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7. RETROSPECTIVE OUTLINE OF THE ELECTROACOUSTIC SYSTEM IN THE NATIONAL MUSEUM “PANORAMA RACŁAWICKA” IN WROCŁAW (1985 – 2020)

7.1. Introduction

”The Panorama of the Battle of Raclawice”, a monumental masterpiece by Jan Styka and Wojciech Kossak – a work of national culture of great historical value, arousing great interest of not only Polish society, required both an appropriate facility and technical equipment. The “Panorama Raclawicka” exhibition consists of the Rotunda with the painting, Small Rotunda with the model of the battle and show-cases with iconographic materials and hall with video systems and film and slide projection screens (Fig. 1).

The specific character of the object imposed special requirements on the designers of the electroacoustic system; among other things, the following were required:

- the expected high interest in the object and the related requirements for the safety of people and canvas were taken into account,
- ensure high throughput of the facility with as much commentary as possible on the viewed work,
- ensure that comments can be submitted simultaneously in several languages,
- take into account the possibility of different ways of organizing visitor traffic in the entrance hall, in the Small Rotunda and on the platform in the Rotunda.

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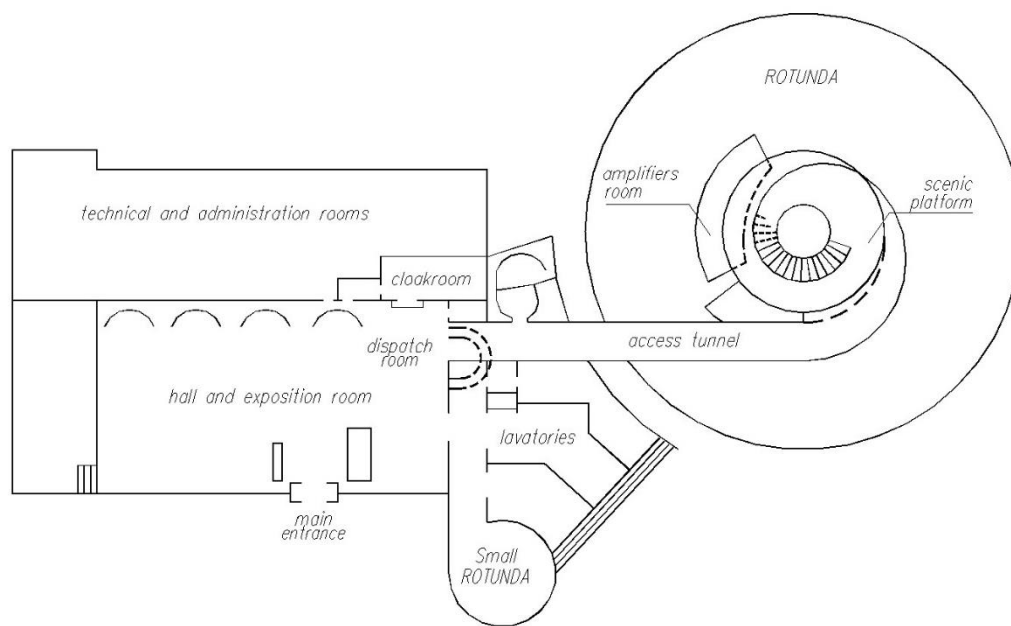


Fig. 1. “Panorama Raławicka” museum – horizontal projection [1]

Rys. 1. Muzeum “Panorama Raławicka” – rzut parteru [1]

The largest possible capacity of the object with a possible widest commentary on the “Panorama Raławicka” in the conditions of limited space and related safety rules concerning visitors and protection of the painting (e.g. stability of climatic conditions inside the building) was the basic problem of design. Eventually it was accepted that no more than two groups of 40 persons on opposite sides of the platform can be on the scenic platform in the Rotunda at the same time. The touring time of one group was determined at 40 minutes. This time is divided into six intervals corresponding with six sectors the painting is divided into.

Taking into account the above-mentioned requirements and a number of other conditions resulting from the ongoing martial law was only possible through the construction of an automatic electroacoustic system, which in conjunction with the information system would provide a comprehensive solution to the problem of organising a tour of the facility. The organisation of the tour was the basis for designing the system, and the unusual acoustic properties of the facility and the analysis of the sound of the viewing platform area were the elements correcting the final form of the system. The implemented solution is a result of the work of a team of employees, led by the main system designer, the author of this work. The result of the system implementation is, among others, obtaining 4 patents.

7.2. The idea of the system (realization as of the day of opening of the building in 1985)

The system consists of 3 independent installations:

- electro-acoustic explanation system,
- radio installation,
- installation of a high-speed service communication system.

Fig. 2 shows a simplified block diagram of the system, which shows 5 main locations where devices fulfilling different functions are located. These locations are:

- entrance hall,
- dispatch room,
- amplifiers room,
- the scene of platforms in Rotunda,
- Small Rotunda.

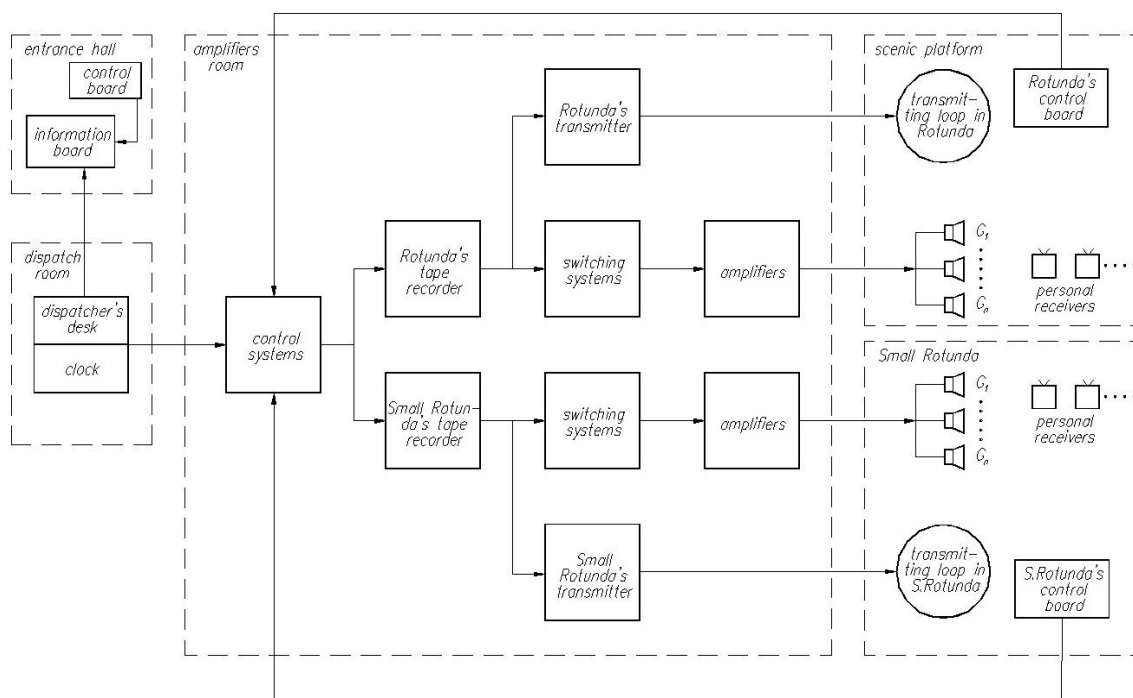


Fig. 2. Simplified block diagram of the electroacoustic system [1]

Rys. 2. Uproszczony schemat blokowy systemu elektroakustycznego [1]

Entrance hall

In the hall above the entrance to the tunnel leading to the viewing platform, there is an information board with the current time, the start time of the next screening and information about the language in which the commentary explaining parts of the picture will be given.

The dispatch/control room

During normal operation, all devices included in the electroacoustic system are controlled from the clock located in the so-called clock and acoustics panel (shown in Fig. 3). In this panel there is also a block which supports the sound system of the Rotunda and the Small Rotunda as well as a radio block. The dispatcher has the possibility to choose a specific way of sounding the viewing platform of the Rotunda, the room of the Little Rotunda with a battle model and control the operation of the whole system.

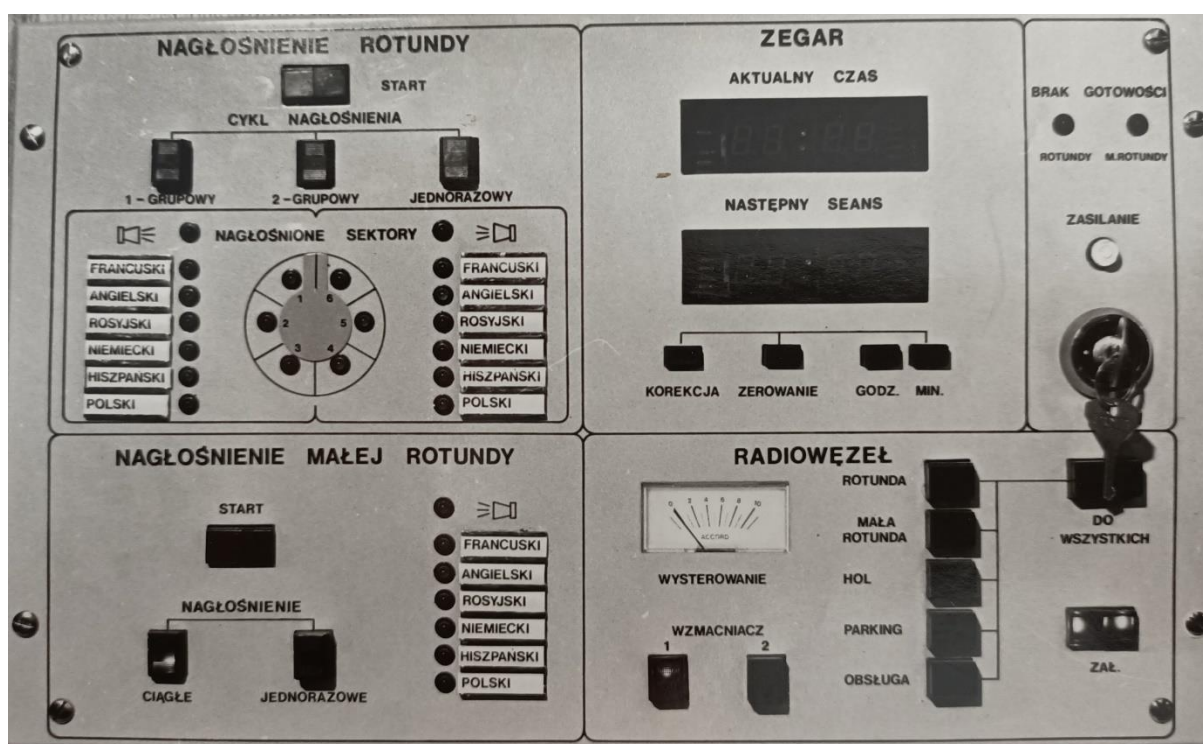


Fig. 3. The fragment of the dispatcher's console – control of sound system in sectors

Rys. 3. Fragment konsoli dyspozytora – sterowanie nagłośnieniem w sektorach

Amplifiers room

Pulses from the clock control all the devices placed on 6 racks in the amplifiers room. The main devices of the system include:

microprocessor control set,

- TTL control system,
- switching systems,
- loop tape recorders,

- power amplifiers,
- wireless explanatory device transmitters,
- power supplies, control equipment.

Equipping the system with two independent control systems allowed to increase the reliability of operation; in the case of simultaneous operation of both controllers, the role of the superior controller is played by a microprocessor control system and is complemented by a TTL control system, compatible due to the output control signals.

Figure 4 shows a full block diagram of the electroacoustic system containing control, diagnostics and sound signal path and Fig. 6 shows a general view of the electroacoustic system devices in the amplifiers room.

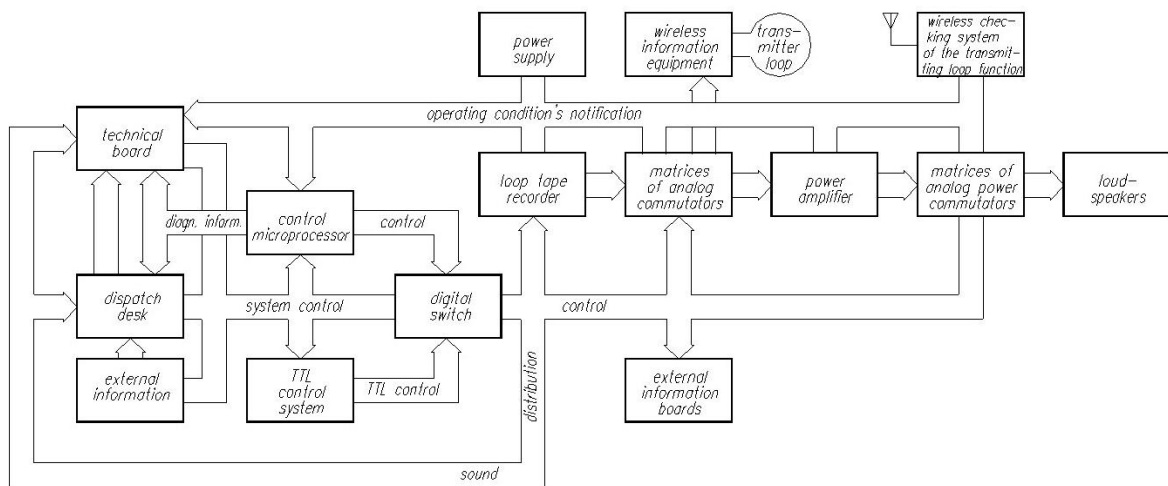


Fig. 4. Block diagram of the electroacoustic system [1]

Rys. 4. Schemat blokowy systemu elektroakustycznego [1]

Two independent subsystems complement the electroacoustic system. The subsystem of the radio relay centre makes it possible to pass dispatcher's information and instructions to all places in the building of the museum, in which people are present (he can use additional loudspeakers in rooms outside the sightseeing route, as well as loudspeakers of the electroacoustic system). The subsystem of quick staff communication "Telvox" is the second subsystem – it is not connected to the basic system.

7.3. Acoustic properties of the object [1], [9]

The shape of the painting "Panorama Raclawicka" (Rotunda) approximates a cylinder with the diameter of the base equal to 42 m (circumference of a circle ca. 114 m) and height

14.5 m (surface ca. 1650 m²). Inside is a scenic platform, which together with the shield over it forms a shape approximating a cylinder. The scenic platform forms a ring and is lifted over surrounding it artificial ground (surface ca. 1000 m²). Inside the ring leading down entry and exit path leading down are located (see Fig. 1).

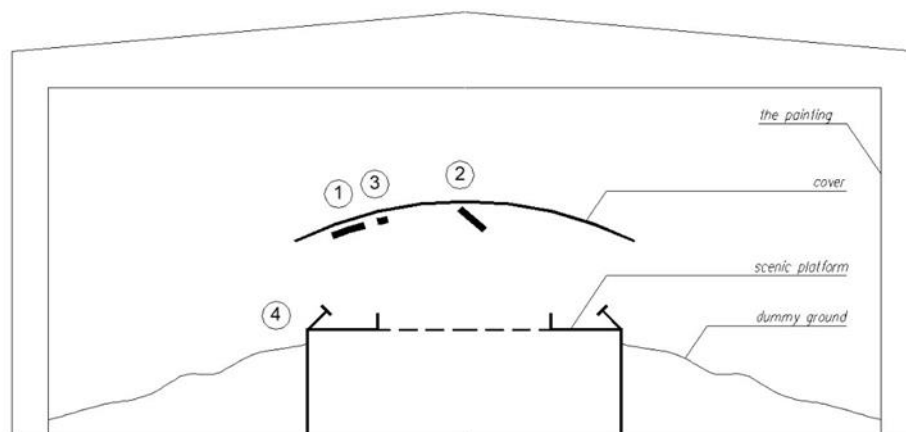


Fig. 5. Diagrammatic section of the Rotunda with position of loudspeakers [1], [9]: (1) – 3 units eight-loudspeaker columns on the cover spaced every 20° over the platform, (2) – one column located in the centre of the shield, (3) – loudspeakers located on the shield above the platform, (4) – loudspeakers located every 20° in the outer railing of the platform

Rys. 5. Schematyczny przekrój Rotundy z zaznaczonym położeniem głośników [1], [9]: (1) – 3 kolumny ośmiogłośnikowe na czaszy, rozmieszczone co 20° wokół platformy, (2) – kolumna umieszczona w centrum czaszy, (3) – głośniki umieszczone na czaszy nad platformą widokową, (4) – głośniki rozmieszczone co 20° na poręczy platformy (c)

The Rotunda has remarkably unfavourable shape from the point of view of acoustics. This was a serious problem which had to be solved during designing the sound system. From the point of view of acoustics the Rotunda can be described as a system of two coupled rooms consisting of a room with volume of about 20 000 m³ containing the painting and „scenic platform room” with volume of about 800 m³, formed by covering the scenic platform with a shield made from roll formed sheet aluminium. The coefficient of coupling between rooms, k , was estimated on the basis of relationship [5]:

$$k = (1 + \alpha \cdot S_2/S_{12})^{-1} \quad (1)$$

where: α – the mean absorption coefficient of the main room, $\alpha = 0.1$, S_2 – surface of the main interior, $S_2 = 4800 \text{ m}^2$, S_{12} – surface joining both rooms, $S_{12} = 190 \text{ m}^2$

The obtained value of coefficient $k = 0.28$ makes it possible to treat the platform region as a practically separate room.

The above considerations find confirmation in results of measurements of reverberation time. Mean values of reverberation time are $T = 2.2 \text{ s}$ for the platform and $T = 3.8 \text{ s}$ for the

main interior. The achievement of high quality transmission of the explanatory commentary for guests of the museum staying on the scenic platform was the fundamental task.

The analysis of sound distribution possibilities of the scenic platform was carried out on the basis of relationship between articulation loss for consonants AI and parameters of the systems [6]:

$$AI = \frac{200D^2T^2(n+1)}{VQ} \quad (2)$$

where: T – reverberation time of the scenic platform room, D – loudspeaker – listener distance, V – room's volume, n – number of sound sources apart from the loudspeaker nearest to the listener, Q – directivity factor of sound source.

The value of directivity factor of average column loudspeaker was 7. The value n was accepted as equal to 3, because of at the same time with the loudspeaker consideration a second loudspeaker will work in the same section and two in the opposite section.

Considering given above data the articulation loss will amount to $AI = 10.9\%$. The calculated AI value equal to 10% corresponds with quality of speech judged as very good [8].

7.3.1. Sub-assemblies and assemblies of the electroacoustic system [1], [7]

Due to a great number of subassemblies and assemblies of the system only main functional elements of accepted solutions are shortly discussed below; some of them have received patents [1], [2], [3], [11].

7.3.1.1. Control system

Sound system control is done with two independent programmers; a microprocessor system is superordinated programmer and its complemented with a TTL control system compatible with respect to input signals. There are 3 methods of sound system control:

- with a microprocessor programmer,
- with a TTL programmer,
- with both programmers working simultaneously.

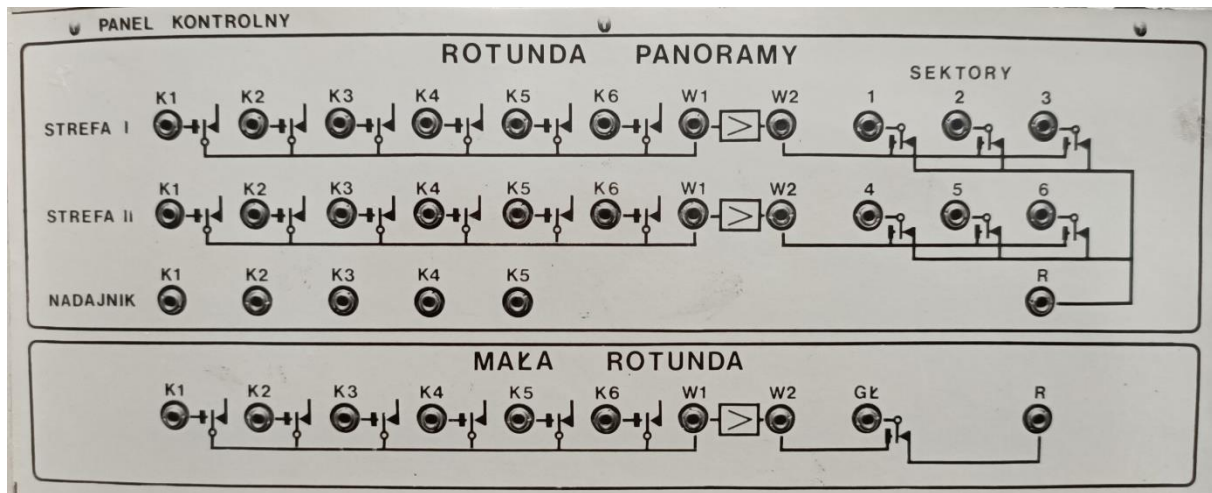


Fig. 6. Front plate of the sound line control unit

Rys. 6. Płyta przednia panelu kontrolnego toru fonii

7.3.1.2. Diagnostic system

It was necessary to equip the electroacoustic system with diagnostic systems, because the design devices in the control room were to work without servicing personnel (during normal operation) and defects were to be possibly quickly localized and eliminated. Figure 7 presents a general block diagram of a system assessing functioning of the electroacoustic system.

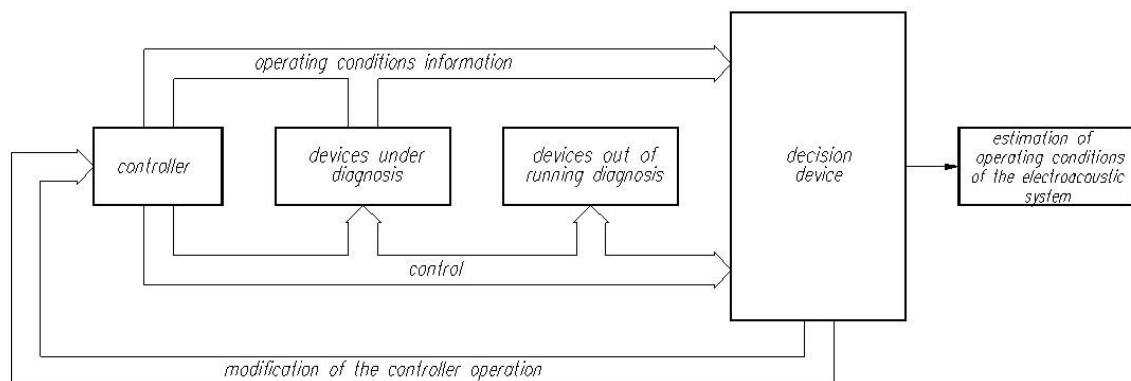


Fig. 7. Block diagram of a system assessing functioning of the electroacoustic system [1]

Rys. 7. Schemat blokowy systemu oceny funkcjonowania systemu elektroakustycznego [1]

7.3.1.3. Loop tape recorders

Double track loop tape recorders equipped with special cassettes which makes it possible to reproduce the commentary in a continuous manner without rewinding. The tape recorder is operated by the control system and verified by diagnostic system.

7.3.1.4. Switching systems

Switching systems consists of system of analogue keys acting as sound signal commutators connecting loop recorders' outputs with amplifiers' inputs and modulation inputs of transmitters of the wireless device.

7.3.1.5. Power amplifiers

In order to increase reliability the electroacoustic system was equipped with 8 amplifiers; 4 amplifiers make a short reserve.

7.3.1.6. Commentary transmitting wireless device

A method of wireless information transfer was applied to make possible to listen to the commentary in language other than is transmitted through loudspeakers. The visitors equipped with a special transistor receiver can listen through earphones to any one of five language versions of the commentary.

7.3.1.7. Monitoring systems

Monitoring systems of the electroacoustic system indicate the functioning of individual elements of the system. They have the form of separate panels placed in stands and have galvanic connections with other elements of the systems. The panels are named as: test panel, control panel of sound transmission path, audio monitoring panel, control panel of tape recorders, technical panel and control receivers of the high frequency circuits.

Fig. 8 shows the front panel of the technical board located in the amplifier room; this panel is one of the most important elements of the electroacoustic system presented above. This panel allows to control the operation of all individual elements of the system as well as the whole system during its normal operation.

Fig. 9 shows a general view of the electroacoustic system devices described in chapter 3, placed on 6 stands in the amplifiers room.

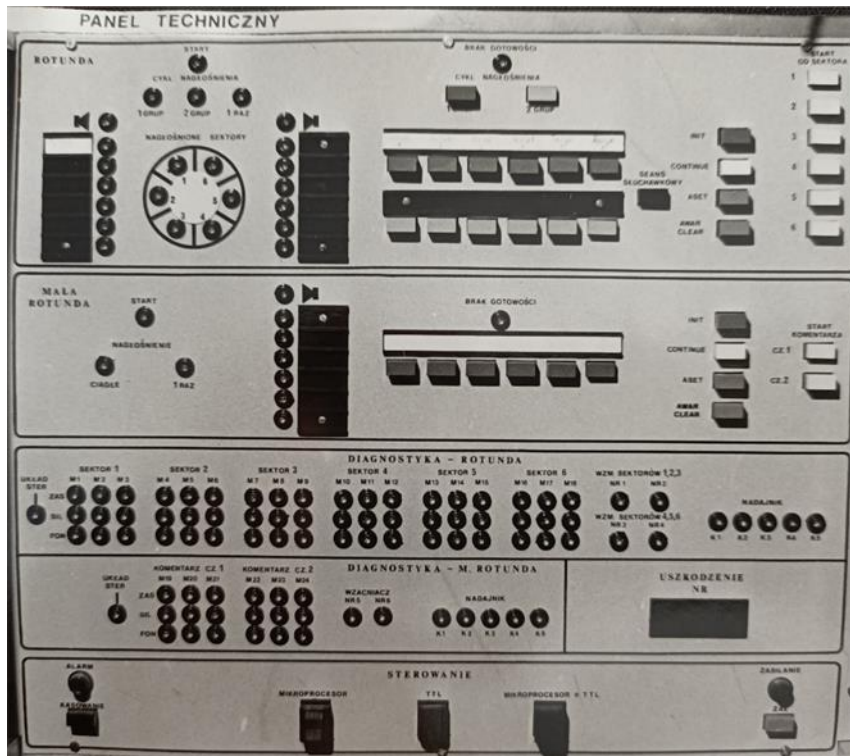


Fig. 8. Front plate of the technical panel
Rys. 8. Płyta czołowa panelu technicznego

7.4. Changes introduced during the 35 years of the system's operation [10]

The main idea of applied system has proved itself in practice during 35 years of its operation, but lots of equipment parts were changed due to new technical possibilities. This includes modifications to the control system and almost all peripheral devices, which have been replaced by modern devices in line with technological developments. High capacity of the object, at the beginning amounting to over 0.5 million visitors a year (during 35 years over 11 million visitors!) at average time spent inside the museum of about 2 hours indicates that the right solution was accepted.

7.4.1. Changes introduced between 1992 and 1993

Intensive use of the electroacoustic system required more and more frequent service intervention. The weakest element of the system turned out to be loop tape recorders, in which, after 6 years of intensive operation, the most frequent failure of the tape shift mechanism took place with comments recorded in 6 languages explaining 6 fragments of the battle picture. One tape recorder was used for each sector – a total of 36 tape recorders were ready for operation; the failure of one tape recorder resulted in a temporary lack of commentary in only one language serving a given sector. Thanks to the diagnostic system it

was possible to quickly locate the failure. Replacing the tape recorders with the available TOK-2000 computer players also required modification of the sound system control; the available AXIOM PC industrial computer was used for this. Additionally, the system was equipped with the TDX-2000 dispatcher computer terminal and the TDX-2000 multiplexer terminal. The previous radio broadcasting module for wireless comment transmission worked with these devices.

7.4.2. Changes introduced between 1997 and 2002

In place of the damaged (due to flooding of the Panorama building) in place of the original control system built mainly of TTL systems, computer control of the model of the battlefield located in the Mala Rotunda was introduced. A new SIEMENS programmable controller was used here.

Instead of the transmitting and receiving system working in radio technology on 6 channels in the long-term range with amplitude modulation, the wireless conference system Auditel TXR-12 XLR M/F, which worked in the infrared (IR) range, was used. This system provided simultaneous transmission of comments, ultimately on 12 channels with frequency modulation (FM).

In 2002 it was necessary to modernize the infrared radiator unit for wireless comment transmission in Rotunda. A multi-channel Auditel TXR-12 infrared transmitter working in the frequency modulated infrared range was installed, which replaced the AM radio transmitter.

7.4.3. Changes introduced in 2006-2007

The acquisition of viewers from the new language areas has exhausted the capacity of the existing solution. In addition, frequent failure rate and high maintenance cost in the absence of service decided to change the existing conference system into a distributed system configured from several dozen independent synchronized players programmable as PDAs. The so-called PDAs were used, in which the function of a programmable player of sound files in mp3 format was used to protect against theft. However, this solution has not been very successful due to the frequent freezing of the device during operation and the difficulty of effective protection against theft.



Fig. 9. Amplifiers room – general view of the electroacoustic system equipment on the day of opening of the “Panorama Raławicka” (14 June, 1985)

Rys. 9. Amplifikatornia – widok ogólny wyposażenia system elektroakustycznego na dzień otwarcia “Panoramy Raławickiej” (14 czerwca, 1985)

7.4.4. Changes introduced in 2010-2013

In 2010-2013, the installation and reconfiguration of a new set of equipment for the sound realization of the “Panorama Raławicka” Rotunda took place. Third generation audio guides were introduced, which work synchronously in a distributed system, which ensures increased reliability. The use of ORPHEO ArtOp player, ORPHEO Player audio guides allowed to

increase the number of languages to 14 and to introduce audio descriptions. The use of ORPHEO Rack 19 charger allowed to extend battery life. Fig. 10 shows the screen view with the choice of language version of the sound system and Fig. 11 shows a set of listening devices located on the viewing platform allowing simultaneous listening to comments in multilingual groups.



Fig. 10. Screen for selecting the language version of listening to the commentary explaining the course of the battle (Fot. Janusz Wieland)

Rys. 10. Ekran wyboru wersji językowej komentarza objaśniającego przebieg bitwy (Fot. Janusz Wieland)



Fig. 11. A set of listening devices located on the viewing platform allowing simultaneous listening to comments in multilingual groups (Fot. Janusz Wieland)

Rys. 11. Zestaw urządzeń odsłuchowych znajdujących się na platformie widokowej, pozwalających na jednoczesny odsłuch komentarza dla grup wielojęzycznych (Fot. Janusz Wieland)

7.5. Conclusions

The electroacoustic system drives the traffic inside the object. Acoustic control of the traffic allows precise organization and reservation in advance. Used in the initial tour of the object in a precisely determined period of time is the only possible solution with such a vast interest in the painting. The acoustic system generally was judged by visitors as good. However, there was a certain discomfort when two groups are touring the museum at the same time. Still, the quality of speech of the commentary transferred to two groups of listeners at the same time was very high. Because of a little lower number of visitors at present at the scenic platform now is only one group of visitors but there is a higher number. The distributed system of equipment for simultaneous commentary listening and the reconfiguration of the new set of equipment for the "Panorama Raławicka" rotunda is a modern solution, ensuring the simultaneous transmission of commentary to individual audiences regardless of the chosen language of all visitors at the venue at the same time.

In 1986 the group of engineers was awarded the Prize of the Minister of Science and Higher Education for the development and realization of the first electroacoustic system.

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