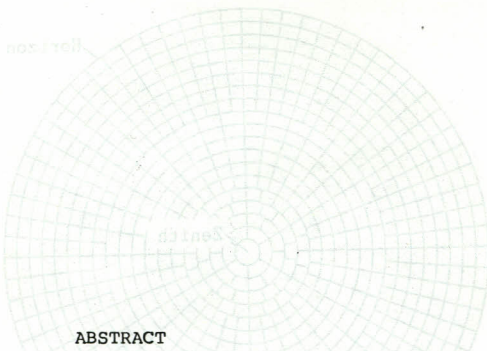


A NEW ARTIFICIAL SKY SYSTEM IN JAPAN

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ABSTRACT

A new type of artificial sky system with an artificial sun has been recently completed in a research institute in Japan. It can simulate not only the luminance distribution of the CIE overcast and clear skies but also that of other various kinds of reference skies. Moreover it can also pretend both blue and crimson skies. This automatically controlled system is considered to be excellent for the application of research works on daylighting and analyses of sunshine problems. Its outline is introduced in this paper.

1. INTRODUCTION

The construction and application of artificial skies began about in the beginning of the 1930s. Since then various kinds of facilities have been contrived. The artificial skies can be roughly classified into five types, that is, mirror box type (e.g. BRE in G.B.), reflection dome type lighted from the centre (e.g. Inst. of Const. and Archi. in Slovak.), reflection dome type lighted from the skirt (e.g. U.C.Berkeley in U.S.A), translucent dome type (e.g. TU Berlin in German), arranged lamps type (e.g. Research Inst. of Building Physics in U.S.S.R.). The mirror box type and translucent dome type may only reproduce the CIE overcast sky. The regulation of the luminance distribution of reflection dome types is supposed to be not easy. The sky of the arranged lamps type looks like a night sky with full of stars. As 853 separate luminaires are arranged for the new artificial sky system, they seem as if they compose a continuous sky. They are arranged closely inside a hemisphere. The lighting level of each luminaire can be easily controlled in order to reproduce the luminance distribution of all kinds of reference skies.

2. CONSTRUCTION OF THE NEW SYSTEM

The new artificial sky system consists of six parts, that is, an artificial sky with luminaires, an artificial sun which can be driven up and down from the horizon to the zenith, an artificial ground which can be rotated from -270° to 270° , colored floodlight luminaires for blue and crimson skies for illumination of sky dome inside, an control system, and a monitoring system.

3. ARTIFICIAL SKY

The inner radius of the artificial sky is 2,500mm, and the clearance between the horizon of the artificial sky and the floor of the room is 1,300mm, so the height from the floor to the zenith is 3,800mm (Fig.1). The artificial sky is divided into 853 elements and covered with 19 kinds of different shaped luminaires, as the sky vault is split horizontally into 19 by its height (Fig.2). The electric light source of each luminaire is an exclusive infrared reflective coating mini tungsten

halogen lamp (85W). All the luminaires are covered with plastic transmitting diffuser (Fig.3). Two luminaires at the sky points of symmetry with respect to the vertical orbit of the artificial sun are combined in order that their lighting levels can be controlled by a control circuit. The total number of control circuits is 427. The lighting levels of each couple of luminaires can be varied in 100 steps. The maximum illuminance at the centre of the artificial ground is 10,700 lx and that at its edge is 10,400 lx.

4. ARTIFICIAL SUN

The artificial sunbeam is simulated with the light from a mini tungsten halogen lamp (500W) which is reflected as parallel rays by a parabolic concave mirror whose diameter is 800mm (Fig.4). The concave mirror with the light source can rise up to 90° height (zenith) and set down to 0° height (horizon) (Fig.5). Its height can be set by every 1° . The illuminance at the centre of illuminated ground is about 13,000 lx and the uniformity ratio to the minimum illuminance in the main part in lighted up area by the mirror is about 6:1.

5. ARTIFICIAL GROUND

The diameter of the round artificial ground is 1,500mm, on which scale models of buildings, rooms' interiors and urban architectures can be arranged to inspect their daylighted environments. Its maximum loading weight is 100kg. The artificial ground can be rotated together with the movement of the concave mirror in order to show the correct solar altitude and azimuth at the time and date at the geographical point to be referred. The minimum time for a rotation is 12 minutes from -270° to 270° , and that of maximum is 48 minutes. The artificial ground can be oriented by every 1° . It can be raised up to 1,300mm from the floor and pulled down to 800mm. Chairs for observers can additionally be attached.

6. FLOODLIGHT LUMINAIRES FOR BLUE AND CRIMSON SKY

40 floodlight luminaires covered with blue transparency have been installed in order to illuminate the artificial sky vault with blue light so that it may look like blue skies. Mini tungsten halogen lamps (500W) have been applied as their light sources. A movable stand with 5 floodlight luminaires covered with orange transparency has been also prepared to show the crimson sky in the twilight. Their light sources are double-ended tungsten halogen lamps (300W). A control device with 15 circuits has been provided in order to vary their lighting level in 100 steps.

7. CONTROL SYSTEM

The luminance distribution of any indicated reference sky is instantly calculated by a micro computer and imitated on the artificial sky. Solar position, i.e. solar altitude and azimuth, of any reference point in the world at any time throughout a year can be estimated by the micro computer, and simultaneously the artificial sun moves and the artificial ground rotates to show the correct sun position. Sunrise and sunset time and solar culmination time also can be easily calculated, if necessary. All the data concerned above are stored in the memory of the computer.

8. MONITORING SYSTEM

A TV and video system has been provided in order to monitor and record the results of the experiments performed in the artificial sky. It has small cameras which can be attached anywhere inside of the artificial sky vault and be put in 'buildings' and urban models.

9. DISCUSSION

There had been only one translucent dome type artificial sky in Japan as a practically applicable facility when the construction of this system was decided. The system introduced in this paper has been developed after inspections of various artificial skies in the world, which has almost completely satisfied the authors. The experiments with the system has been attracting not only daylight research workers in Japan but also amateur visitors to the Institute as their experiments are easily understood by them. Moreover TV programmes and newspapers in Japan sometimes report various articles on this new system.

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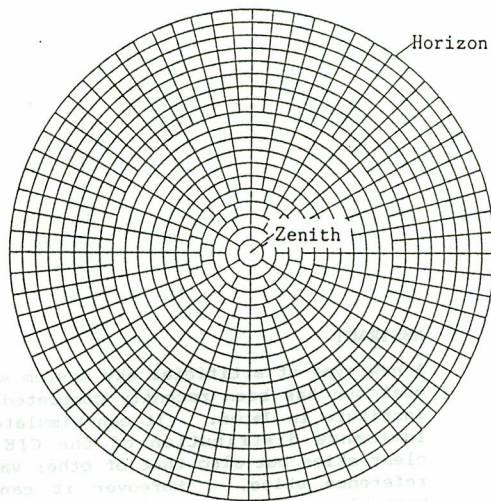


Fig.2 Arrangement of 853 luminaires

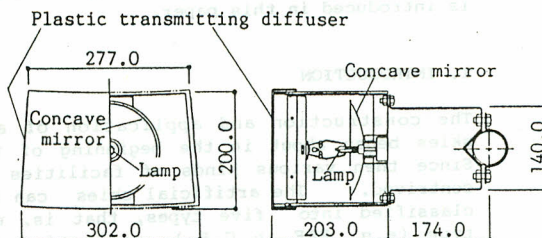


Fig.3 Luminaires at 45° height

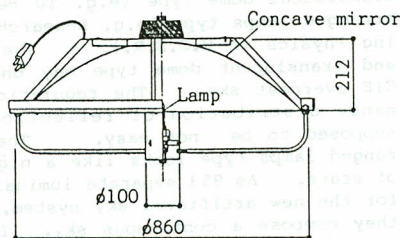


Fig.4 Artificial sun

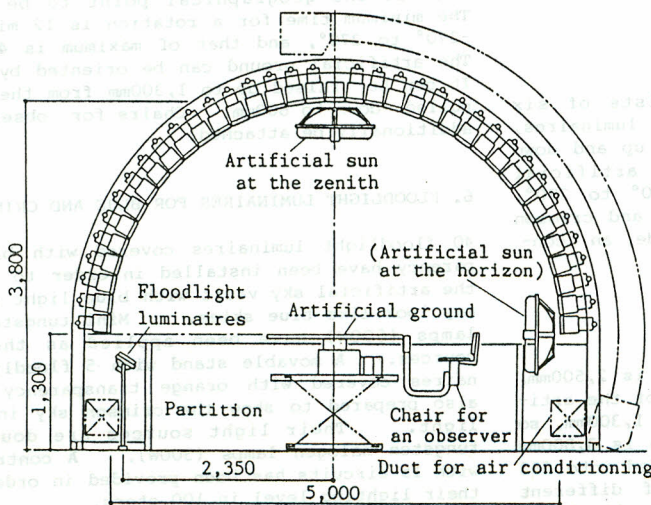


Fig.1 Artificial sky system

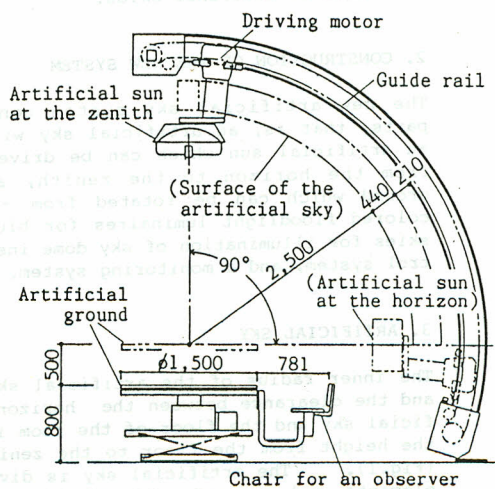


Fig.5 Solar driving mechanics