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FESTIVAL PLAZA CONTROL SYSTEM FOR 1970'S JAPAN WORLD EXPOSITION

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I. INTRODUCTION

The Japan World Exposition held in the Senri Hills of Osaka between March 14 and September 13, 1970 was a great success. The Exposition held many attractions but the festivities at the Festival Plaza in the middle of the Symbol Zone was the world's first experiment in open air entertainment utilizing sound and light performances and various other mechanical equipment. Fuji computer control techniques played a great part in the systematic performance and operation of this equipment.

II. FESTIVAL PLAZA

The Festival Plaza was the site of continuous entertainment for the whole 184 day period starting from the opening ceremony on March 14. Its was here that the national day festivities of all the countries participating in the exposition were held. The theme was changed weekly and small scale shows were performed in the middle of fair goers from morning until night

These shows were performed on a 100 m width × 30 m high open air stage in special surroundings in the middle of the fair goers and changed every several hours. Consequently, it was neither an outdoor theater, indoor theater, nor merely a plaza and a complex mixture of space was required.

III. FESTIVAL PLAZA PERFORMANCE EQUIPMENT AND SYSTEM

1. Performance equipment

The performance equipment was centered around level and on the ceiling. Roughly classified by function it consisted of lighting, sound, mechanism, and control equipment and was either fixed or movable depending upon the purpose.

The lighting equipment was mounted to the ceiling. Indirect lighting and down lighting were used for general lighting at night. Strobo lighting mounted to the ceiling and a lighting booth suspended from a trolley on the ceiling were used for performance lighting.

In addition, spot lights and special effects lighting equipment were also employed.

The sound equipment employed a 6 ch tape recorder, 2 ch tape recorder, stereo player, electronic music syntherizer, and microphones as the primary input devices. These were formed into a 11 ch sound source system by the sound mixing control desk in the main control room. The output devices consisted of approximately 700 speakers arranged in 288 groups within the plaza.

The mechanism equipment was divided into ceiling equipment and ground level equipment. The ceiling equipment was mounted to 6 trolleys and 1 traverser mounted to rails on the ceiling and could be freely moved to any position required by the particular performance.

The ground level equipment consisted of a mobile stage, 8 wagon stages, 6 mobile visitor's stands, and a performance robot equipped with various performance functions.

The control equipment consisted primarily of various control desks, a control computer, and tele-control set, all installed in the main control room. In addition, a lighting control desk, sound control desk, and stage-setting control desk were installed in a sub-control room.

These performance and control equipments formed a computer control (performance) system utilizing the large memory and high level judgement functions of an electronic computer which connected the various equipment on-line through a real time controller and tele-control equipment at a central processor. An outline of the computer system is given below.

Central processor	F270–30	1
Magnetic tape unit	F606A	2
Line printer	F643A	1
Paper tape reader	F749A	1
Paper tape punch	F767A	1
FACOM writer	F801A	1

2. Performance system

Four control systems were employed; a manual system, a remote control system through the control

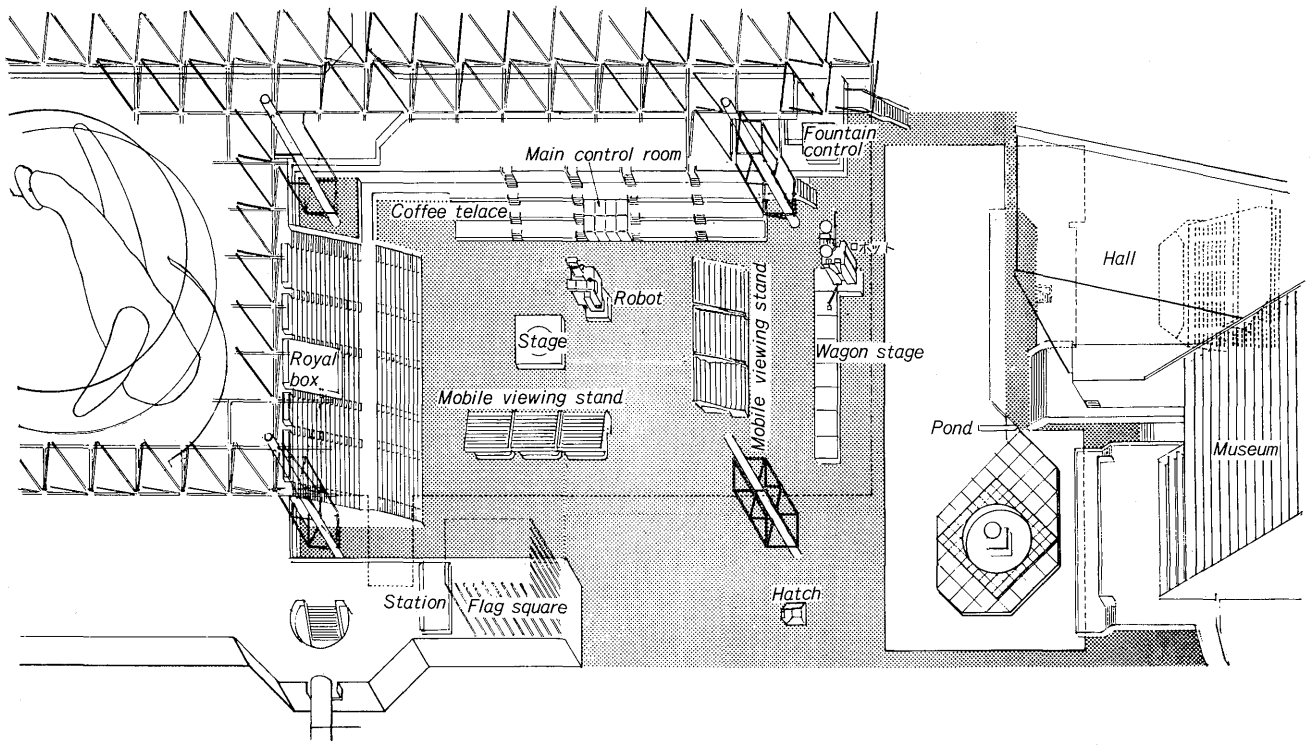


Fig. 1 Layout of mechanical equipments on the floor

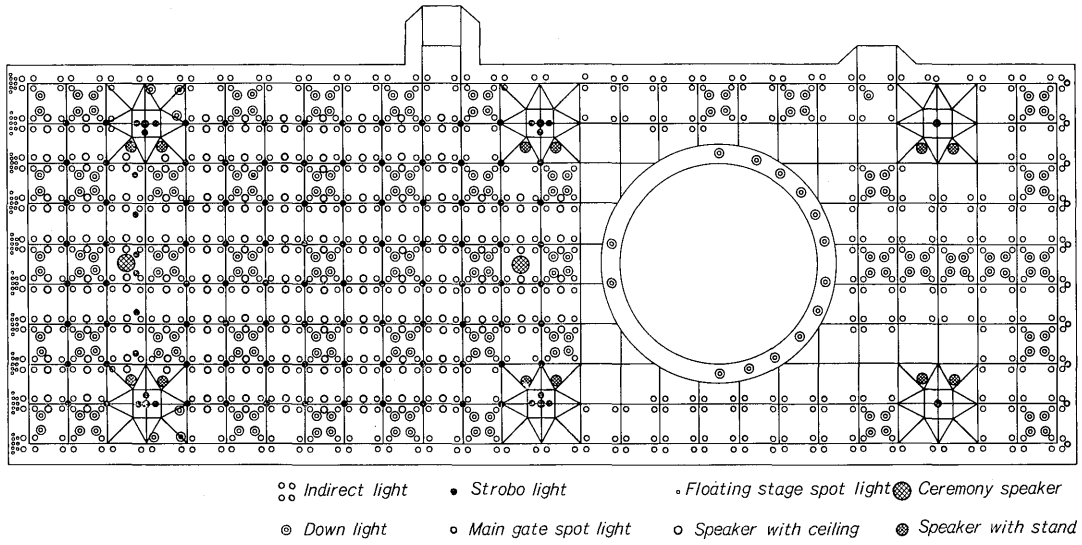


Fig. 2 Layout of the equipments on the ceiling

desk or radio control panel, a system in which the control pattern stored in the control computer in advance was called out by a starting signal from the control desk, and a control system in which the control pattern and its call out were stored in the control computer and synchronized with the entertainment of the 6 ch tape recorder.

The first system was used when the movement of the performers had to be followed manually and in the case of maintenance, etc. The second system was the same as that used in normal theaters. The third system employed the so-called preset function, but had a hundred preset steps instead of the three preset steps normally found in theaters, etc. The fourth system was a special feature of performances at the plaza and provided superb entertainment through the use of an electronic computer.

IV. CONTROL OBJECTIVES

The performance equipment installed in the Festival Plaza were described above. In the following we will describe the relation between the electronic computer and the performance equipment.

1. Lighting equipment

The control objective was indirect lighting, down lighting, strobo lighting and the lighting booth.

Indirect lighting consisted of 400 W metal-halleid bulbs mounted pointing upwards on grids spaced 10.8 m apart under the roof and installed in sets of four. A total of 222 sets consisting of 789 bulbs divided into 14 groups were used. Flashing of any one of the 4 bulbs of any single group could be controlled.

Down lighting consisted of 215 halogen bulbs mounted pointing downward on grids in the same manner as the indirect lighting. These were divided into 120 groups whose flashing could be freely controlled.

The strobo lighting consisted of 112 xenon flash light bulbs installed pointing upward on grids. These were divied into 104 groups whose flashing could be controlled.

Three lighting booths ware used. Each booth was equipped with 112 one kW halogen lamps divided into 4 groups. Four step lighting control and 4 color mixing was possible for each group. Control was performed by the tele-control set through control lines run between the rails.

2. Sound equipment

As previously described, the sound source consisting of 11 systems at the sound control desk in the main control room flowed to the plaza through 288 speakers. These 11 sound sources could be connected to any number of the 288 outputs. Control was performed by switching the contacts of a 11×288 matrix.

3. Trolley and traverser equipment

Six rails in 3 sets and one set of 2 rails at right angles to these three sets were installed below the ceiling. Six trolleys were suspended from the former and one traverser was suspended from the latter. The trolleys were equipped with 33 stop positions and the traverser with 5 stop positions. Starting and stopping was controlled by the tele-control set through wires placed the rails. Raising and lowering (3 points) and tilting (7 directions) of the lighting boothes and raising and lowering (5 points) of the stage attachments were also possible at the stop positions. The traverser was used when shifting the trolleys between the three sets of rails. The trolley was moved between the rails and shifted to the new position by riding on the traverser. The tele-control set was not used for traverser control.

4. Performance robot

The performance robot was equipped with effect lights, spot beams, scent nozzles, mist nozzles, and other special effects equipment. In addition to being controlled from the control desk inside the robot,

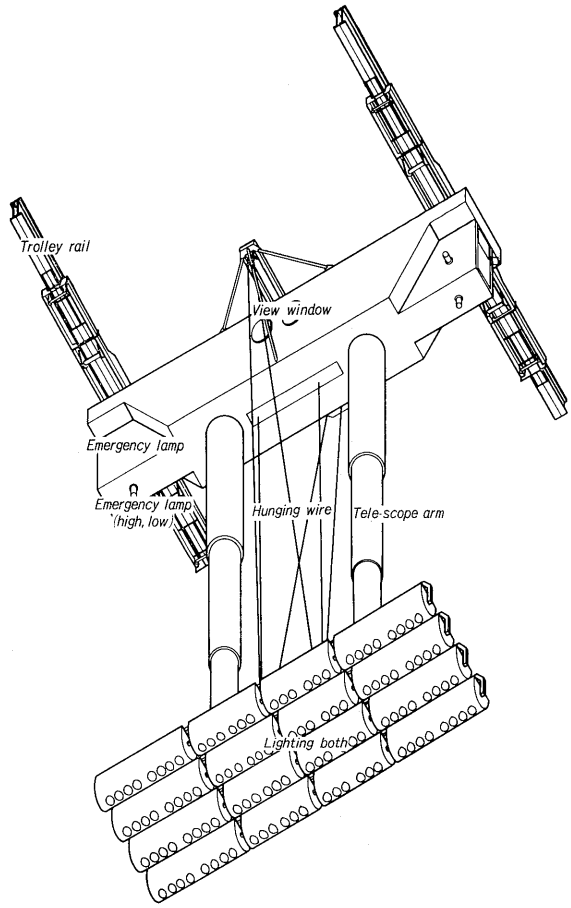


Fig. 3 Lighting booth trolley

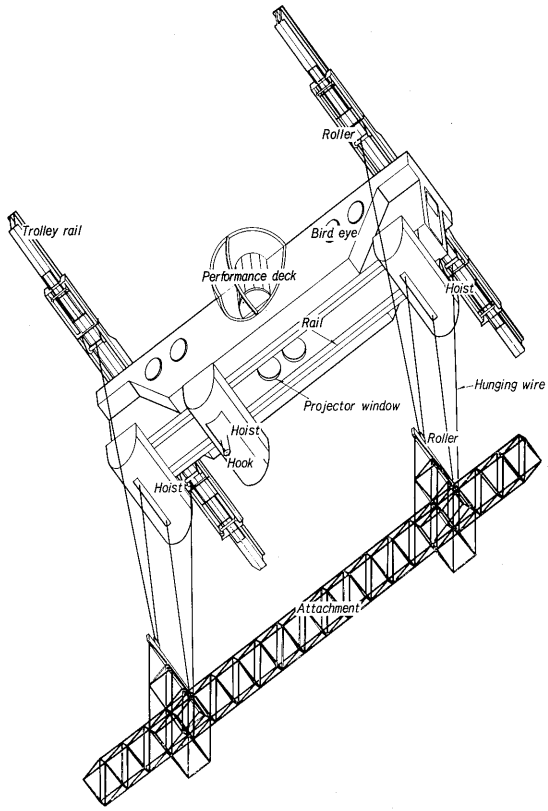


Fig. 4 Performance trolley

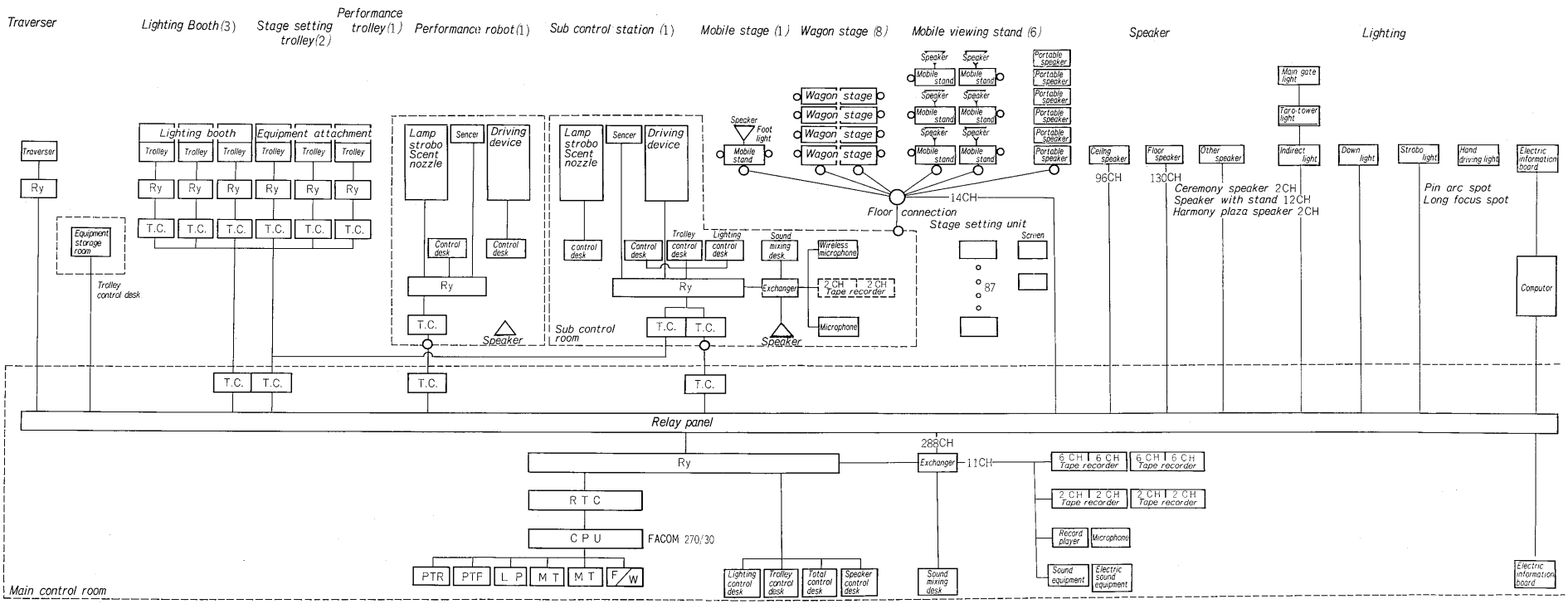


Fig. 5 **Block diagram of control system**

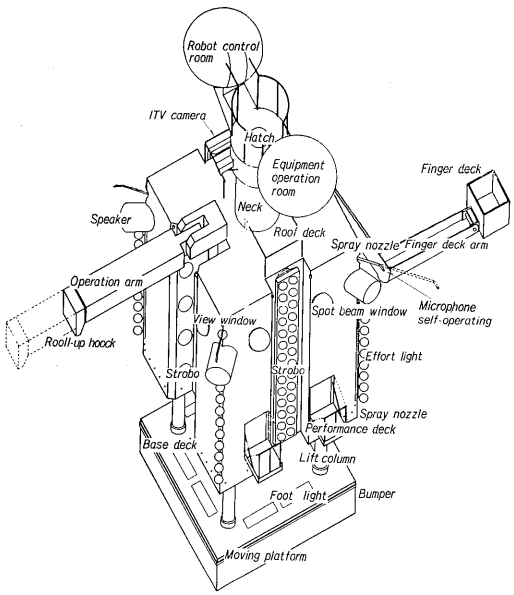


Fig. 6 Performance robot

its pattern could also be controlled by the computer in the main control room through a receptacle on the floor. The on-site data obtained by means of directional microphones, light meters, and other sensors installed to the body of the robot was used as start signals. The data from the start signal switches was also used.

5. Sub-control station

The sub-control station was not a control objective in itself but was used to control the lighting booths. When the lighting operation for a distant stage couldn't be controlled from the main control room, local control was performed from the sub-control station lighting control desk.

V. CONTROL SYSTEMS

1. Lighting control system

There were two indirect lighting, down lighting, strobo lighting, and lighting booth control systems. One system was a preset system (automatic) in which numbered preset patterns were stored in the computer and the desired lighting pattern executed by calling out the preset pattern by specifying its pattern number when required. The other system was an entertainment system (computer) which switched the lighting patterns in accordance with the entertainment schedule memorized in advance.

In the preset system, up to 100 preset patterns classified by the type of lighting could be written into magnetic drum from the lighting control desk and the pattern rapidly and positively switched when necessary by reading out the pattern by specifying the type of lighting and pattern number. Since each pattern was processed as a sub-pattern by a

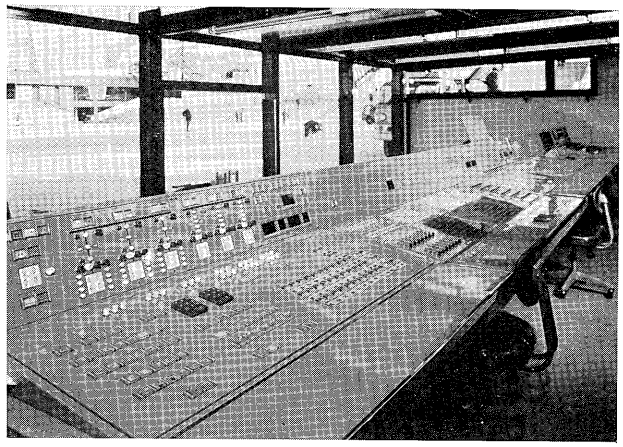


Fig. 7 View of operator desks

matrix processing program, a new pattern could be superimposed on an old pattern and only one pattern among the superimposed patterns eliminated by specification when reading out the pattern. Preset operation when two or more activities were taking place in different areas of the Festival Plaza was also possible.

The entertainment system permitted automatic entertainment by the computer or by extemporaneous entertainment by the entertainer.

The lighting pattern could be changed by synchronization with 1 second timing signals from the tape recorder or by button operation at the total control desk. In order to simultaneously process a large number of patterns, each entertainment pattern was transferred to a matrix processing buffer at an entertainment demand processed while taking the logic sum of all the entertainment patterns.

2. Sound control system

Connection and disconnection of the 11 ch sound sources and 288 ch speaker system was performed automatically. The sound control system consisted of a preset system and an entertainment system the same as the lighting control system.

In the preset system, the desired input channel could be connected to the desired output channel by reading out the connection pattern of the speaker unrelated to the input channel memorized on the magnetic drum by specifying the input channel and pattern number at the speaker exchange control desk. In the entertainment system, connection of the speakers was switched in synchronization with the timing pulses from the tape recorder.

3. Trolley and traverser control system

The pattern of the 6 trolleys for the lighting boothes and stage setting had to be changed in accordance with the composition of the stage in the Festival Plaza. Since interchanging of the patterns and regularity of trolley movement could not be expected, a signal transmission system for mutual

exchange between the control room and trolleys and a system to verify the current position of the trolleys was complex and demanded a high level of control equipment.

Moreover, in this type of system, perfect protection against erroneous operation is extremely difficult even in an on-site manual control system in which the operator directly operates the trolleys and traverser. Consequently, a trolley-traverser control system employing external equipment having a minimum number of functions and utilizing computer software system to directly control the movement of the trolleys and traverser while deciding the trolley switching sequence and monitoring the operating state was employed.

The interlock function vital in external control equipment was given dual safety features through the use of a software system which compensated for the deficiencies in the functions of the external control equipment in addition to the normal hardware.

(1) Independent automatic

In this system, the sophisticated judgement function of the electronic computer was utilized and sequential operation of each trolley or the traverser was perfomred while monitoring the present position and operating state of the trolley and traverser. Operation was performed by means of the operating buttons at the trolley control desk. In most respects, the remote manual function remained unchanged. However, complex functions were performed with respect to simultaneous operation of a number of trolleys on the same rail.

(2) Pattern automatic

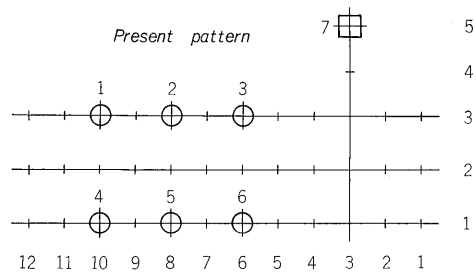
Changing the position pattern of the 6 trolleys at short periods was required to respond to changes in the layout of the stage or to utilize its movement for performances in the Festival Plaza. In this system, the specified trolley pattern was automatically pattern switched without regards to the current position of each trolley by reading out the preset trolley pattern from the trolley control desk at the required time.

To switch from the current pattern to the objective pattern, a sequence table for a single trolley or when switching while executing movement of the traverser was first prepared by means of an algolism program. After that, switching to the objective program was performed by simultaneously operating each trolly and the traverser within the permissible range while referring to the current position of all the trolleys and the traverser and the sequence table. An example of the sequence table prepared in real time by the computer is shown in *Fig. 8*.

4. Performance robot equipment control system

Performance by the performance robot was controlled by feeding the preset pattern and its changed sequence correspoding to the atmosphere in the plaza detected by the direction microphones, luxmeters and other sensors or by direct operation of the control buttons inside the robot to control the various performance robot equipment described in IV. 4.

However, since signal transmission between the main control room and performance robot was performed by the tele-control set through the floor receptacle, computer control was impossible while the performance robot was travelling.



STP	TN	XP	YP	XF	YF
1	7	3	5	3	3
2	3	6	3	1	3
3	2	8	3	2	3
4	1	10	3	3	3
5	7	3	3	3	2
6	1	3	2	11	2
7	7	3	2	3	3
8	2	2	3	3	3
9	7	3	3	3	2
10	2	3	2	2	2
11	7	3	2	3	3
12	3	1	3	3	3
13	7	3	3	3	2
14	3	3	2	10	2
15	7	3	2	3	1
16	6	6	1	2	1
17	5	8	1	3	1
18	7	3	1	3	2
19	5	3	2	9	2
20	2	2	2	8	2
21	7	3	2	3	1
22	4	10	1	3	1
23	7	3	1	3	2
24	4	3	2	7	2
25	7	3	2	3	1
26	6	2	1	3	1
27	7	3	1	3	2
28	6	3	2	6	2
29	7	3	2	3	5

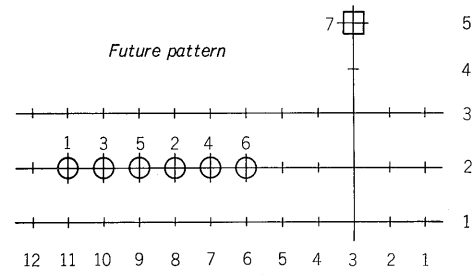


Fig. 8 Example of trolleys traverser operating schedule

VI. PERFORMANCE PREPARATION SYSTEM

In the lighting, sound, and performance robot entertainment systems, the switching sequence of the various speakers and the flashing sequence of the various lighting was stored in magnetic tape as raw data and called out by specifying the standard pattern and its working conditions when required.

There were two call out methods; (1) a call out method in which the call out schedule (play) pre-

pared in advance and stored in the magnetic drum was called out in synchronization with the timing signals of the tape recorder (in synchronizing with the music) and (2) a call out method by means of button operation by the entertainer either extemporaneously or in accordance with the play.

The entertainment preparation system was prepared by the standard pattern and DISPLAY (Display Instrument Systematic Programming Language at Anytime by Yourself—play representation and its processor for easy, positive design, testing, registering and deletion at the magnetic drum of the standard pattern and play. The standard pattern and play represented by DISPLAY was registered as the formal standard pattern and play after testing grammatical errors, etc. by the processor.

1. Standard pattern preparation and registering

In order to memorize the position of the various lighting equipments flashing sequence, and speaker switching sequence into the computer as pattern material after completion of the study of the contents of performance effect, etc., the information was coded in accordance with the DISPLAY representation rule and punched in paper tape. The paper tape was tested for coding and punching errors by a check program, and errors which violated the representation rule were classified by type of error by the check program.

Upon completion of testing of this step, the standard pattern was registered in magnetic tape (standard pattern file) by the registration program. When the standard pattern was deleted, this file was always kept up to date by updating.

The standard pattern could be loaded into the magnetic drum from this file as required by means of the load program. However, the standard pattern at the stage where it was converted into the internal code of the computer produced differences in the specified memory capacity due to its type and contents and the standard pattern in the magnetic drum was memorized by sequential packing from the beginning and its heading address memorized in the magnetic drum as a pointer table.

2. Play preparation and registering

The stepped standard pattern loaded in the magnetic drum was raw data and only become a pattern having concrete effects by giving the following working conditions to it.

(1) Specification of entertainment start time
(2) Specification of static or dynamic representation
(3) Specifications of one-shot or repetitive representation
(4) Specification of continous time
(5) Specification of input channel with respect to speaker

To automatically perform Festival Plaza perform-

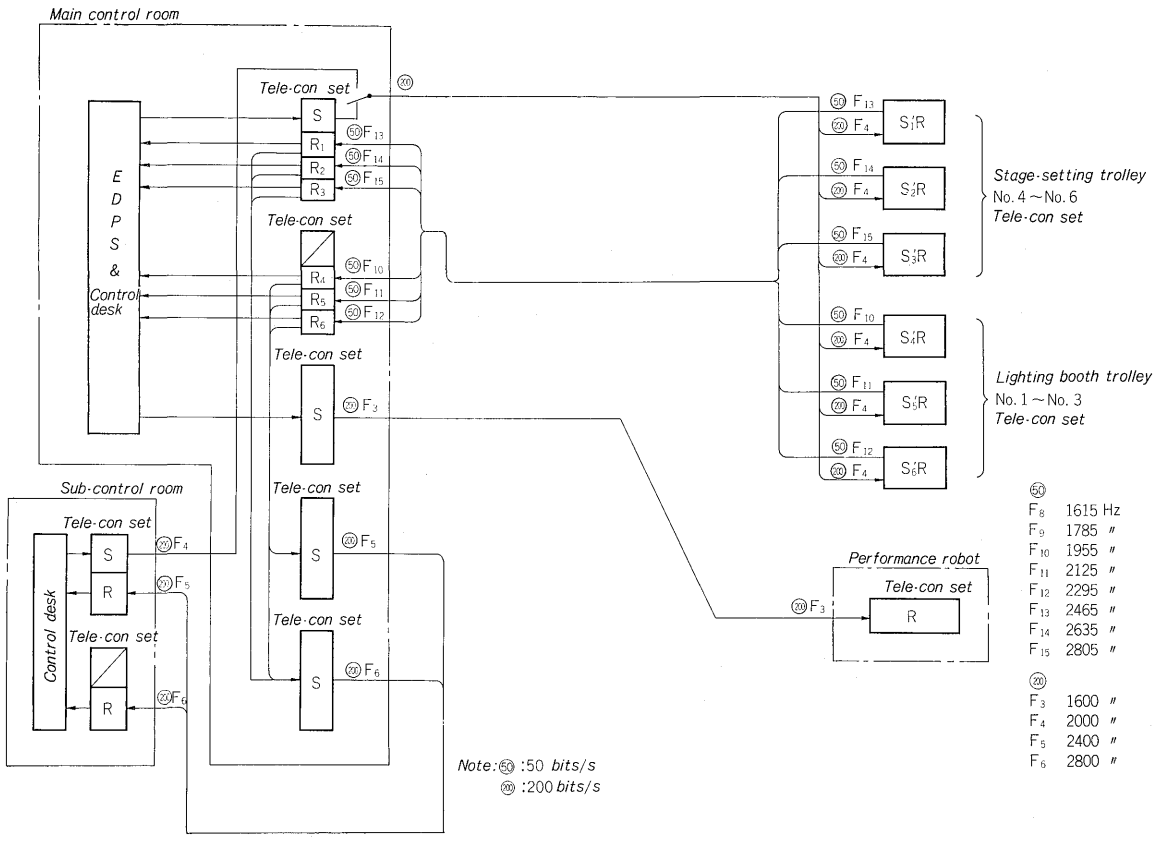


Fig. 9 Diagram of telecontrol system

ances by computer, standard pattern call out schedule (play) matched to the music tape compiled in accordance with the image of the performer had to be prepared. Coding of this play was performed in accordance with the DISPLAY representation rule as shown in *Fig. 9* and was tested for coding punching errors by the play check program. Errors violating the representation rule were classfied by type of error by the play check program.

VII. TELE-CONTROL SYSTEM

The tele-control set was trolley lighting booth and performance robot control signal and verification signal transmission equipment.

Control of the trolleys and lighting booths was performed from the main control room or sub-control room and control of the performance robot was performed from the main control room.

Interlocking of control of the trolleys and lighting booths was performed at either the main control room or sub-control room using two tone channels in the main control room to sub-control room direction and the signal from the associated equipment was locked during control single transmission.

1. Trolley and lighting booth use tele-control set

The number of control signals from the main control room and sub-control room were 20 items for the stage setting trolleys and 40 items for the lighting booth. The control signals were coded from the relay panel to the tele-control set and connected by no-voltage contacts. The coded control signals consisted of trolley No. 3 bits, control item 3 bits and control contents 16 bits for a total of 22 bits. These control signals were converted to a long or short pulse code by the tele-control set, FS modulated by a tone channel, and transmitted twice.

The tele-control set at the trolley received these signals, performed triple verification of double reception, total pulsecount and parity, and sent out a control output if all of these were OK. Verification of the effect and state of control was sent to the main control room and sub-control room by FS modulation by tone channel as an indication signal. As for the indication signal, ON or OFF was made a long or short pulse and transmitted in sequential cyclic for each 10 items. At the main control room and sub-control room, double reception, total pulse count, and parity verification ware performed and an indication output sent out if all of these were OK.

2. Performance robot control use tele-control set

The number of control signals from the main control room was 100 items. The control signals were connected from the relay panel to the tele-control set by no-voltage contacts by on-off signals. This control signal was converted into a long or short pulse code by the tele-control set, FS modulated by a tone channel, and sent twice by sequential cyclic at each 10 items.

VIII. MAIN CONTROL ROOM AIR CONDITIONING AND SIGNAL TRANSMISSION CIRCUIT

Since the electronic computer and its ancillary equipment was installed in the main control room, air conditioning considering temprature, humidity, and dust was provided. The air conditioning also used the wiring pit. The wiring was passed through the bottom of the pit and the air conditioning air flow path used the top. A special package cooler was installed in the computer room. The air was kept at 26°C, 50% RH.

Plaza wiring for the ground level sub-control station and performance robot was connected by means of receptacles on the floor and wiring for the ceiling trolley used sliding contacts as a dual connection so that there would be no broken wires even when the trolley was moving.

IX. CONCLUSION

As described above, this computer organization differs from conventional business or process control and has attracted attention as a large scale system for application in special fields such as theaters, etc. Completion of this control system will lead to the wire use of computers in such fields a wharehouse control, marshalling yards, outdoor stages, etc.