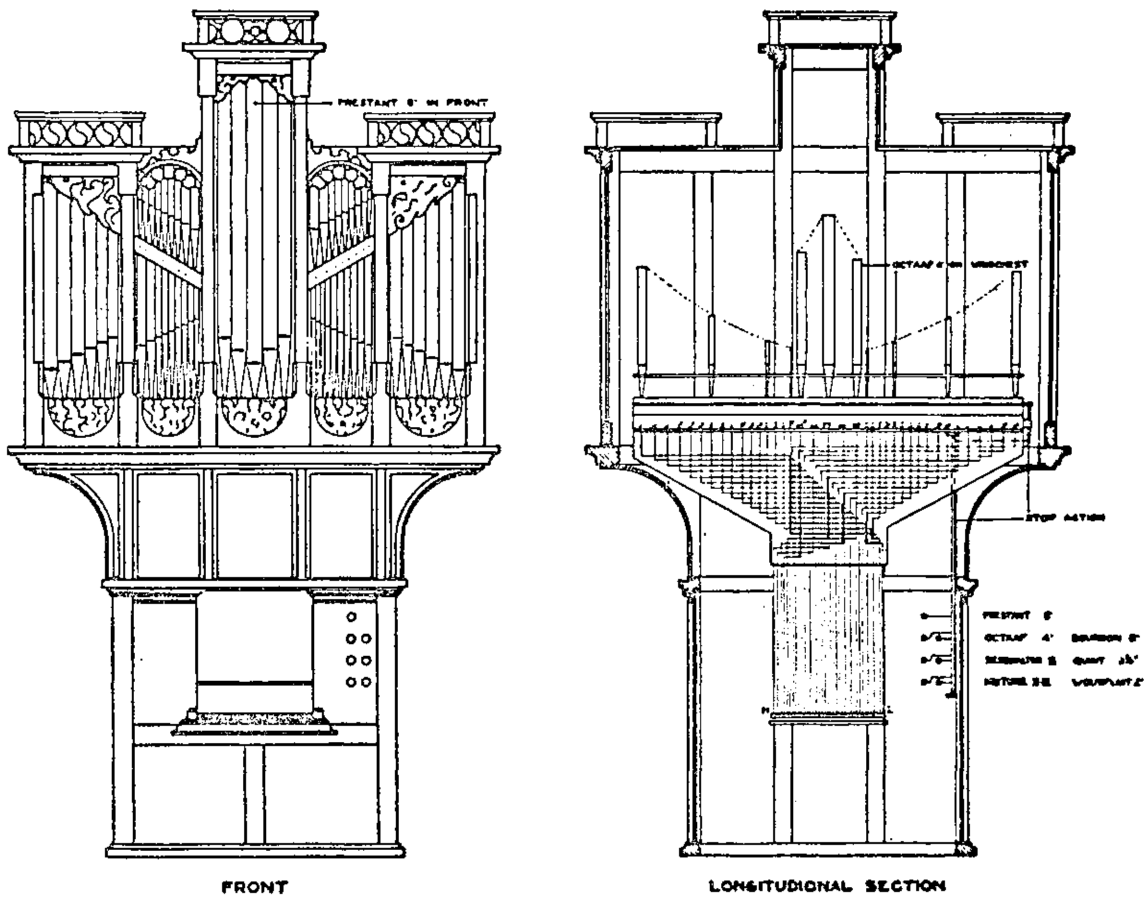

Fig. 1--Elevation and longitudional section of Oosthuizen organ.[8]

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[7]Blanton, p. 120.

[8]*Ibid.*, p. 121.

This instrument has one division of seven stops. The pipes are arranged in three towers, called flat towers because the pipes in each tower grouping are set in a straight line, and four flats, arranged in two tiers on either side of the center tower. The longitudional section shows the roller-board rising from the keyboard to the windchest and the Octaaf 4' in place on the chest.

By the seventeenth century the concept of separate divisions in separate cases had expanded to include not only the main division, or Hauptwerk, and the Rück-positiv, but others as well, notably the Brustwerk, located below the Hauptwerk, and the Pedal.[9] These divisions were organized through the werk-prinzip, or "work-principle." The lowest-pitched principal stop in each division determined the character of the division. Since each division was to have a tonal character different from the others, the pitch of this principal stop was different for each. Thus, in an organ of four divisions (Hauptwerk, Rück-positiv, Brustwerk, and Pedal), if the lowest-pitched principal stop in the Pedal were 16', the lowest-pitched principal stops for the remaining divisions would be 8' for the Hauptwerk, 4' for the Rück-positiv, and 2' for the Brustwerk. In every instance but the Brustwerk there were usually no pipes of longer length than these principal pipes; thus the compartment for each division

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[9]Charles B. Fisk and others, "Organ," Harvard Dictionary of Music, 2nd ed., edited by Willi Apel (Cambridge, Massachusetts, 1969), p. 611.

within the main case was of a different height. The arrangement of these divisions most often followed the same plan: immediately above and in front of the organist was the Brustwerk, above this was the Hauptwerk, the Pedal was arranged in two towers on either side of the Brustwerk and Hauptwerk, and the Rück-positiv was located on the gallery rail. A fifth division, the Oberwerk, was sometimes added above the Hauptwerk.[10]

This arrangement, most common to the North German builders, represents a high point in organ case design. Organ and case were conceived as a multi-divisional unit, the case based upon and reinforcing the tonal structure. Beginning in the eighteenth century, builders became interested primarily in experimenting with the organ's tonal design. At first the established patterns of case design were reproduced, but inevitably builders began to modify the case as well. These changes differed from those that had gone before, since instead of continuing to develop the case as an increasingly effective part of the instrument, builders began to ignore its importance.

Most nineteenth-century organs built on the Continent appear to have retained a fairly functional case design; this is actually so in some instances, but more often than not the case served visual effect only. During the period 1865-1915 the roof of the case was often dispensed with,[11] as was the

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[10]Andersen, p. 304.

[11]Blanton, pp. 71-72.

concept of separate cases for separate divisions, with the exception of the swell box. This box, enclosing one division, with shutters on the front to adjust the volume, remained a true divisional case.[12]

It only remained for builders to remove the visual as well as the acoustical aspect, thus dispensing with the case entirely. The case was replaced by an arrangement known as the "organ chamber." The pipes were placed in a thick-walled chamber adjoining the room in which the audience was seated; the sound reached the listeners through an opening in one wall of the chamber which was, many times, entirely too small. The pipes within the chambers were not seen by the audience and were arranged more for mechanical convenience than tonal effectiveness. Builders in the United States adopted the chamber as the standard placement for the organ. Joseph Blanton comments: "There was no sudden change from organ cases to organ chambers but rather a very gradual displacement of the case by the chamber which became almost complete in the United States in the third decade of the 20th Century."[13] Most organists and builders today would agree with W. L. Sumner's appraisal: "A badly designed case may prevent the egress of sound but hardly to the extent that is found in

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[12] Ibid., p. 74.

[13] Ibid., p. 69.

organs which have been packed away in 'organ chambers' . . ."[14] The Romantic degradation of the organ was even more evident in the tonal structure than in placement. As it existed in this form, the organ was less sensitive musically than it had been for hundreds of years.

The revival of the organ as a sensitive musical medium began with a pamphlet, "The Art of Organ Building and Organ Playing in Germany and France," written by Albert Schweitzer and published in 1906. In it he advocated a return to pipe scales based on empiricism, slider chests operated by mechanical action, lower wind pressures, no imitative or string stops, free-standing placement, and the inclusion of a Rückpositiv. In general, the pamphlet suggests discarding the building practices of the previous one hundred and fifty years and returning to the organs of Bach's time as a point of departure for developing adequate modern instruments.[15]

At the time of its publication this pamphlet was largely ignored. The ideas it contained first received careful consideration from a significant section of builders at an organ-building conference in Freiburg in 1926. This conference accepted the ideas stated in Schweitzer's pamphlet and even chose a specific builder, Arp Schnitger, as an historical

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[14]William Leslie Sumner, The Organ: Its Evolution, Principles of Construction and Use (New York, 1953), p. 241.

[15]Lawrence I. Phelps, "A Short History of the Organ Revival," Church Music, I (1967), 13.

model and a point of departure. This was the beginning of the Orgelbewegung (organ reform movement).[16]

In 1957 Blanton wrote: "The modern organ case is practically nonexistent in America and England . . . ."[17] This is primarily because many American builders accepted some of the concepts of the Orgelbewegung without adhering to the concepts of case design. One of the alternatives was the unencased organ, which Lawrence Phelps explains as follows:

> Some of the first instruments of the German reform were built without cases, with all pipes exposed, and with the smaller pipes at the front . . . However, this method soon gave way to a modified system with the larger pipes in front. Gradually the importance of the case in producing the superior musical effect in old instruments became apparant and, as economics permitted, complete casework was more generally used on new instruments, but this became common practice only after World War II. . . . Since about 1950 unencased organs have become virtually extinct in Germany . . .[18]

Builders in the United States who have become known for unencased organs include Holtkamp, Aeolian-Skinner (under G. Donald Harrison), McManis, and Reuter.[19] It is common to find combinations of unencased divisions and divisions in chambers within the same organ, and some builders have also used combinations of unencased and encased divisions.[20]

In the past fifteen years the contemporary organ case has become increasingly used in American instruments. In this,

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[16]Ibid., pp. 13-15.

[17]Blanton, p. 393.

[18]Phelps, pp. 17-18.

[19]Blanton, p. 80.

[20]Ibid., pp. 75-77.

America has been able to draw upon the advances made throughout the twenty years previous in Europe. Commenting on the re-introduction of the organ case into European building, Blanton noted: ". . . the remarkable thing about it is that it did not grope through an awkward age but seemingly burst into full flower at the outset."[21]

The Orgelbewegung concept of the organ case is explained by Phelps as follows:

> The organ should speak freely toward the main listening area and therefore must be placed in a freestanding and somewhat elevated position within the room it is to serve, and it should preferably be located on the central and longest axis of the listening area. In order to accomplish the most efficient projection of the sound of the instrument throughout the room, in order to provide maximum contrast between the sound of each division, and in order to provide maximum resonance, blend, balance, and warmth of tone, the pipework of each division should be encased in a suitable shallow enclosure, open only on the side toward the listening area, with the principal rank of the division standing "en facade" in the open side . . . The physical arrangement of the organ and its architectural appearance should be worked out according to the principles of the functional "Werk" concept of the Schnitger and similar schools. Thus the displayed facade of the organ offers a functional presentation of the tonal design of the instrument and the pitch relationship of the component divisions. The organ should normally have a shallow vertical structure with the manual divisions placed generally one above another with the pedal at the sides, but above all the treatment should be suitable to the individual situation.[22]

What Phelps has described is in essence what had been achieved by the eighteenth century in Germany. A straight-forward

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[21] Ibid., p. 393.

[22] Phelps, p. 15.

example of this is seen in Fig. 2, an outline of the case of the organ in Sankt Jacobs Kirke, Copenhagen, built by Frobenius in 1953. The Rück-positiv is placed on the gallery rail. Directly above the console behind the Rück-positiv is the Brustwerk, and above it the Hauptwerk. The Pedal is divided on either side.

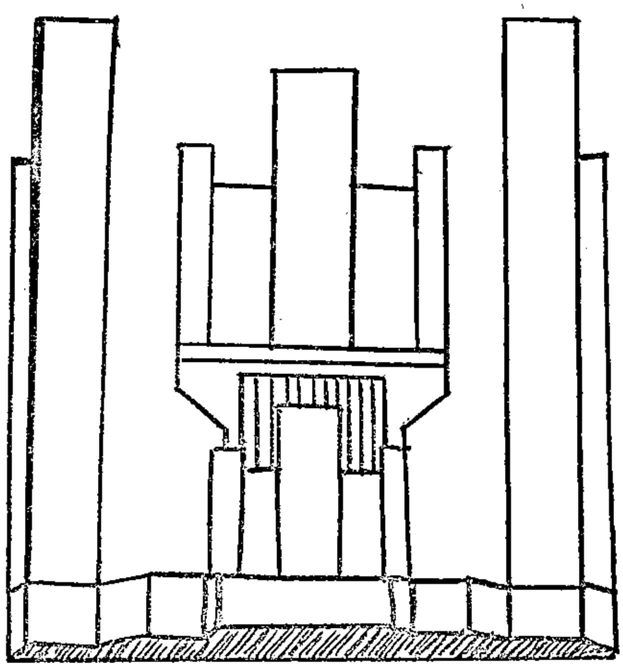

Fig. 2--Outline of Frobenius case in Sankt Jacobs Kirke[23]

Blanton and Phelps agree that in the first years of contemporary case design, the firm of Marcussen & Son of Denmark, under the direction of Sybrand Zachariassen,[24] "led the world in the excellence of its case design."[25] Since that

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[23]Blanton, p. 412.

[24]Joseph Edwin Blanton, The Revival of the Organ Case (Albany, Texas, 1965), p. 14.

[25]Phelps, p. 17.

time many builders have developed innovative and excellent case designs. The Baroque builders, notably Arp Schnitger, had brought case design to a high level of musical effectiveness. Contemporary builders returned to this model not because it represented perfection, but rather because they recognized the principle that case design can still be, as it once was, a steady process of experimentation and expansion based upon existing concepts. Modern developments in organ mechanics have opened new possibilities. Many new ideas have been tried with which this paper cannot deal, since they have not yet demonstrated their degrees of effectiveness.

The important element in contemporary organ case design is the way in which it continues to develop; builders today are expanding and developing case design as have the builders of the past.

CHAPTER II

THE PLACEMENT OF THE CASE

The first factor which helps determine case design is the tonal and mechanical structure of the instrument.[1] The case must allow adequate space for the mechanism and pipes, and the builder must form it into a musically and visually effective part of the instrument. The position of the organ within the room is vital. In choosing this position, the builder is limited in many ways. The placement of the console must be planned carefully to allow the organ to respond as promptly and accurately as possible to the touch of the player; the limitations inherant in the relationship between console and case in tracker instruments have proved effective and have helped to illustrate to builders and players alike the advantages of having the organist close to his instrument. Adequate access space for tuning and maintenance must be provided. The temperature in the portion of the room in which the organ is located should remain fairly constant. Also, the supporting structure for the organ must be strong enough to bear its weight. Within these limitations, the builder has one main criterion for choosing a position for the instrument--effective use of the building's acoustics. The frequent disagreements

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[1] Josef Schäfer, "The Modern Organ Case," ISO-Information (December, 1971), pp. 505-506.

between builders and churches are summed up by Joseph Blanton as follows: "The organ can be located so as to take greatest advantage of the natural acoustics of the interior or, if demanded by the building committee, it can be placed in any one of various inferior locations."[2] A single position does not work equally well in all buildings; rather, the location of the organ must be determined separately for each situation, taking the acoustical peculiarities of the room into account.

As was first discovered in 1895 by Wallace C. Sabine, the most important acoustical attribute of a room is its reverberation period.[3] In addition to enhancing blend and resonance, reverberation can result in more uniform loudness of the organ throughout the seating area. The portion of the audience nearer the organ will receive more of the direct sound of the instrument. The seating areas further from it should therefore draw on reverberated sound to make up for the loss in intensity of the direct sound.[4]

In order to achieve maximum benefit from the room's acoustics, the builder must keep several principles in mind. The most important of these is stated by Walter Holtkamp as follows: "A golden rule to follow is not to pierce the walls

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[2]Joseph Edwin Blanton, The Organ in Church Design (Albany, Texas, 1957), p. 69.

[3]Vern O. Knudsen, Modern Acoustics and Culture (Berkeley, California, 1937), p. 3.

[4]Leo L. Beranek, Music, Acoustics, and Architecture (New York, 1962), p. 22.

to accomodate the organ."[5] In other words, the organ "should be within the enclosed space in which it is to be heard."[6] This, of course, eliminates organ chambers, which are outside the room and adjoin it through openings in the walls. A problem arises in churches with transcepts or any other arrangement in which there are two or more fairly separated seating areas. If a position cannot be found to give equal access to all areas, Hans Klotz suggests putting the organ in the "spatially largest of these locations."[7]

A second consideration is the distance between the organ and the surrounding reflecting surfaces of the room. Klotz directs the builder to "make provisions for the sound to travel forward, sideways, and upward without obstruction . . ." to the walls and roof.[8] However, Klotz's diagrams of good case placements also show the organ elevated, so that the sound travels downward as well. The reflected sound that reaches the listener should come as much as possible from the walls, roof, and floor of the room rather than from any other architectural structure.[9] Adequate space for the sound to travel

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[5]Walter Holtkamp, "Organ Music and Organ Architecture," Architecture (June, 1934), p. 355.

[6]Blanton, p. 81.

[7]Hans Klotz, The Organ Handbook, translated by Gerhard Krapf (Saint Louis, 1969), p. 102.

[8]Ibid.

[9]William Leslie Sumner, The Organ: Its Evolution, Principles of Construction and Use (New York, 1963), p. 239.

upward and downward are the most important considerations. W. L. Sumner suggests at least twenty feet from the floor to the base of the organ for a medium-sized instrument.[10] In reflecting the sound, the efficiency of the architectural surfaces, especially the ceiling, is vital to the organ.[11] Lawrence Phelps states that "suitable acoustics for an organ require that the major surfaces of the room remain natural and 'untreated.'"[12]

The clarity and uniformity of sound throughout the room are hindered by curved architectural forms, such as domed ceilings or cylindrical walls, which reflect sound in such a way as to produce echoes or focusing points. For this reason, the reflecting surfaces near the organ should be plane surfaces, and, if possible, they should reflect the sound toward that portion of the audience sitting further away from the instrument.[13]

"When sound waves are reflected and collide, on their return, with the succeeding sound waves from the sound source, a reciprocal effect is produced (interference), which may result in 'standing' waves."[14] Such standing waves are especially

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[10] Ibid., p. 240.

[11] Herbert Norman and H. John Norman, The Organ Today (New York, 1967), p. 184.

[12] Lawrence I. Phelps, "A Short History of the Organ Revival," Church Music, I (1967), 15.

[13] Knudsen, p. 6.

[14] Poul-Gerhard Andersen, Organ Building and Design, translated by Joanne Curnutt (New York, 1969), p. 105.

common in connection with low pedal tones with a strong fundamental and weak overtones. The result is that, depending on where within the room the listener is sitting, he may hear the standing-wave tone as very loud or very soft. This is, of course, an undesirable effect. It is difficult for the organ builder to prevent standing waves in all instances, but should one occur, careful positioning of small amounts of sound-absorbing material will correct the problem.

In addition to placing the organ so as to derive maximum benefit from the acoustical environment, the builder must carefully consider the relation between the positions of organ and audience. Whatever acoustical benefits are achieved must be transmitted to the listeners. One of the prime factors, the distance between organ and audience, has already been noted. The organ should be placed above the audience and far enough away from it to allow reverberation to develop. Thus, a Rück-positiv is sometimes inadvisable in a small building, since it would be too close to some of the listeners.[15] To best accomplish the necessary projection of sound, only the side of the case facing the audience should be open. The pipes should speak in a straight line from organ to audience with no obstruction between.[16] The reason for this is that long sound waves (perceived as low pitches) travel around

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[15]Norman, p. 181.

[16]Phelps, p. 15.

corners better than short waves (high pitches).[17] As the sound of the organ travels around an obstruction, the higher pitches, including overtones, which contribute clarity and tonal color, are weakened or lost.

Organ authorities generally agree that the position which is most advantageous in the majority of rooms is in an elevated rear gallery with the organ centered on the longest axis of the room. This is certainly the position which should be considered first. However, there are situations which prevent this placement. There may be insufficient ceiling height or the organ, placed thus, might be too close to a portion of the audience.[18] The shapes of some buildings may negate the advantages of such a placement in other ways as well.

A variety of other solutions may work in certain situations. For buildings with large transcepts, a position atop a choir or "rood" screen, placed at the juncture of the transcepts, may be effective. This placement is most common in England.[19] A position in a "cul-de-lampe" or "swallow's nest," centered on a side wall, has been used often, as in the cathedrals in Strasbourg, Freiburg, and Ulm. The sound of a very small organ in a very large room may be distributed more efficiently through this placement.[20] Especially common

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[17]Sumner, p. 237. [18]Norman, p. 181.

[19]Cecil Clutton and Austin Niland, The British Organ (London, 1963), p. 151.

[20]Blanton, p. 98.

in German Lutheran and Dutch Reformed churches are placements on the front wall of the room. Provided that the organ is in an elevated position, centered, speaking directly toward the listeners, and surrounded by plane reflecting surfaces, this position has the same acoustical effect as a rear-gallery placement. Many other positions have proved to be less effective acoustically than these. The builder meets his greatest challenge in designing a case for an irregularly-shaped contemporary room. With no previous experience in a similar room, he must carefully weigh all of the factors discussed above, often with the help of an expert on acoustics.

In addition to establishing a position for the case, the builder must decide on an arrangement for the divisions within the general case. Here again, mechanical and tonal limitations must be recognized. In order that the organ may sound as a single, unified instrument, all divisions should be kept together within the same general case plan.[21] Within this main case, each division should have its own case or compartment, suited to the size of the division. This helps emphasize the differences in tonal structure of each division inherant in the _werk-prinzip_ concept.[22] The zones of pitch having the greatest sound intensity should vary from division to division in order to preserve the independence of each when played

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[21] _Ibid._, p. 90.

[22] Clutton, p. 157.

separately and to avoid mere duplication of sound when played together. Individual compartments help accentuate these differences.[23]

The sound of each division must project effectively toward the listener. This may be done by making each division part of the façade. Good acoustical placement may be maintained and overly-high structures avoided by placing the Positiv in the Rück-positiv position. The various positions of the divisions within the main case may be planned to exploit differences in distance and height from the audience to a certain degree. The North German Baroque arrangement accomplished this well. The Rück-positiv was nearest the audience. The Brustwerk was near and bright yet removed in depth from the Rück-positiv. The Hauptwerk was higher and spoke freely over the two lower divisions. The Oberwerk, when added, was still higher and more removed. The Pedal, divided on both sides of the manual divisions, was spatially near them and could support all equally well.[24] Such separation of a division should be used, however, only when the organ is of sufficient distance from the audience to avoid the effect of the sound jumping from side to side.[25] Care must also be taken to avoid problems in tuning resulting from a difference in temperature at different heights within the room.

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[23]Klotz, p. 67.

[24]Andersen, p. 304.

[25]Schäfer, p. 506.

Contemporary builders have further exploited the effect gained by placing divisions at different depths in the main case, notably the swell division, which is often placed behind and above the great. This is effective so long as all divisions project their sound toward the listener. For this reason, placing one division directly behind another with no difference in height is objectionable in most instances.[26]

Working within the limitations of the instrument, the organ builder uses all of the above factors in determining an acoustically effective case design. Fortunately there is no one perfect case for any room. Rather, the builder may use his creativity and knowledge to integrate case, mechanism, and tonal design into a unique artistic statement.

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[26] Andersen, p. 304.

CHAPTER III

THE SHAPE OF THE CASE

The shape of the organ case has a definite effect on the sound. As in the matter of case placement, there is no one correct case shape. Rather, the builder must design the case to accomplish specific goals for each individual situation. In instances where each division is encased in a separate compartment, each compartment functions acoustically as a separate case. The shapes of the compartments for various divisions may be the same or different.

The shape of the case is limited and generally determined by the internal arrangement of the instrument. The prime consideration is the order of pipes on the chest. There are four common arrangements: the chromatic chest, in which pipes are arranged in order, the longest at the left, the shortest at the right; the "N-chest," in which approximately one octave of the longest pipes alternate between the left and right ends of the chest, the remainder being arranged chromatically in the center; the "M-chest," in which the longest pipe is placed at the left, the next longest at the right, with successive pipes alternating between left and right, the shortest pipes being in the center; and the "A-chest," in which the longest pipes are in the center, with successive pipes alternating on either side, so that the shortest pipes are at the ends of the chest.[1] All four sequences are common in modern organs, and others have been tried as well. Combinations of an A-chest and an M-chest arrangement for two manual divisions of the same organ are common.[2] Whatever is done with the shape of the case must, of course, allow room for the pipes inside. Although a square or rectangular box will enclose all four chest arrangements equally well, many case shapes may be used only with one particular arrangement.

One of the factors to be considered in determining the chest arrangement is the shape of the façade. Since these pipes seldom sit directly on the chest, usually being connected to it by tubing, any arrangement of this rank is theoretically possible. Usually the builder chooses a façade arrangement that reflects the chest arrangement behind it, but the important acoustical factor for the façade is its shape. The pipes may be set in a straight line, or the line may curve or jut inward (toward the rear of the case) or outward (toward the audience). The convex shapes (the outward curve) improve the projection of sound; the concave shapes (the inward curve) hinder it. This may be used by the builder to balance the organ to the room. If a room is more responsive to the treble than to the bass, the builder may arrange the longer pipes in towers, separated by flats of shorter pipes; if the towers

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[1] Joseph Edwin Blanton, The Organ in Church Design (Albany, Texas, 1957), pp. 122-124.

[2] Ibid., p. 124.

are placed further forward than the flats, the lower-pitched pipes will project slightly better than those of higher pitch. If, on the other hand, the room is not sufficiently responsive to the treble, he may project the flats.[3]

The depth of the case, that is, the distance from front to back, is of decisive importance to the organ's sound. Experimentation within the Orgelbewegung has led builders to conclude that the projection of sound is adversely affected by deep cases; in general, cases should be as shallow as possible.[4] Hans Klotz suggests a depth of from two to four-and-a-half feet for manual divisions, slightly more depth being allowed for the Pedal case.[5] In very small organs, some builders have been successful in placing the manual divisions on the same level, one behind the other, and enclosing them in a single case. This system has also been used to gain a perceptable "depth" for the rear division in small rooms where projection is not a problem. Deeper cases have also been employed successfully in acoustically "dead" rooms; the added depth enhances the blending of the sounds and creates a certain amount of reverberation within the case.

Still another factor which the builder must adjust to each situation is the closeness of the pipes to the surfaces

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[3]Hans Klotz, The Organ Handbook, translated by Gerhard Krapf (Saint Louis, 1969), p. 114.

[4]Poul-Gerhard Andersen, Organ Building and Design, translated by Joanne Curnutt (New York, 1969), p. 304.

[5]Klotz, p. 114.

of the case. As is discussed in Chapter IV following, the case acts as a reflector for the sound and as a resonator. The closer a pipe is to the case panels, the more efficiently the case will reflect and resonate. This is especially important for open flue and reed pipes, since the vibrations eminating from the top and sides of these pipes are essential in the development of their tonal character.[6] For this reason, a case that is considerably larger than the division it encloses is not as effective as a close-fitting one.[7] In a square or rectangular case, the longest pipes are closest to the roof of the case and thus derive maximum benefit from its reflection and resonance. If the builder wishes all pipes to gain equal benefit from the case roof, he may slant it as the pipe lengths change, so that it is an equal distance from all pipes. An example of such a treatment is the organ at St. Peter in Bonn-Vilich, built by Rieger in 1958. As shown in Fig. 3 following, the compartment roofs follow the chromatic or reversed chromatic sequence of the chests.

In like manner, the stop which is placed at the rear of the chest derives maximum benefit from the rear walls. As the case reflects and resonates, one of its chief effects is

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[6]William Leslie Sumner, _The Organ: Its Evolution, Principles of Construction and Use_ (New York, 1953), p. 241.

[7]Cecil Clutton and Austin Niland, _The British Organ_ (London, 1963), p. 171.

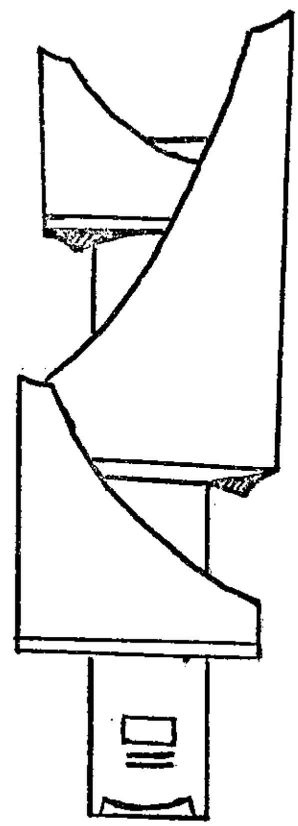

Fig. 3--Outline of Rieger case in St. Peter, Bonn-Vilich[8]

to blend the sounds.[9] For this reason, mixture ranks are often placed at the rear of the case, sometimes with the pipe mouths facing the rear wall. The case thus helps blend the sound of the mixture stop before it reaches the listener. This same principle is in operation for the mounted cornet. The ranks of the cornet, tubed off from the chest, are placed closer to the case roof than the rest of the pipes. The roof then helps blend the cornet and project it as a single sound

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[8]Josef Schäfer, "The Modern Organ Case," ISO-Information (December, 1971), pp. 505-506.

[9]Dirk Flentrop, Letter to the editor, The Diapason, XII (November, 1956), 8.

rather than as a number of separate ranks. An interesting application of this principle is found in the organ at Maria Königin des Friedens, Königswinter, built in 1970 by Klais. "The screen above the pipes consists of a board of tin with asymmetrical beams cut into it. By bending it as necessary, it becomes a useful voicing aid."[10]

Reflection of sound from a plane surface decreases in intensity smoothly; concave or cylindrical surfaces cause "uneven distribution of the sound and its concentration at focal points."[11] It is essential in case design to avoid any curved surfaces which will interfere with the smooth distribution of sound. Convex surfaces, such as the case roofs in the Rieger organ shown in Fig. 3 above, will cause a wider disbursement of the sound, but if sufficient reflecting surfaces surround the organ, they may be used safely. In general, any concave surface should be avoided.[12]

In designing the case so as to take greatest advantage of its reflective properties, it must be remembered that the ultimate goal is to project the sound toward the listener. The listener receives sound from any reflecting surface in the room, but the reflected sound is most effective when it

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[10]Schäfer, p. 523.

[11]Sumner, p. 237.

[12]Vern O. Knudsen, Modern Acoustics and Culture (Berkeley, California, 1937), p. 6.

reaches the ear of the listener through one path rather than many.[13]

The effect of the case on the blending of pipes has already been noted. The case also makes use of the tendency of pipes to "draw" or "pull," "i.e., to synchronize pitch... via the concentrated sound field inside the case." The cavity resonance in the case also causes "an attractive burgeoning of the sound in tenor or bass octaves even from pipes of slender scale, an effect similar to the baritone bloom in antique harpsichords although derived differently, i.e., by air resonance rather than timber resonance." In addition, the case has a band-shell effect, furnishing good attack even in resonant rooms that ordinarily confuse the sound to some extent.[14] By carefully planning the case shape for each situation, the builder may control these elements as necessary, compensate to a certain extent for the acoustical shortcomings of the room, and project the result effectively to the listener.

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[13] Herbert Norman and H. John Norman, The Organ Today (New York, 1967), p. 177.

[14] Charles B. Fisk and others, "Organ," Harvard Dictionary of Music, 2nd ed., edited by Willi Apel (Cambridge, Massachusetts, 1969), p. 611.

CHAPTER IV

MATERIALS AND METHODS OF CONSTRUCTION USED IN THE CASE

One of the primary acoustical functions of the organ case is to reflect the sound toward the listeners. The efficiency of the case in reflecting sounds depends on its stability and the nature of its surface.[1] The degree to which the reflected sound reaches the listener depends on its placement and shape, as discussed in previous chapters.

The other primary acoustical function of the case is to act as a resonator, imparting warmth and blend to the sound.[2] It is important to distinguish between reverberation and resonance. Reverberation is the prolonging of sound vibrations through reflection after the source has stopped and is chiefly a function of the room. Resonance occurs when "a vibrating system tends to yield a maximum of vibration with a minimum of driving force."[3] There are degrees of resonance rather than an absolute condition that is either present or absent. The case is such a system, set into vibration by the sound

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[1] Poul-Gerhard Andersen, Organ Building and Design, translated by Joanne Curnutt (New York, 1969), p. 26.

[2] Dirk Flentrop, Letter to the editor, The Diapason, XII (November, 1956), 8.

[3] Jody C. Hall and Earle L. Kent, The Language of Musical Acoustics (Elkhart, Indiana, 1957), p. 12.

waves carried to it through the air from the pipes. This case resonance is an example of "broad resonance," which means that the case will respond to a "comparitively wide range of exciting frequencies."[4] The case, as it vibrates in resonance to the pipes, imparts its vibrations to the air, where they are transmitted to the listener. Thus, the entire case structure is "capable of forced vibration and sound transmission."[5] The sound produced by the case when in resonance is important because it is different in structure from the direct sound of the organ. It should also be remembered that the case responds more effectively to relatively large amounts of energy; thus, the participation of the case in the organ's total sound grows as the volume of the organ increases.[6]

Only a limited amount of energy reaches the case. Whatever energy is reflected toward the listener will not contribute to the case's resonance. Since the case must both reflect and resonate in order to achieve the best musical result,[7] the energy which reaches the case must be divided between these two functions. The builder must adjust this balance to suit the musical effect, and in addition, try as much as

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[4]Charles A. Culver, Musical Acoustics, 3rd ed. (New York, 1951), p. 39.

[5]William Leslie Sumner, The Organ: Its Evolution, Principles of Construction and Use (New York, 1953), p. 239.

[6]Leo L. Beranek, Music, Acoustics, and Architecture (New York, 1962), p. 23.

[7]Joseph Edwin Blanton, The Revival of the Organ Case (Albany, Texas, 1965), p. 14.

possible to prevent a loss of energy through absorption or any other manner which will not enhance the sound which reaches the listener.

The amount of sound which a material reflects and the amount it absorbs are relative to the pitch of the sound. Table I shows sound-absorbing properties of several materials related to pitch. The table is based upon perfect absorption (an open window) equaling a value of 1.000.

TABLE I

SOUND-ABSORPTION COEFFICIENTS FOR THREE MATERIALS[8]

Cycles per Second	64	128	256	512	1024	2048	4096
Pitch	CC	C	c^1	c^2	c^3	c^4	c^5
Open window	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Brick wall, 16 inches thick, unpainted	.021	.024	.026	.032	.041	.052	.069
Wood sheathing, 3/4 inch thick, N. C. pine	.063	.097	.112	.103	.081	.081	.112
Thin hardwood paneling (0.2 to 0.4 inch with air space behind[9]	....	.42	.21	.06	.05	.04	.04

[8]Joseph Edwin Blanton, <u>The Organ in Church Design</u> (Albany, Texas, 1957), p. 113.

[9]Beranek, p. 547.

Although brick generally absorbs less sound than wood, the proportion of higher pitches in relation to lower pitches absorbed by brick is greater than it is with wood. The surface quality of the materials is decisive with respect to absorption. The pine sheathing absorbs more than the hardwood paneling because its surface is rougher.[10] In the bass range of the organ, the upper partials are stronger; in the treble, the fundamental. Thus, it is always the high pitches which are necessary to the tonal color of the organ. In this respect, the wood paneling in Table I is the most acceptable of the three materials, since it actually absorbs less of the high pitches than of the low ones. Plywood is a very poor reflector of organ sound. This is because the alternating layers of varying density used in its construction cause the panel to absorb sound.[11] Glass reflects organ sound much better than does wood. When a large amount of reflection is necessary, it may be used to advantage, as in the organ in Kaiser-Wilhelm Gedächtniskirche in Berlin, built by Berliner in 1962. The rear walls of the case compartments are glass, and "the increased reflection capacity makes up for the relatively dry acoustic of the room."[12] A similar situation is found in St. Barnabas' Episcopal Church in Denton, where the

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[10]Sumner, p. 237.

[11]Wilmer T. Bartholomew, Acoustics of Music (New York, 1946), p. 73.

[12]Josef Schäfer, "The Modern Organ Case," ISO-Information (December, 1971), p. 509.

pipes for the upper manual speak toward the rear of the organ and are reflected toward the listener from a glass sheet.

If the sole acoustical purpose of the case were to reflect sound, then cases should certainly be built of glass or similar material. But the resonating properties of the case are at least equally important. As noted above, wood, especially hardwood, is in most instances an adequate reflector. However, it is superior to other materials chiefly because of its resonance properties.[13]

The thinner the panels in a case, the more freely they will resonate in sympathy with the pipes.[14] This has long been known to harpsichord builders, who constructed the wooden casework to be as light as possible within the limits of necessary strength to provide maximum resonance.[15] Strong wood, such as oak, may be made into much thinner panels while retaining the necessary structural strength than may lighter, softer wood, such as pine. Plywood, a poor reflector, is an even poorer resonator. Any layered material will hinder the transmission of sound waves and should be avoided.[16] In order to obtain maximum resonance, the panels of the case should be

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[13]Siegmund Levarie and Ernst Levy, Tone: A Study in Musical Acoustics (Cincinatti, 1968), p. 148.

[14]Herbert Norman and H. John Norman, The Organ Today (New York, 1967), p. 178.

[15]Raymond Russell, The Harpsichord and Clavichord (London, 1959), p. 20.

[16]Bartholomew, p. 73.

made of thin, hard wood. It is fortunate that such panels also reflect the sound well enough for most situations, as discussed above.

Poor construction techniques may result in a loss of part of that portion of energy reaching the case which is available for resonance characteristics. "Liberally planed and well-joined woodwork" is important to the case, since energy will pass best through joints that are firmly coupled.[17] In this way, the case may vibrate as a unit rather than as individual panels. When panels are arranged for easy removal, any slots or joints should be tightly fitted (with felt if necessary) not only to improve the resonance properties but to eliminate rattles. In order to assure that the case joints remain tightly fitted, seasoned wood should be used, since it is least apt to warp.[18]

With careful design and placement, the builder may be assured that in most instances a wooden case will reflect sound adequately. But only through careful construction techniques, keeping wood thicknesses as small as possible, may he be certain that the instrument will take full advantage of case resonance.

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[17] Sumner, p. 239.

[18] *Ibid.*, p. 241.

CHAPTER V

SUMMARY

The preceeding chapters have presented a number of acoustical considerations in the design and construction of the organ case. There is no specific order for the builder to follow in planning a case. All of the factors discussed in this paper, and a multitude of others, such as visual effect, are not successfully integrated merely through an orderly consideration of each in turn. Rather, the builder must use his artistic creativity in considering all factors together, thereby arriving at a design which combines all of them. The considerations in this paper are of little value without this leap from craftsmanship to artistry.

Fortunately, there is no one perfect organ or case for any given situation. The number of musically and visually effective cases possible for each room is limited only by builders' imaginations. However, on the basis of the information in the previous chapters, it is possible to describe a general type of case construction which would be successful in most instances. Such a case would be in a free-standing position, centered on the longest axis of the room, and would speak in a straight line toward the audience with no intervening obstruction. Ample space would be allowed between the organ and the floor, walls, and ceiling (which would be plane surfaces with good reflective properties). Each division would have its own compartment within the general case, placed so as to project the sound toward the listeners. These compartments would fit closely about the pipes of the division and would be made of plane surfaces of thin wood. A great degree of latitude is possible within these generalizations, of course, and a variety of other courses are open to the builder as well. New advances in action and new materials will continue to challenge the builder to find increasing flexibility in the effective design of cases.

With such continuing experimentation, what prevents the case from entering a decline similar to that of the nineteenth century? This decline was preceeded by a period of fairly static reproduction of existing concepts of the case; experimentation will ensure eventual improvement. But chiefly, each builder has at his disposal a tool which may be used in all instances to judge his own work and the work of others--the ear. As long as builders and players continue to listen and judge, the result will be musically satisfying. The importance of the acoustical considerations presented in this paper as well as all others is their effect on music as perceived by the listener.

BIBLIOGRAPHY

Books

Andersen, Poul-Gerhard, Organ Building and Design, translated by Joanne Curnutt, New York, Oxford University Press, 1969.

Bartholomew, Wilmer T., Acoustics of Music, New York, Prentice Hall Inc., 1946.

Beranek, Leo L., Music, Acoustics, and Architecture, New York, John Wiley and Sons, Inc., 1962.

Blanton, Joseph Edwin, The Organ in Church Design, Albany, Texas, Venture Press, 1957.

________________ The Revival of the Organ Case, Albany, Texas, Venture Press, 1965.

Clutton, Cecil and Austin Niland, The British Organ, London, B. T. Batsford Ltd., 1963.

Culver, Charles A., Musical Acoustics, 3rd ed., New York, The Blakiston Co., 1951.

Hall, Jody C. and Earle L. Kent, The Language of Musical Acoustics, Elkhart, Indiana, C. G. Conn Ltd., 1957.

Klotz, Hans, The Organ Handbook, translated by Gerhard Krapf, Saint Louis, Concordia Publishing House, 1969.

Knudsen, Vern O., Modern Acoustics and Culture, Berkeley, California, University of California Press, 1937.

Levarie, Siegmund and Ernst Levy, Tone: A Study in Musical Acoustics, Cincinatti, Kent State University Press, 1968.

Norman, Herbert and H. John Norman, The Organ Today, New York, St. Martin's, 1967.

Russell, Raymond, The Harpsichord and Clavichord, London, Faber and Faber, 1959.

Sumner, William Leslie, The Organ: Its Evolution, Principles of Construction and Use, New York, Philosophical Library, 1953.

Articles

Flentrop, Dirk, Letter to the Editor, The Diapason, XII (November, 1956), 8.

Holtkamp, Walter, "Organ Music and Organ Architecture," Architecture (June, 1934), 355-356.

Phelps, Lawrence I., "A Short History of the Organ Revival," Church Music, I (1967), 13-30.

Schäfer, Josef, "The Modern Organ Case," ISO-Information (December, 1971), 505-528.

Dictionary Articles

Fisk, Charles B. and others, "Organ," Harvard Dictionary of Music, 2nd ed., edited by Willi Apel, Cambridge, Massachusetts, Belknap Press, 1969.